

A		B	X	C	
---	--	---	---	---	--

File Number: T 631/91 - 3.4.1
Application No.: 85 905 561.8
Publication No.: 0 199 793
Title of invention: SINGLE MIRROR INTEGRAL RAMAN LASER

Classification: H01S 3/30

D E C I S I O N
of 27 January 1993

Applicant: Hughes Aircraft Company

Opponent: Firma Carl Zeiss

Headword: Raman laser/HUGHES

EPC Articles 56, 83 and 108; Rule 64(b)

Keyword: "Content of notice of appeal" - "extent to which amendment or
cancellation of the decision is requested" - "admissibility (yes)
(Reasons, paragraph 1)" - "sufficiency (yes)" - "inventive step
(yes)"



Case Number : T 631/91 - 3.4.1

D E C I S I O N
of the Technical Board of Appeal 3.4.1
of 27 January 1993

Appellant : Firma Carl Zeiss
(Opponent) Postfach 13 69 / 13 80
W - 7082 Oberkochen (DE)

Representative : Breitschwerd, Gerda
(authorised employee)
Firma Carl Zeiss (DE)

Respondent : Hughes Aircraft Company
(Proprietor of the patent) 7200 Hughes Terrace
PO BOX 45066
Los Angeles, CA 90045-0066 (US)

Representative : Brandl, Ferdinand Anton
KUHNER, WACKER & PARTNER
Alois-Steinecker-Straße 22
Postfach 15 53
W - 8050 Freising (DE)

Decision under appeal : Decision of the Opposition Division of the
European Patent Office dated 2 July 1991
rejecting the opposition filed against European
patent No. 0 199 793 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. 0 199 793.

The independent claims of this patent read as follows:

"1. A Raman laser comprising:

a pump laser (120), for providing radiation at a first wavelength, having an output reflector (124);

a Raman medium (32) disposed along the optical path of said first wavelength radiation from said pump laser (120) for converting the wavelength of said first wavelength radiation to a predetermined second wavelength by Raman scattering processes;

focusing means (40) disposed between said output reflector (124) and said Raman medium (32) and positioned suitably adjacent said Raman medium (32) for focusing said first wavelength radiation into said Raman medium (32);

said output reflector (124) being partially reflective of said first wavelength radiation so as to transmit said first wavelength radiation from said pump laser (120) towards said Raman medium (32), and substantially 100% reflective of said second wavelength radiation so as to act as a Raman reflector for said Raman medium (32);

said output reflector (124) being aligned relative to said focusing means (40) and said Raman medium (32) so as to enhance desired wavelength conversion and substantially avoid feedback damage to said pump laser (120).

13. A method for laser wavelength conversion, comprising the steps of:

exciting a lasing medium to produce pump laser radiation at a first wavelength;

passing said pump laser radiation, along a first path, first through an output reflector (124) which is

particularly reflective of said pump laser radiation, and second through a focusing means (40) which focuses said pump laser radiation to a focus within a Raman medium (32), stimulated conversion of said pump laser radiation to a second wavelength occurring in said Raman medium (32), and

reinforcing said stimulated conversion of said pump laser radiation by passing said second wavelength radiation back through said focusing means (40) along a second path;

then reflecting said second wavelength radiation, from said output reflector (124) which is substantially 100% reflective of said second wavelength radiation, along a third path back through said focusing means and into said Raman medium, and

aligning said output reflector (124), focusing means (40) and said Raman medium (32) so that said first, second and third paths are substantially identical so as to reduce undesired scattered radiation to enhance desired wavelength conversion."

Claims 2 to 12 are dependent on Claim 1.

II. The grant of this patent was opposed by the Appellant based on Article 100(b) EPC and additionally on the ground of lack of inventive step (Article 100(a) EPC) in view of the prior art which can be derived from documents:

D1: DE-C-2 144 201;

D2: IEEE Journal of Quantum Electronics, Vol. QE-8, No. 4, April 1972, pages 427 to 428;

D3: Journal of Applied Physics, Vol. 48, No. 5, May 1977, pages 1973 to 1975; and

D4: Proc. Int. Conf. on Lasers, 1980, pages 406 to 413 (handwritten bibliographic data on a copy of the document submitted by the Opponent).

