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Datasheet for the decision of 8 November 2024

Case Number: T 0762/21 - 3.4.02

12719791.1 Application Number:

Publication Number: 2699962

G02F1/33, G02B21/00 IPC:

Language of the proceedings: EN

Title of invention:

METHODS AND APPARATUS TO CONTROL ACOUSTO-OPTIC DEFLECTORS

Patent Proprietor:

UCL BUSINESS PLC

Opponent:

Femtonics Kft.

Relevant legal provisions:

EPC Art. 56, 83, 84, 100(a), 111(1), 113(1), 123(2) RPBA 2020 Art. 11, 12(2), 12(3), 12(4), 12(5), 12(6), 13(2) EPC R. 121

Keyword:

Substantial procedural violation during first-instance oral proceedings (no)

Admittance or consideration of submissions in appeal Inventive step (main, first and second auxiliary request: no) Added subject-matter (third auxiliary request: no) Clarity (third auxiliary request: yes) Sufficiency of disclosure (third auxiliary request: yes) Remittal for further prosecution (yes)

Decisions cited:

G 0003/14, G 0001/21, R 0012/22



Beschwerdekammern Boards of Appeal

Chambres de recours

Boards of Appeal of the European Patent Office Richard-Reitzner-Allee 8 85540 Haar GERMANY Tel. +49 (0)89 2399-0

Case Number: T 0762/21 - 3.4.02

DECISION
of Technical Board of Appeal 3.4.02
of 8 November 2024

Appellant: Femtonics Kft.

(Opponent) Tüzoltó utca 59
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Representative: Kacsuk, Zsófia

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Respondent: UCL BUSINESS PLC

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Representative: J A Kemp LLP

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Decision under appeal: Decision of the Opposition Division of the

European Patent Office posted on 16 March 2021 rejecting the opposition filed against European patent No. 2699962 pursuant to Article 101(2)

EPC.

Composition of the Board:

Chairman R. Bekkering

Members: F. J. Narganes-Quijano

B. Müller

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Summary of Facts and Submissions

I. The opponent (appellant) lodged an appeal against the decision of the opposition division rejecting the opposition against European patent No. 2699962.

The opposition filed by the appellant against the patent as a whole was based on the grounds for opposition of added subject-matter (Article 100 (c) EPC), insufficiency of disclosure (Article 100 (b) EPC) and lack of novelty and of inventive step (Article 100 (a) EPC in conjunction with Articles 52 (1) EPC, 54 and 56 EPC).

- II. During the appeal proceedings the parties referred inter alia to the following documents already considered during the first-instance proceedings:
 - O1: "Acousto-optic lens with very fast focus scanning", A. Kaplan *et. al*; Optics Letters Vol. 26 (2001), pages 1078 to 1080
 - 02: WO 2008/032061 A2
 - O3: "Dynamic wavefront shaping with an acoustooptic lens for laser scanning microscopy", G.
 Konstantinou et al.; Optics Express, Vol. 24
 (2016), pages 6283 to 6299
 - O4: "Signal Analysis: Time, frequency, scale and structure", R. L. Allen et al.; IEEE Press, Wiley-Interscience, 2004; two bibliographic pages, pages vii and viii, and pages 70 and 71
 - O5: "Sinusoidal function", calculus.subwiki.org/ Sinusoidal function; one page

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- O10-op (also referred to as O13 by the appellant in the statement of grounds of appeal): Technical Analysis by P. Maák, pages 1 to 12
- O10-pr (filed as O10 by the patent proprietor):

 "Signal Processing, Modulation and Noise", J.

 A. Betts; Unibooks, English Universities Press,

 1970; three bibliographic pages, index page, and
 pages 32 to 35
- Oll-pr (filed as Oll by the patent proprietor):

 "Acousto-optic scanning system with very fast nonlinear scans", N. Friedman et al.; Optics
 Letters Vol. 25 (2000), pages 1762 to 1764.
- III. In the decision under appeal the opposition division held that none of the grounds for opposition raised under Articles 100 (a), (b) and (c) EPC by the appellant prejudiced the maintenance of the patent as granted. In particular, the opposition division decided that
 - none of the objections raised under Article 100
 (c) EPC in respect of the patent as granted was persuasive,
 - none of the objections raised under Article 100
 (b) EPC in respect of each of claims 1 to 16 as granted was persuasive and
 - the subject-matter of the claims as granted was new and involved an inventive step, in particular over document O1 (Article 100 (a) in conjunction with Articles 52 (1), 54 (1) and 56 EPC).
- IV. With the statement setting out the grounds of appeal the appellant submitted *inter alia* the following documents:
 - O18: "Taylor's Series of sin x", MIT
 OpenCourseWare, ocw.mit.edu, 2010; three pages

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- O19: "Annex A1: Correction of the formula of par. [0162] of the Patent"; one page.
- V. With the letter dated 13 December 2021 filed in reply to the statement of grounds of appeal the patent proprietor (respondent) filed patent documents amended according to a first to sixth auxiliary requests.
- VI. In a communication under Article 15 (1) RPBA annexed to summons to oral proceedings the board presented a preliminary assessment of the case.
- VII. By letter dated 8 October 2024 the appellant filed inter alia the following documents:
 - O21: Power-Point presentation, "Submission at [first-instance] oral proceedings"; 22 pages O27: "Taylor series", extract from en.wikipedia.org/wiki/Taylor_series, 2024; 13 pages.
- VIII. Oral proceedings before the board were held on 7 and 8 November 2024.

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

The respondent requested that the appeal be dismissed (main request) or that the decision under appeal be set aside and the patent be maintained in amended form on the basis of the claims according to one of the first to sixth auxiliary requests all filed with the letter dated 13 December 2021.

At the end of the oral proceedings the chairman announced the decision of the board.

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IX. Claim 1 as granted (main request) reads as follows:

"An acousto-optic lens comprising:

a first acousto-optic deflector (30) arranged to support a first acoustic wave;

a second acousto-optic deflector (40) arranged to support a counter-propagating second acoustic wave;

a driver (12) for synthesizing first and second drive signals for said respective first and second acousto-optic deflectors; characterised in that said driver (12) is arranged to synthesize the first drive signal that is phase-modulated by a non-sinusoidal first function that can be expressed as a Taylor series having one or more coefficients greater than second order; and in that said driver (12) is arranged to synthesize the second drive signal that is phase-modulated by a non-sinusoidal second function that can be expressed as a Taylor series having one or more coefficients greater than second order."