The Opposition Division rejected the opposition. It took in particular the view that the subject-matter of independent Claims 1 and 13 involved an inventive step, because none of the cited documents disclosed a Raman laser employing an output reflector of a pump laser which acts as well as a Raman reflector, in order to prevent the pump laser from feedback damage due to radiation produced by stimulated Brillouin scattering (SBS), a solution based on the finding that the threshold for stimulated Raman scattering (SRS) can be set below the threshold for stimulated Brillouin scattering by guiding the Raman radiation on an identical path with the pump radiation. Furthermore, a person skilled in the art would be able to carry out the subject-matter of the independent claims on the basis of the original disclosure due to the fact that the claimed alignment of output reflector, focussing means and Raman medium is not contradictory but derivable from the description, column 7, lines 7 to 27, and ensures the automatic alignment of the Raman radiation with the pump radiation for lowering the SRS-threshold relative to the SBS-threshold.

III. The Appellant lodged an appeal against the decision of the Opposition Division citing for the first time a document:

D5: Journal of Applied Physics, Vol. 38, 1967, pages 2254 to 2260,

and following the description of the opposed patent and regarded document

D6: EP-A-0 063 205

and not document D1 as in the appealed decision, as the nearest prior art.

IV. Oral proceedings were held on 27 January 1993, during which the Appellant (Opponent) filed

D7: a graph showing the dependence of the reflectivity R of a Raman laser mirror on the wavelength λ with R = 1.3% at $\lambda = 1064$ nm and R = 99.6% at $\lambda = 1550$ nm.

At the end of the oral proceedings the Appellant requested that the decision under appeal be set aside and that European patent No. 0 199 793 be revoked.

The Respondent (Patentee) requested that the appeal be dismissed as both inadmissible and unallowable and that the patent be maintained as granted.

V. In support of his request, the Appellant made essentially the following submissions:

- (a) It is evident from the patent under appeal, column 4, lines 38 to 41, that an output reflector of a pump laser has a typical transmissibility for pump radiation in the range of 70%. Also document D3, page 1973, right column, lines 18 and 19, discloses for Raman reflector M2 70% transmission of pump radiation. Hence, the claimed combined reflector for pump and Raman radiation is known from document D3 and a replacement of output reflector 5 and Raman reflector 8 in the Raman laser disclosed in Figure 3 of document D6 by such combined reflector would be obvious for the following reasons:
- (b) It is generally known and moreover derivable from document D1, that an alignment of the optical axis of the pump system with that of the Raman system

increases the yield of useful Raman radiation. Any additional alignment in the direction of the optical axis for phase-matching is not disclosed in the patent under appeal and, therefore, cannot support inventive step. Due to the fact that the pump laser output reflectors in the Raman lasers disclosed in documents D2 and D4 automatically have a non-negligible reflectivity for Raman radiation, the automatic alignment according to the patent under appeal is already present in this prior art. The contention, that the claimed alignment of output reflector, focussing means and Raman medium prevents feedback damage of the pump laser, is physically wrong.

- (c) Document D5 shows that SRS and SBS appear simultaneously. SBS radiation lying within the amplifying band width of a pump laser, would not be a problem in a Raman-laser as supported by documents D1, D2 and D3. Therefore, from a physical viewpoint the presence of SBS-radiation decouplers 6, 7 in the Raman laser of document D6 is superfluous and only serves the scientific purpose of exploring the isolated Brillouin radiation, so that the simplification by combining output reflector 5 and Raman reflector 8 into one element was obvious.
- (d) Thus, all the individual elements of the subject-matter claimed were known beforehand as also admitted in the presentation of the background art in the description of the patent under appeal.
- (e) Document D7 demonstrates that it is difficult to produce a conventional Raman reflector and the claimed combined one.

- (f) The claimed alignment of output reflector, focussing means and Raman medium remains unclear. Hence, a skilled person will be unable to realize by alignment the claimed effects.

VI. The above submissions were contested by the Respondent who argued essentially as follows:

- (a) The notice of appeal contains no statement identifying the extent to which amendment or cancellation of the decision under appeal is requested. Therefore, the appeal is inadmissible in view of Rule 64(b) EPC. Moreover, the appeal is not substantiated with regard to the dependent claims and therefore in view of decision T 293/88, OJ EPO 1992, 220, it has to be assumed that the prima facie validity of the dependent claims is not objected to.
- (b) The Raman laser disclosed in document D6 comprises a pump resonator, the pump radiation of which is imaged into a mechanically independent Raman system with a Raman reflector which prevents Raman radiation from entering into the pump laser. The imaging affords elaborate mechanical alignment means allowing only an imperfect superposition of the path of the pump radiation with the path of the Raman radiation returning from the Raman reflector. Moreover, the known pump laser uses additionally a light diode in order to prevent backscattered Brillouin radiation from damaging the pump laser. This indispensable presence of the light diode (i.e. Brillouin radiation decoupler) 6, 7 between pump laser and Raman system prevents a skilled person from transferring the function of the Raman reflector 8 onto pump radiation output reflector 5.

- (c) No cited document gives any hint to a skilled person to realize a 100% automatic alignment of the pump and Raman radiation paths by making the output reflector of a pump laser simultaneously reflective for Raman radiation, i.e. by providing both reflectors in the identical plane. Mirror M_2 of document D3 acts exclusively as a Raman mirror in the centre of the pump resonator. The fact that in such an intracavity arrangement mirror M_2 has only a 70% transmissibility for pump light is clearly not desired but a result of the experimental incapacity of producing a better transmissibility for pump radiation at 1080 nm when - due to the particular Raman medium - high reflectivity is necessary already at 1180 nm and not at 1540 nm as in the embodiment of the invention.

- (d) None of the cited documents teaches a skilled person that a 100% alignment of the optical paths of pump radiation and Raman radiation in the Raman laser of document D6 decreases the threshold of SRS-radiation below that of SBS-radiation, in particular not to such an extent that light diode 6, 7 can be left out.

- (e) Due to the fact that the description of the patent under appeal explicitly discloses in column 6, lines 51 to 56, that the embodiment of the invention makes use of a pump laser and a Raman cell, which are arranged in the same manner as in the prior art according to D6, a skilled person is clearly informed that the unexpected claimed effects of the use of the claimed combined reflector as indicated in detail in column 6, lines 7 to 27 - allowing the omission of the prior art light diode - can be achieved by a conventional alignment technique.

VII. At the conclusion of the oral proceedings, the decision was announced that the appeal is dismissed.

Reasons for the Decision

1. Admissibility of the appeal

The question whether the extent of the appeal within the meaning of Rule 64(b) EPC is sufficiently identified can only be decided in the context of a particular case, and the context of a particular case will normally include the contents of the decision under appeal. If an opposition has been rejected by the decision under appeal and it is simply stated in the notice of appeal that an appeal is lodged against that decision, such notice should properly be interpreted as meaning that the Appellant wishes to challenge such decision to the extent that the decision has rejected the requests made by the Appellant in his notice of opposition.

In the present case the notice of opposition includes a request to revoke the European patent in its entirety and this request is substantiated by an indication of facts, evidence and arguments against each claim of the patent in suit. Thus in the Board's view the notice of appeal in the present case should be interpreted as implicitly including a statement that the decision under appeal should be amended or cancelled to the extent that the Appellant's request for revocation of the patent in its entirety has been rejected in such decision.

Decision T 293/88 which is identified in paragraph VI(a) above was concerned with a case in which the Opponent in his notice of opposition only challenged the validity of certain specified claims of a European patent (Claims 1 to

6 and 8), and did not challenge the validity of three dependent claims (Claims 7, 9 and 10). This case is therefore quite different from the circumstances of the present case, where as explained above the patent was opposed to its full extent, and there are therefore no dependent claims which are not objected to.

For the above reasons, in the Board's judgment the notice of appeal in the present case satisfies Rule 64(b) EPC and Article 108 EPC, and is admissible.

2. Sufficiency of the disclosure for carrying out the invention

The wording of Claim 1 objected by the Appellant in paragraph V(f) refers to an alignment of the claimed combined - i.e. pump radiation transmitting and Raman radiation reflecting - output reflector 124 of the pump laser. In the Board's view, a skilled person derives from the description of the patent under appeal, column 7, lines 7 to 27, that the claimed combined reflector automatically aligns pump and reflected Raman radiation along substantially the same path from the reflector through focussing means 40 into enclosure 34 of the Raman medium, and that this closely identical path of pump and Raman radiation within Raman medium enclosure 34 causes the claimed enhancement of conversion of pump radiation into Raman radiation and the reduction of Brillouin radiation or avoidance of feedback damage. Hence, it is regarded to be a mere logical thinking of a skilled person to recognise that the claimed alignment of the three components - combined reflector, focusing means and Raman medium - reduces technically to the aim of imaging the pump light within the Raman medium in order to produce the claimed effects. Such an alignment, in the Board's view, is a mere experimental routine and moreover indicated in

the description, column 4, lines 51 to 56, to be feasible by conventional means.