Claim 1 of the first and second auxiliary requests is identical to claim 1 of the main request.

Claim 1 of the third auxiliary request differs from claim 1 of the main request in that the claim further reads as follows:

"; wherein:

- (a) said drive signals are phase or frequency modulated so as to partially or substantially correct aberrations arising in an associated optical system; or
- (b) said drive signals are phase or frequency modulated so as to partially or substantially correct aberrations arising in a specimen such as a tissue sample being examined; or

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(c) when said acousto-optic lens is oriented substantially in an X-Y plane such that electromagnetic radiation impinges upon it travelling in the -Z direction, said driver (12) is arranged to synthesize drive signals that are phase-modulated to the third order so that said first and second acoustic waves would diffract said electromagnetic radiation so that, subsequent to an objective lens, it would form a focused point that smoothly travels with at least a component in the -Z or Z direction."

Claims 2 to 16 of the third auxiliary request read as follows:

- "2. The acousto-optic lens of claim 1, wherein at least one of said Taylor series coefficients greater than second order has a magnitude of at least 3.2/n!, where n is the order of the coefficient."
- "3. The acousto-optic lens of any one of the preceding claims, wherein the first and second acoustic waves can be represented by respective wave functions in the form of a Taylor series as follows:

$$W_f^+(x,t) = A \exp\left(2\pi i \left(f\left(t - x/V_{ac}\right) + \sum_{n=0}^{n=N} P_{xt}\left(n\right) \left(\frac{t - x/V_{ac}}{\tau/2}\right)^n\right)\right)$$

$$W_f^-(x,t) = A \exp\left(2\pi i \left(f\left(t + x/V_{ac}\right) + \sum_{n=0}^{n=N} P_{xt}\left(n\right) \left(\frac{t + x/V_{ac}}{\tau/2}\right)^n\right)\right)$$

where

 $\label{eq:condinate} \textbf{x} = \textbf{lateral distance coordinate measured from}$ centre of AOD

t = time measured from centre of wave function

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 V_{ac} = speed of sound wave in crystal

f = reference centre frequency of AOD drive

 W_f^+ (x,t) (W_f^- (x,t)) = wave function propagating towards +x (-x)

A = amplitude of wave function

 $P_{\rm xt}$ (n) = Coefficient n of Taylor series measured at $t\text{-}x/V_{ac}$ = $\tau/2$

N = highest order of aberation [sic] considered

L = length of AOD

 $\tau = L/V_{ac} = AOD$ fill time

N > 3"

"4. The acousto-optic lens of any one of the preceding claims,

wherein said drive signals are phase or frequency modulated so as to partially or substantially correct aberrations arising in an associated optical system."

"5. The acousto-optic lens of any one of the preceding claims,

wherein said drive signals are phase or frequency modulated so as to partially or substantially correct aberrations arising in a specimen such as a tissue sample being examined."

"6. The acousto-optic lens of any one of the preceding claims,

wherein when said acousto-optic lens is oriented substantially in an X-Y plane such that electromagnetic radiation impinges upon it travelling in the -Z direction, said driver (12) is arranged to synthesize drive signals that are phase-modulated to the third order so that said first and second acoustic waves would diffract said electromagnetic radiation so that, subsequent to an objective lens, it would form a

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focused point that smoothly travels with at least a component in the -Z or Z direction."

- "7. The acousto-optic lens of any one of the preceding claims, wherein said driver (12) is arranged to synthesize drive signals that are phase-modulated to the third order but with substantially no components greater than third order."
- "8. The acousto-optic lens of any one of claims I to 6, wherein said driver (12) is arranged to synthesize drive signals that are phase-modulated to the third order and to additionally add in components greater than third order that serve to correct aberrations arising in an associated optical system or in a specimen under examination."
- "9. The acousto-optic lens of any one of the preceding claims, further comprising:
 - a third acousto-optic deflector (50);
 - a fourth acousto-optic deflector (60);

wherein said third and fourth acousto-optic deflectors are for deflecting said beam of electromagnetic radiation in a direction having a component perpendicular to the direction in which said first and second acousto-optic deflectors deflect said beam of electromagnetic radiation;

said driver (12) being for synthesizing third and fourth drive signals for said respective third and fourth acousto-optic deflectors;

wherein said driver is arranged to synthesize a third drive signal that is phase-modulated by a non-sinusoidal third function that can be expressed as a Taylor series having one or more coefficients greater than second order, and

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wherein said driver is arranged to synthesize a fourth drive signal that is phase-modulated by a non-sinusoidal fourth function that can be expressed as a Taylor series having one or more coefficients greater than second order."

"10. A microscope comprising:

the acousto-optic lens of any one of the preceding claims; and

objective optics."

"11. A method of determining drive signals of the acousto-optic lens according to claim 1 for use in deflecting a beam of electromagnetic radiation with said acousto-optic lens, said method comprising:

determining the first drive signal that is phasemodulated by a non-sinusoidal first function that can be expressed as a Taylor series having one or more coefficients greater than second order, and

determining the second drive signal that is phasemodulated by a non-sinusoidal second function that can be expressed as a Taylor series having one or more coefficients greater than second order."

- "12. The method of claim 11, further comprising:
 providing said first and second drive signals to
 respective first and second acousto-optic deflectors so
 as to cause respective first and second acoustic waves
 to propagate in said first and second acousto-optic
 deflectors for focusing an incoming beam of
 electromagnetic radiation."
- "13. The method of claim 11 or 12, further comprising:

determining third and fourth drive signals that will, when provided to the acousto-optic lens in

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addition to the first and second drive signals, cause an incoming beam of electromagnetic radiation to be focussed by objective optics in three dimensions during a time period;

wherein said third drive signal is phase-modulated by a non-sinusoidal third function that can be expressed as a Taylor series having one or more coefficients greater than second order;

wherein said fourth drive signal is phase-modulated by a non-sinusoidal fourth function that can be expressed as a Taylor series having one or more coefficients greater than second order."

- "14. The method of any one of claims 11 to 14 [sic], wherein said drive signals are phase-modulated so as to partially or substantially correct aberrations arising in an associated optical system or are phase-modulated so as to partially or substantially correct aberrations arising in a specimen such as a tissue sample being examined."
- "15. A method of deflecting a beam of electromagnetic radiation using the acousto-optic lens according to claim 1, said method comprising:

determining first and second drive signals according to any one of claims 11 to 14;

applying said first drive signal so as to cause a first acoustic wave to propagate in a first acousto-optic crystal;

applying said second drive signal so as to cause a second acoustic wave to propagate in a second acousto-optic crystal;

passing an incoming beam of electromagnetic radiation through said acousto-optic lens so as to deflect it."

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"16. The method of claim 15, wherein said electromagnetic radiation is travelling in the -Z direction and is diffracted by said acousto-optic lens, said method further comprising using objective optics to focus said diffracted electromagnetic radiation so that it forms a focused point that travels with at least a component in -Z or Z direction."

Reasons for the Decision

- 1. The appeal is admissible.
- 2. Appellant's allegations of a substantial procedural violation
- 2.1 The appellant submitted that the opposition division disregarded arguments presented by the appellant in respect of sufficiency of disclosure (Article 100 (b) EPC) of the invention defined in the claims as granted. In particular, during the oral proceedings the opposition division acknowledged its difficulties in following the appellant's mathematical arguments, it was not willing to listen to and to consider the arguments, and the opposition division should have commissioned an expert in the pertinent field under Rule 121 EPC. In addition, the issues to be discussed were very complicated and they could have been more efficiently discussed in person, and not during the oral proceedings held by videoconference in spite of the appellant's request to hold the oral proceedings in person at a later date after the travel ban due to the Covid-19 pandemic had been lifted. Moreover, during the oral proceedings the appellant was denied on several occasions the possibility to share their screen to

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explain with the Power-Point presentation shown in document 021 the complex mathematical subject, and it was not possible in the videoconference to manually write the diagrams and calculations possibly required to further elaborate on these submissions. In addition, the appellant was also repeatedly denied the possibility of commenting on the respondent's submissions even though they contained new arguments. In particular, while the appellant's expert was allowed to respond to the respondent's arguments on issues relating to document O10-op filed by the appellant and subsequently not admitted into the proceedings, the appellant's representative was denied the opportunity to also respond and also the opportunity to exercise its responsibility on the submissions made by the appellant's expert. No chance was given to the representative and to the expert of the appellant to comment on an error of calculation in the mentioned document alleged by the respondent or to comment on additional objections given for the first time in the decision under appeal in respect of the admittance of the document. The appellant was systematically denied the opportunity to comment on other respondent's submissions, and in particular on the respondent's allegation that the results presented by the appellant on pages 30 and 31 of the letter dated 23 December 2020 were wrong.

The appellant submitted that all these circumstances amounted to a violation of the right to be heard (Article 113 (1) EPC), of the principle of procedural equality of all parties to the proceedings, of the principle of good faith, and of the principle of a fair trial (Article 125 EPC).

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- 2.2 The board, however, is not convinced by the appellant's submissions.
- 2.2.1 The board first notes that there are cases, as the present one, in which oral proceedings can be more efficiently conducted in-person than by videoconference. In the present case, however, the board sees - as submitted by the respondent by reference to decision G 1/21 (OJ EPO 2022, A 49) - no procedural deficiency in the fact that the oral proceedings were conducted by videoconference. In particular, the appellant's submission that they were not allowed to share their screen during the oral proceedings in order to show a Power-Point presentation (document 021), in addition of not being supported by the minutes, would not amount to a procedural deficiency that could be attributed to the oral proceedings being held by videoconference because the same would have happened if the oral proceedings had been conducted in-person and the appellant had tried to present arguments on the basis of the mentioned Power-Point presentation which, as submitted by the respondent, was not previously announced and was not submitted in writing in advance. The same applies to further elaborations in writing of formulas and mathematical expressions shown in the mentioned Power-Point presentation and that would, in the appellant's view, have possibly been required to present their arguments.
- 2.2.2 It is also noted that it is incumbent on the opposition division to conduct the oral proceedings in an efficient way, especially in cases such as the present one in which during the first-instance proceedings the appellant submitted numerous substantive submissions, some of them based on complex mathematical arguments.

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It was therefore incumbent on the opposition division to focus the discussion during the oral proceedings on the issues which, in its opinion, were pertinent to the outcome of the case and also to address in its decision, among all the parties' arguments, those considered by the opposition division as being essential for the outcome of the case. In particular, arguments which are considered by the opposition division not relevant for the outcome of the case (see minutes of the oral proceedings, point 4.1) do not need to be discussed in extenso or in detail during the oral proceedings as a party wishes, and they do not need to be addressed in detail in the decision if the opposition division gives reasons why, in its opinion, they are not pertinent to the outcome of the case (see, for instance, decision under appeal, point 5.2.1, last sentence; point 5.2.2; point 5.2.3.7, last sentence; point 5.2.3.8, last sentence; point 5.2.3.10; page 18, second sentence; point 5.2.4.4, last sentence; and point 5.2.4.5, last sentence). This is particularly the case for the appellant's three-dimensional scanning analysis in point 4.3.2 of the letter dated 23 December 2020, pages 29 to 31, relating to the equation in paragraph [0162] of the patent specification being allegedly wrong because the opposition division considered that neither this equation nor the features of the XY-scanning mentioned by the appellant were, in its view, pertinent to the issues to be decided (see decision under appeal, points 5.2.4.3 to 5.2.4.5). Apart from that, the Enlarged Board of Appeal has held that, for purposes of compliance with the right to be heard, a board need not address submissions in a decision that it does not consider to be pertinent to the case (see most recently R 12/22, headnote 1 referring to point II.2.B of the Reasons). This also applies to an opposition division.