For the above reasons, in the Board's judgment, the ground of opposition laid down in Article 100(b) EPC does not prejudice the maintenance of the European patent.

3. Inventive step - Claims 1 and 13

3.1 Documents D5 and D7, which were cited for the first time in the grounds of appeal and in the oral proceedings respectively, have been examined by the Board according to Article 114(1) EPC with the result that they have no influence on the decision to be taken, and could therefore be disregarded under Article 114(2) EPC.

3.2 The Appellant concedes implicitly that Claims 1 and 13 are novel, in particular over document D6; see paragraph V(a). Thus, the only further substantive issue raised in this appeal is that of inventive step.

3.3 The Board agrees with the view of both parties as implicitly expressed in paragraphs V(a) and VI(b) and regards the Raman laser and method for laser wavelength conversion represented in document D6 as the nearest prior art.

Document D6 discloses in the wording of Claim 1:

"A Raman laser comprising: a pump laser (see D6, Figure 3, parts 1 to 5) for providing radiation at a first wavelength, having an output reflector (5); a Raman medium (13) disposed along the optical path of said first wavelength radiation from said pump laser for converting the wavelength of said first wavelength radiation to a predetermined second wavelength by Raman scattering

processes; focusing means (9) disposed between said output reflector and said Raman medium and positioned suitably adjacent said Raman medium for focusing said first wavelength radiation into said Raman medium, said output reflector (5) being partially reflective of said first wavelength radiation so as to transmit said first wavelength radiation from said pump laser towards said Raman medium and "a Raman mirror (8)" which is substantially 100% reflective of said second wavelength radiation, said output reflector (5) being aligned relative to said focusing means (9) and said Raman medium (13)."

Document D6 discloses in the wording of independent Claim 13:

"A method for laser wavelength conversion (D6, page 1, paragraph 1) comprising the steps of exciting a lasing medium (4; page 4, lines 19 to 23) to produce pump laser radiation (18 in Figure 3) at a first wavelength; passing said pump laser radiation, along a first path, first through an output reflector (5) which is particularly reflective of said pump laser radiation, and second through a focusing means (9) which focuses said pump laser radiation to a focus within a Raman medium (13), stimulated conversion of said pump laser radiation to a second wavelength occurring in said Raman medium (page 2, lines 11 to 16 and page 5, line 32) and reinforcing said stimulated conversion of said pump laser by passing said second wavelength radiation back through said focusing means (9) along a second path; then reflecting said second wavelength radiation "from Raman mirror 8" which is substantially 100% reflective of said second wavelength radiation along a third path back through said focusing means and into said Raman medium, and aligning said output reflector (5), focusing means (9) and said Raman medium (13)."

3.4 Starting from the closest prior art as disclosed in Document D6, the objective problem underlying the present invention as claimed in Claims 1 and 13 is in the wording of these claims "to enhance desired wavelength conversion, to reduce undesired scattered radiation" and thus "to substantially avoid feedback damage to said pump laser".

3.5 This problem is solved according to Claim 1 in that not a separate Raman mirror (8) is used but the known output reflector (5) of the known pump laser (1 to 5) is additionally made "substantially 100% reflective of said second wavelength radiation so as to act as a Raman reflector for said Raman medium". In the language of independent method Claim 13 this problem is solved in that the second wavelength radiation is not reflected along a third path from a separate Raman mirror (8) but "from said output reflector which is 100% reflective of said second wavelength radiation ... so that said first, second and third paths are substantially identical".

Hence, the issue of inventive step underlying both independent claims reduces to the question whether it would be obvious for a skilled person to modify the conventional Raman laser disclosed in Figure 3 of document D6 by leaving aside conventional Raman mirror 8 and by making the conventional output reflector 5 of the pump laser reflective for Raman radiation instead in order to achieve the advantages defined in the formulation of the objective problem in paragraph 3.4 above, allowing in particular to eliminate conventional light diode 6, 7.