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- 2.2.3 The mere fact that the opposition division had not commissioned any expert under Rule 121 does not contravene any procedural principle, especially in the present case in which none of the parties had submitted a request in this respect. In any case, the board notes that, in spite of the complexity of the case and, in particular, of the mathematical arguments submitted by the appellant, the examiners of the opposition division had as shown, for instance, in the assessment in points 5.2.3.1 and 5.2.3.2 of the reasons of the contested decision sufficient technical expertise themselves to appropriately assess the parties' submissions and to substantiate their decision.
- 2.2.4 The appellant's submissions that they in particular, the appellant's representative were not allowed on several occasions to present their case are not supported by the minutes of the first-instance proceedings and there is no record on file that the appellant had requested correction of the minutes in this respect. In addition, since the appellant's expert was supposed to make oral submissions under the continuing responsibility and control of the appellant's professional representative, the board cannot see in what respect the opposition division could be made responsible for the way the appellant's representative exercised their own responsibility in this respect.

In particular, as regards the issue of the admittance of document O10-op into the proceedings, the board notes that this issue was extensively discussed during the oral proceedings (minutes, points 4.16 to 4.19) and that at least the essential reasons given by the opposition division in the decision under appeal to

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justify the non-admittance of the document (i.e. that the document was late filed and was not pertinent because it contained errors and failed to specify substantial features, see reasons, page 17, lines 4 to 30) was sufficiently discussed during the firstinstance oral proceedings.

- 2.2.5 In view of all these considerations, the board is unable to identify in the first-instance proceedings and in particular in the decision under appeal a procedural violation, let alone a fundamental deficiency that would have justified the remittal of the case under Article 11 RPBA and/or a substantial procedural violation that would justify the reimbursement of the appeal fee under Rule 103 (1) (a) EPC.
- 3. Main request (patent as granted) Claim 1 Inventive step
- 3.1 Interpretation of claim 1

Claim 1 is directed to an acousto-optic lens comprising a driver arranged to synthesize a drive signal for each of a first and a second acousto-optic deflector (in the following "AOD"), each of the drive signals being phase-modulated by "a non-sinusoidal [...] function that can be expressed as a Taylor series having one or more coefficients greater than second order" (in the following "the claimed class of functions"). As submitted by the appellant, the claimed class of functions encompasses a broad range of functions, and in particular any function that can be expressed as a Taylor series (Σ C_i z i) other than

- a sinusoidal function (such as the sin function, i.e. $\sin(z) = \Sigma (-1)^n z^{2n+1}/(1+2n)!$ (document O18),

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linear combinations of the sin and the cos functions (see document O5), etc.), and

- a polynomial function of the form $C_0+C_1z+C_2z^2$.

The admittance into the proceedings of documents O5 and O18 referred to above was objected to by the respondent. However, these two documents constitute mere mathematical background on the definition of sinusoidal functions and on the Taylor's series of the sin function, respectively, and the board sees no reason not to admit these two documents into the proceedings pursuant to Article 12 (4) and/or Article 12 (6) RPBA.

In the board's opinion the person skilled in the technical field under consideration would, in view of the formulation "said driver (12) is arranged to synthesize [...]", not understand claim 1 as merely requiring that the driver is suitable for synthesizing drive signals that are phase-modulated - among other possibly functions - by a function falling within the claimed class of functions, but in its technical context in the sense of requiring that the driver is specifically arranged - in particular, set, configured or pre-programmed - to generate (not just a predetermined pair of, but) the different phase modulation functions falling within the claimed class of functions and to synthesize the corresponding drive signals. This interpretation is consistent with that followed by the parties in some of their submissions and, in addition, also consistent with the dependent claims (see, for instance, dependent claim 8), and also supported by the description of the patent specification, see for instance paragraphs [0028] to [0062], page 13, lines 38 to 40, page 15, lines 26 to

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50, page 16, lines 20 to 31, page 17, lines 33 to 50, etc.

3.2 Inventive step - document 01

3.2.1 Admittance

With the statement of grounds of appeal the appellant raised an objection of lack of inventive step of the subject-matter of claim 1 as granted over document O1 alone as closest prior art. The respondent submitted that the appellant's arguments in this respect were new arguments that played no part in the first-instance proceedings and, in particular, in the decision under appeal, and that for this reason the corresponding arguments were inadmissible under Article 12 (4) RPBA.

The board notes that the objection of lack of inventive step over document O1 alone was already raised by the appellant during the first-instance proceedings and that it was based, among other reasons, on claim 1 as granted not having a technical effect over document O1 (see, for instance, decision under appeal, point 6.2.1 of the reasons). In addition, in the statement of grounds of appeal this argument was further elaborated on by the appellant on the basis of facts already considered during the first-instance proceedings in order to contest the reasons given by the opposition division in the decision under appeal. In these circumstances, the appellant's submissions on appeal do not constitute an amendment to the appellant's case within the meaning of Article 12 (4) RPBA, but only arguments substantiating the appeal on the basis of facts already considered in the first-instance proceedings, and the board considers that it has no

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discretion not to admit the corresponding appellant's submissions.

3.2.2 Distinguishing features

Document O1 discloses an acousto-optic lens (Fig. 1 and the corresponding description) comprising two AODs each arranged to support an acoustic wave, the respective acoustic waves propagating in opposite directions with respect to each other and being generated by respective drive signals synthesized by a driver ("AOS driver" and "Function generator" in Fig. 1). The document discloses that the frequency - and therefore the phase - of the drive signals is modulated by a sinusoidal function ("sinusoidal chirp of the acoustic frequencies", see page 1078, right column, first paragraph, last sentence, and page 1079, left column, lines 17 to 21). In addition, the introductory part of the document refers to the use of linearly chirped acoustic frequencies (paragraph bridging pages 1078 and 1079) and, since the frequency is the derivative of the phase (patent specification, page 12, lines 7 and 8), the corresponding drive signals are phase modulated by a second-order polynomial function.

The classes of phase modulation functions disclosed in document O1, i.e. the sinusoidal and the second-order polynomial functions, are expressly excluded by the claimed class of functions ("non-sinusoidal [...] function[s] that can be expressed as a Taylor series having one or more coefficients greater than second order"). Therefore, the acousto-optic lens of claim 1 differs from that disclosed in document O1 in that the driver - in particular the "Function generator" shown in Fig. 1 of document O1 - is specifically arranged to generate phase modulation functions within the claimed

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class of functions, i.e. functions other than the functions falling within the two classes of functions disclosed in document O1.

3.2.3 Technical effect(s)

The question arises as to what technical effect is achieved by arranging - i.e. setting, configuring or pre-programming - the driver to generate functions falling within the claimed class of functions within the meaning of claim 1 (see point 3.1 above). As submitted by the respondent, the patent specification discloses different technical effects that can be achieved with functions falling within the claimed class of functions, such as the correction of aberrations (see dependent claims 4, 5 and 8), forming with the AODs a focused point and smoothly moving it with at least a component in the Z-direction (dependent claim 6), etc. However, contrary to the respondent's contention that the claimed acousto-optic lens was capable of having a technical effect and in particular of correcting aberrations and also contrary to the opposition division's view that claim 1 provided the technical effect of allowing a focal point to be scanned in space and the correction of aberrations, claim 1 is silent as to any feature or limitation from which it could be derived that a technical effect is achieved with the claimed class of functions as such. In particular, as submitted by the appellant, only specific functions within the claimed class of functions are such that at least one of the technical effects mentioned by the respondent and by the opposition division by reference to the dependent claims and to the description of the patent specification would be achieved, and the claimed class of functions encompasses a huge - as a matter of fact

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and as submitted by the appellant, an infinite - number of sub-classes of functions that have no apparent technical function. In particular, the claimed class of functions encompasses functions such that, when the AODs are driven with the corresponding phase-modulated drive signals, the light emerging from the acousto-optic lens would not have any precise technical effect, and claim 1 even encompasses - as submitted by the appellant - driving the AODs in a way such that the emerging light would not be deflected in any specific manner, but in a purely arbitrary way.

It is also noted in this respect that the fact that the claimed device constitutes an "acousto-optic lens" does, in the board's view and contrary to the respondent's submissions, not limit the claimed class of functions to functions achieving a predetermined optical functionality of the acousto-optic lens - in particular, focusing the light into a focal spot - because what is called an acoustic-optic lens is constituted by the corresponding AODs and the corresponding driver and it remains an acoustic-optic lens independently of how the AODs are specifically being driven.

In view of these considerations, the board is of the opinion that the claimed acousto-optic lens, when compared with that disclosed in document O1, does - as submitted by the appellant - not go beyond the mere provision of a tool for working with arbitrary phase modulation functions other than the two specific classes of phase modulation functions disclosed in document O1 (i.e. sinusoidal and second-order polynomial functions), and that no specific technical effect - other than just working and experimenting with functions other than those known from document O1,

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possibly with the aim to find useful phase modulation functions - can be attributed to the claimed acousto-optic lens over the whole breadth of the claim.

3.2.4 Objective technical problem

In view of the considerations in point 3.2.3 above and, in particular, in view of the absence of any technical effect, the board considers that the objective technical problem solved by the subject-matter of claim 1 over document 01 only resides in finding alternative phase modulation functions for the drive signals - wherein the alternative functions are arbitrary in the sense that they are not even required to have any of the technical effects of the phase modulation functions disclosed in document 01.

The respondent objected to this formulation of the objective technical problem and submitted various technical considerations relating to the technical effects (obtaining a focal spot, displacement of the focal spot, aberrations, etc.) disclosed and discussed in document O1 - and also in other documents, in particular in documents O2 and O11-pr - and submitted that the skilled person would be dissuaded from considering alternative functions to those disclosed in document O1, and in particular from considering dispensing with the sinusoidal functions and introducing non-linear terms in the functions as disclosed in the patent. More particularly, the claimed invention was based on the introduction of non-linear terms to compensate aberrations, in particular aberrations of an optical system used with the acoustooptic lens and of a specimen being examined, and this idea was not disclosed or suggested in the prior art.

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However, the respondent's arguments are, as submitted by the appellant, based on an analysis of technical effects which, in view of the considerations in point 3.2.3 above, are not supported by the subject-matter actually claimed. In addition, and as submitted by the appellant, it falls within the normal development activities of the person skilled in the technical field under consideration to explore alternative drive signals, and in the board's view there is no preconceived idea - let alone a prejudice - that would have deterred the skilled person from considering and investigating alternative phase modulation functions to those disclosed in document O1. In particular, document O1 first mentions the known use of linearly chirp acoustic frequencies (page 1078, left column, second paragraph, lines 4 to 8, together with the paragraphs bridging pages 1078 and 1079) and then proposes going beyond the mere use of a linearly chirp of the frequency and considering a (non-linear) sinusoidal chirp (page 1078, right column, first paragraph, last sentence, together with page 1079, left column, lines 17 to 21), and in this technical context the skilled person would consider the possibility of investigating other non-linear chirps different from the sinusoidal chirp already considered and analysed in document O1.

3.2.5 Obviousness

In the board's view the skilled person confronted with the objective technical problem formulated above would consider setting, configuring or preprogramming the driver of document O1 (in particular, the "Function generator" represented in Fig. 1) so that it generates functions other than the functions (sinusoidal and second-order polynomial functions) already disclosed in document O1, the mentioned functions being for use as

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phase modulation functions in the AODs and therefore being regular - i.e., as submitted by the appellant, smooth and continuous - functions which can generally be expressed as a Taylor series. In addition, as already mentioned in point 3.2.3 above, last paragraph, the claimed invention does not go beyond the mere provision of a tool for working with arbitrary ones of the claimed class of functions, i.e. working with functions other than those disclosed in document O1. The skilled person would therefore arrive in an obvious way at the claimed acousto-optical lens without the exercise of inventive skills (Article 56 EPC).

- 3.3 The board concludes that the opposition ground of lack of inventive step (Article 100 (a), together with Article 56 EPC) prejudices the maintenance of the patent as granted.
- 4. First and second auxiliary requests Claim 1 Inventive step

Claim 1 of the first and second auxiliary requests is identical to claim 1 of the main request. Therefore, the subject-matter of claim 1 of the first and second auxiliary requests does not involve an inventive step for the same reasons given in point 3 above in respect of claim 1 of the patent as granted (Article 56 EPC).

- 5. Third auxiliary request Article 84 EPC
- 5.1 Claim 1 of the third auxiliary request is based on the combination of claim 1 as granted with the features of dependent claims 4, 5 and 6 as granted, the respective features of these three dependent claims being defined as three different variants of the claimed subjectmatter (see features (a), (b) and (c) of claim 1,

respectively). Dependent claims 2 to 16 of the third auxiliary request correspond to dependent claims 2 to 16 as granted, respectively.