3.6 The Board follows the Appellant's view according to paragraph V(b) only insofar as a skilled person might expect an increase of stimulated Raman scattered (SRS) radiation in line with an improved alignment of the optical axis of the pump cavity with that of the

conversion system. In order to reduce stimulated Brillouin scattering (SBS) in a Raman cell on the basis of the known experimental result disclosed in the cited prior art, a skilled person's logical thinking would lead to either a reduction of the pressure in the Raman cell (see Figure 5 of document D5) or to a reduction of the intensity of the pump radiation in the Raman cell (see the last three lines on page 409 of document D4). Hence, in the Board's view, a skilled person is not able to foresee that an improvement of the experimental parameters for an enhancement of the stimulated conversion into Raman radiation represents as well a technical measure to reduce the intensity of stimulated Brillouin scattering.

3.7 Contrary to the conclusions of the Appellant in paragraph V(c), the fact that documents D1, D2 and D3 are silent about detrimental effects of SBS-feedback to the used pump laser cannot be interpreted as suggesting that backscattered Brillouin radiation is harmless to the pump laser. Knowing that SRS- and SBS-radiation always appear simultaneously, a skilled person in the Board's view will rather ascribe the lack of particular protective measures for the pump laser used in the devices of these documents to either a negligible SBS-radiation which is due to its particular excitation conditions in the used Raman cell, or to an overdimensioned thermal capacity of the used pump laser. Moreover, document D6 states explicitly on page 5, lines 8 to 11, that light-diode 6, 7 prevents the optical elements of the pump laser from being damaged. In particular this statement keeps a skilled person from speculating that in view of the claimed kind of Raman system an elimination of SBS-radiation might be superfluous. Document D6 discloses light diode 6, 7 positioned between output reflector 5 and Raman mirror 8 as an indispensable element of the known Raman laser and thus logically excludes the technical possibility to

combine output reflector 5 and Raman reflector 8 in one element as a measure of a routine simplification.

- 3.8 Though the pump laser output reflector in the devices of documents D2 and D3 might have a non-negligible reflectivity for Raman radiation (see paragraph V(b)), there is no statement nor a physical effect disclosed in these documents guiding a skilled person to see therein a technical means for automatic alignment. On the other hand, despite its certain amount of pump radiation reflectivity, mirror M_2 of the apparatus disclosed in Figure 1 of document D3 is exclusively used as the central Raman mirror within the pump laser resonator of this intracavity arrangement. Its limited transmissibility for pump radiation is without a significant influence on the functioning of the pump laser and will be interpreted by a skilled person, in the Board's view, as an experimental limit in manufacturing a Raman mirror of narrow bandwidth; see also paragraph VI(c). The reflector corresponding to an output reflector coupling pump radiation into an extracavity type Raman cell, in the Board's view, is not mirror M_2 but mirror M_1 or M_3 limiting the resonant cavity of the pump laser and thus forming the standing wave of the pump radiation. Hence, in the apparatus disclosed in document D3 the reflectors determining the effective propagation directions of the pump and Raman radiation are not arranged in the same plane. For these reasons, contrary to the Appellant's opinion in paragraph V(a) the Board regards a skilled person not to be able to recognise from the functioning of the device disclosed in document D3 that mirror M_2 , with its combined reflectivity for pump and Raman radiation might represent a technical means which would automatically align pump radiation leaving the pump laser resonator with radiation reflected from a Raman mirror arranged outside the pump laser cavity.

Furthermore, the cited prior art does not enable a skilled person to recognise in mirror M2 of document D3 a means for achieving the final technical aim of the patent under appeal, i.e. a prevention of SBS-feedback damage in the pump laser, enabling a replacement of means 5 to 8 in the apparatus of document D6 by mirror M2 of document D3. Though a reflector with the claimed physical properties was known beforehand (see also paragraph V(d)) and not difficult to manufacture (see paragraph V(e)), it was not obvious from the cited prior art to make use of such known reflector in order to solve a different technical problem as shown above; see also decision T 39/82, OJ EPO 1982, 419.

3.9 For the above reasons, the Board finds that the subject-matter of Claims 1 and 13 involves an inventive step within the meaning of Article 56 EPC.

4. Hence, it follows that granted Claims 1 and 13 are maintained. Granted Claims 2 to 12 concern particular embodiments of the Raman laser according to Claim 1 and are likewise maintained.

Order

For these reasons, it is decided that:

The appeal is dismissed.

The Registrar:



M. Beer

The Chairman:



G.D. Paterson

Handwritten initials
2
R14
1