During the oral proceedings before the board the appellant submitted that dependent claims 4 to 6 repeated the respective features of variants (a) to (c) of claim 1 and that for this reason the combination of claim 1 with dependent claims 4 to 6 was not clear (Article 84 EPC). In particular, it was not clear in dependent claim 4 together with variant (a) of claim 1 whether the claimed invention involved only one "associated optical system" or two different associated optical systems.

The claims of the third auxiliary request were filed with the respondent's reply to the statement of grounds of appeal and the objection under Article 84 EPC was first raised by the appellant during the oral proceedings before the board - and not, for instance and as submitted by the respondent, with the appellant's reply letter dated 8 October 2024. In addition, the objection under Article 84 EPC constitutes an amendment to the appellant's case within the meaning of Article 13 (2) RPBA and the board does not see any exceptional circumstance - and the appellant submitted none - that would justify raising the objection under Article 84 EPC at such a late stage of the proceedings. In these circumstances the board, in the exercise of its discretion under Article 13 (2) RPBA and in the absence of any exceptional circumstance justified by cogent reasons by the appellant, decided not to take into account in the proceedings the mentioned objection under Article 84 EPC.

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- 5.3 During the appeal proceedings the appellant raised other issues which directly or indirectly pertain to the requirement of clarity of Article 84 EPC. These issues are addressed in point 7.2, paragraph i), point 7.3, paragraph ii), and point 7.5.3 below.
- 6. Third auxiliary request Article 123 (2) EPC

The appellant raised objections under Article 100 (c) EPC in respect of granted dependent claims 2 and 3 and of parts of the description of the patent as granted and these objections were maintained in respect of the corresponding parts of the third auxiliary request (Article 123 (2) EPC).

- 6.1 Dependent claim 2
- 6.1.1 The appellant submitted that, when compared with dependent claim 2 as originally filed, dependent claim 2 as granted omitted the term "waves" in the original expression "3.2/n! waves", and that this omission resulted in subject-matter going beyond the content of the application as filed and, in particular, that the mentioned omission was unallowable as a correction of an error under Rule 139 EPC. The appellant submitted that there were 2π radians in a wave and that a value given in units of waves or of cycles had to be multiplied by 2π in order to obtain the corresponding value in radians, which is the dimension of phase. The appellant referred in this respect to the phase $(2\pi ft)$ of a signal of the type $A\cos(2\pi ft)$ having a constant frequency f expressing the number of cycles per time unit, and wherein the number of cycles was given by the product ft and the phase in radians was given by the product of ft and 2π . In the case of a phase modulation function $2\pi f_0 t + m(t) - i.e.$ of a phase modulation

function of the type given in the patent and also by the respondent for the corresponding voltage functions of the invention -, f_0t expressed the number of cycles without modulation and the quotient $m(t)/2\pi$ expressed the number of waves of aberration, and 1 wave of aberration did not equal the dimensionless number 1, but a phase shift of 2π radians. In addition, measuring the Taylor series coefficients in waves of aberration meant that the Taylor coefficients of the Taylor series of m(t) had been divided by 2π , i.e. that they were measured in units of $1/2\pi$, as supported by the factor 2π applied in the exponent of the formulas of the patent specification. Therefore, the information derivable from the application as filed was that 1 wave (of aberration) was 1 cycle, i.e. 2π radians, and therefore the value of "at least 3.2/n! waves" defined in dependent claim 2 as originally filed meant that the value was of at least 3.2/n! cycles = 3.2/n! 2π radians, and not of at least the number "3.2/n!" as defined in the amended dependent claim 2.

6.1.2 The board first notes that claim 1 and claim 2 do not define the specific Taylor series of the drive signal, but that this series has the general form Σ C_iz_i , where z is, in the case of a modulation function, a time variable. Furthermore, claim 1 as granted refers to the drive signal being "phase-modulated by a [...] function" and, therefore, the claimed Taylor series defines the phase modulation function, and not the modulated phase itself. This is, in addition, consistent with the formulas of the acoustic waves disclosed in the application as filed (page 10, first paragraph, page 14, third paragraph, page 25, first paragraph, page 26, second paragraph, and dependent claims 7 and 26) in which the Taylor series are expressed as powers of a non-dimensional time variable

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 $(t/(\tau/2))$ and they are multiplied by the quantity $2\pi i$ in the argument of the exponential functions expressing the mathematical form of the waves. The person skilled in the technical field under consideration would therefore understand that the phase (such as the quantity $\varphi 1$ in the formula $A_1 \exp(j[\Omega t + \varphi_1])$ on page 70 of document 04 cited by the appellant and which in their context constitutes not just a coefficient, but a phase) is constituted not by the Taylor series itself, but by the product of 2π - which represents, as it is conventional in this art, the phase measured in radians of one entire wave or cycle - and a (non-dimensional) number expressed by the corresponding Taylor series.

Therefore, in the technical context of the application as filed the skilled person would understand the term "waves" in the expression "at least one of said Taylor series coefficients [...] has a magnitude of at least 3.2/n! waves" of dependent claim 2 as originally filed not as referring to the physical waves as such (in particular, to the phase of the waves measured in radians), but - as submitted by the respondent - to the number of waves or cycles (i.e. to the waves measured in units of waves), so that both the expression "3.2/n!waves" of original dependent claim 2 and the expression "3.2/n!" of granted dependent claim 2 express, in their respective technical context, a specific value (3.2/n!) of one of the Taylor coefficients such that the multiplication of the corresponding Taylor term by 2π results in the contribution of the Taylor term to the value of the phase measured in radians.

As regards the appellant's argument that the skilled person would consider interpreting the expression "at least one of said Taylor series coefficients [...] has a magnitude of at least 3.2/n! waves" in the sense that

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the coefficient would have a value of 2π multiplied by 3.2/n! and that, therefore, the corresponding phase would be given by $(2\pi)^2$ multiplied by 3.2/n! is in the board's view not persuasive for the reasons given above and also because this interpretation – in addition of implying that, in view of the origin of the two factors 2π , the phase would then be measured in radian² – is only based on a literal interpretation of dependent claim 2 as filed taken in isolation, without consideration of claim 1 and of the context of the application as filed and, in particular, of the meaning in physics of the mathematical terms defined in claims 1 and 2.

In view of these considerations, the board concludes that the omission of the term "waves" in dependent claim 2 as granted has, in its technical context, no effect on the subject-matter of the claim. It also follows from this conclusion and from the above considerations that the mentioned omission does not constitute the correction - let alone the unallowable correction - of an error in the application as filed because the term "waves" was not erroneous when interpreted in its technical context.

6.2 Dependent claim 3 and description, page 6, line 22, and page 8, line 26

The appellant also submitted that, when compared with dependent claim 7 as originally filed, dependent claim 3 as granted omitted the expression "units are waves (of aberration)" in the expression " $P_{xt}(n) = Coefficient\ n$ of Taylor series units are waves (of aberration)" and that as a consequence of this omission the units of $P_{xt}(n)$ had been changed. The same objection applied to the corresponding features on page

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6, line 22, and page 8, line 26 of the description of the patent specification.

As regards the omission of the expression "units are waves", considerations analogous to those set forth in point 6.1.2 above in respect of dependent claim 2 also apply in respect of this omission. As regards the omission of the expression "(of aberration)", the board notes that dependent claim 3 already specifies that "N", i.e. the highest order of the Taylor series, is "the highest order of aberration considered", and this feature already implicitly establishes a technical relationship between the Taylor coefficients and the aberrations, this specific technical relationship being determined by the exponential functions defined in the claim for reasons analogous to those given in point 6.1.2 above. These considerations also apply to the corresponding amended features on page 6, line 22, and page 8, line 26, of the description of the patent specification.

6.3 Description - Paragraph [0127]

The appellant also objected under Article 123 (2) EPC that the formula in paragraph [0127] of the description of the patent specification presented substantial amendments when compared with the corresponding formula in the second paragraph on page 28 of the application as originally filed.

The board notes that the appellant's objection was already raised in the notice of opposition under Article 100 (c) EPC, but that the appellant's submissions - as submitted by the respondent - only identified the amendments made and the objection was not substantiated during the first-instance opposition

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proceedings and with the statement of grounds of appeal. In particular, the appellant did not explain in what respect the modification of the mentioned formula changed the technical content of the corresponding disclosure in the technical context of the application as filed and of the patent specification. More particularly, the statement of grounds of appeal was silent as to whether, or in what sense, the mentioned amendments presented the skilled person with new technical information not derivable from the content of the application as filed.

In view of these considerations, the board concludes that this objection was - as submitted by the respondent - not admissibly raised and maintained during the first-instance proceedings within the meaning of Article 12 (4) RPBA and, additionally, that the appellant's case was not complete within the meaning of Article 12 (3) RPBA in respect of this objection. For these reasons, the board decided not to admit this objection into the appeal proceedings (Articles 12 (4) and 12 (5) RPBA).

- 6.4 The board concludes that the objections raised by the appellant under Article 123 (2) EPC are either not admitted or not persuasive. In these circumstances, the board sees no reason to question that the patent amended according to the third auxiliary request meets the requirements of Article 123 (2) EPC.
- 7. Third auxiliary request Article 83 EPC

The appellant raised objections under Article 100 (b) EPC in respect of the invention defined in each of claims 1 to 16 as granted and the same objections were maintained in respect of the corresponding features now

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defined in claims 1 to 16 of the third auxiliary request (Article 83 EPC).

7.1 Claim 1

The appellant submitted in respect of the feature of 7.1.1 claim 1 requiring a driver arranged to synthesize drive signals phase-modulated by the claimed class of functions that no single exemplary drive signal was presented in the description that could assist the skilled person in producing the phase modulated drive signals. In particular, the description disclosed exemplary wave functions for the acoustic waves propagating within the AODs, but it gave no guidance on how to obtain therefrom the corresponding drive signals to be synthesized by the driver and on how to obtain the corresponding modulation functions. The formalism of the acoustic wave functions $W_f^+(x,t)$ and $W_f^-(x,t)$ was new to the skilled person and the patent disclosed the Taylor coefficients $P_{xt}(n)$ of these functions, but not the Taylor coefficients of the corresponding drive signals, which were only dependent on time and not on x. This applied particularly when the technical effects defined in variants (a) to (c) where to be achieved (see points 7.1.2 to 7.1.4 below). Furthermore, the "Technical annex by inventor" submitted by the respondent in opposition proceedings and re-submitted in appeal (reply to the statement of grounds of appeal, pages 101 to 105) relied on document 04 which was not cited in the patent. In addition, neither document 04, nor document 010-pr also relied upon by the respondent, nor the content of the mentioned annex belonged to the common general knowledge in the technical field of AODs.

The board, however, adheres to the opposition division's view that the pertinent skilled person would have no difficulties in obtaining the drive signals generating in the AODs the acoustic waves disclosed in the patent. The board notes in this respect that the person skilled in the specific technical field under consideration is - as submitted by the respondent aware of the techniques relating to frequency and phase modulation (document O10-pr) and of the technical and the mathematical relationship between the drive signal applied to an AOD and the wave functions of the acoustic waves generated by the drive signal in the AOD and travelling therethrough, and that the derivation of the drive signal from the acoustic wave to be generated with it - and in particular from the acoustic waves disclosed in paragraph [0044] of the patent - in the mentioned "Technical annex by inventor" in the respondent's letter of reply, pages 101 to 105, does in the board's view not go beyond what is expected from the skilled person in this technical field. It is also noted that documents O4 and O10-pr are not extracts from textbooks on AODs, but that they are extracts from signal analysis books, and that the content of these extracts pertains to the general mathematical background of the mathematical description of wave functions and in the board's view this general mathematical background pertains to the common general knowledge of the skilled person working with wave functions and therefore also of the skilled person working in the specific technical field of AODs.

7.1.2 Variant (a) of claim 1

i) The appellant objected that the skilled person would not know how to determine the aberrations introduced by an associated optical system. In the

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patent it was assumed that these aberrations could be represented or decomposed as independent wave functions in the x- and y-directions (paragraph [0124]). However, this approach was incorrect because it assumed "rectangular" aberrations and it could introduce even more aberrations.

However, the board notes that the problem of the compensation or correction of optical aberrations of an optical system is generally solved - not only in the technical field under consideration, but also in general optics - following different, generally nonequivalent approaches each having its own limitations and each assuming a predetermined degree of approximation and a predetermined compromise between the different types of aberrations and the optical characteristics of the optical system. In this respect, the appellant's arguments are in part based on the approach proposed in the patent in suit not solving completely or accurately all the possible aberrations, and the corresponding arguments are not persuasive because variant (a) only requires "partially or substantially correct[ing] aberrations arising in an associated optical system", and not compensating or correcting - let alone optimally - every possible aberration of any possible associated optical system. In particular, the description discloses an approach based on modelling the aberrations of an optical system by two separate aberration functions $W_f(x)$ and $W_f(y)$ expressed as Taylor series (paragraphs [0124], [0125], [0129], [0131] and [0132]; see also paragraph [0121]) allowing - as emphasized by the opposition division in its decision - at least to a predetermined degree for the correction of aberrations of the optical system by the superposition of independent corrections in the Xand Y-directions (paragraphs [0125] to [0141] and Fig. 4 to 8, together with the characteristics of the

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different order terms in paragraphs [0146] to [0152] and in Fig. 11). The mere fact that other approaches (such as, for instance, the approach submitted by the appellant and based on a common aberration function $W_f(x,y)$ that cannot be decomposed in independent components in the x- and y-directions) might provide a better correction of aberrations does not prejudice sufficiency of disclosure of variant (a) of claim 1. In particular, the skilled person would understand that the superposition of the aberration functions $\textbf{W}_{f}\left(\textbf{x}\right)$ and $W_f(y)$ provides a first approximation to the description of the aberrations present in the optical system, and that these aberrations are corrected, at least to a predetermined extent, in one of the two directions X or Y by driving the two AODs of claim 1 - and in the other one of the two directions by two further AODs such as those defined in dependent claim 9.

ii) The appellant also submitted in this respect that the Taylor decomposition terms of the functions $W_f(x)$ and $W_f(y)$ were not independent from each other as shown in document O10-op and requested that document O10-op be admitted into the proceedings.

The board notes that the respondent objected to the consideration of document O10-op in the appeal proceedings, that this document was not admitted by the opposition division into the proceedings, and that the board sees no reason that would justify the admittance of the document into the appeal proceedings. In particular, as already noted in point 2.2.4 above, second paragraph, there was no substantial procedural violation in the opposition division's decision not to admit this document in the opposition proceedings. In addition, a discretionary decision taken by a department of first instance is generally only overturned by the board if the discretion was exercised

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incorrectly, for example by applying wrong criteria or making use of its discretion in an arbitrary or unreasonable way, and in the present case (see point 2.2.4, second paragraph) the board is unable to see an improper exercise of discretion in the way the examining division decided not to admit document O10-op into the proceedings. For these reasons the board decided not to admit document O10-op in the appeal proceedings (Articles 12 (4) and 12 (6) RPBA).

iii) The appellant submitted by reference to Table 1 of document O3 that it was only possible to correct even orders of aberration with the same Taylor coefficients for both drive signals, and that in order to correct odd orders of aberration the Taylor coefficients of the drive signals should have the same magnitude and opposite signs. In addition, as shown in document O3, any type of aberration correction was accompanied by an unwanted movement of the focused spot. However, the patent did not address these issues and the skilled person would not be in a position to correct the aberrations.

The appellant's submissions are based on an analysis of the specific data - in particular, of the data relating to the correction of aberrations and to the lateral and axial accelerations of the focused spot - shown in Table 1 of document 03 which is a post-published document by the inventors of the patent in suit. In addition, the appellant's substantive submissions relating to document 03 - in particular, the specific data of Table 1 of document 03 on which the submissions are based - have been addressed for the first time in the statement of grounds of appeal. Therefore, these submissions do not constitute mere counter-arguments contesting the reasons given by the opposition division in the decision under appeal, but

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new arguments based on a new allegation of facts not considered during the first-instance proceedings. In these circumstances, these submissions constitute - as submitted by the respondent - an amendment to the appellant's case on appeal within the meaning of Article 12 (4), first sentence, RPBA. Furthermore, the submissions are based on new facts which should have been submitted in the first-instance proceedings within the meaning of Article 12 (6), second sentence, RPBA, and the board does not see any circumstance of the appeal case that would justify their admittance. Accordingly, the board decided not to admit the submissions in the appeal proceedings pursuant to Article 12 (4) and (6) RPBA.

iv) The appellant also submitted by reference to the mathematical relationship $P_{xt}(n) = \pm 0.5P_{x}(n)$ in paragraph [0127] of the patent that the n-order Taylor coefficient $P_{xt}(n)$ in the two wave functions disclosed in paragraph [0122] had the same sign because in all the examples of the patent the coefficients were the same in both functions. However, odd orders of aberration could not be corrected using the same Taylor coefficients for both drive signals. In the firstinstance submissions in the letter dated 23 December 2020 it was demonstrated that only the relationship $P_{xt}(n) = -0.5P_x(n)$ was valid and only for even values of n. For these reasons, the scope of protection extended to the correction of aberrations with coefficients that were different and for which there was no disclosure in the patent specification. In addition, the patent did not even provide a hint on how to correct aberrations when only a third-order Taylor coefficient was present.

The board notes that the passages of the letter dated 23 December 2020 referred to by the appellant

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(point 3.2 starting on page 5) acknowledge the correction of at least fourth-order aberrations, and that the fact that other aberrations, in particular of odd-order aberrations, might not be corrected does not prejudice sufficiency of disclosure; see in this respect paragraph i) above. In any case, and as submitted by the respondent, the appellant's arguments are based on a restrictive interpretation of the formula of paragraph [0127] in the context of the disclosure in paragraphs [0149] to [0152], together with Fig. 11, and the skilled person would not assume that the Taylor coefficients of the first and second wave functions - or of the first and second drive signals - had to be necessarily the same, at least not the same in the strict sense as submitted by the respondent. In addition, paragraph [0176] of the patent specification teaches that third and fourth order aberrations can be corrected using the appropriate signs and scaled coefficients, and the skilled person would - as submitted by the respondent - understand that, for counter-propagating waves, if the waves are identical in magnitude and sign, even orders will reinforce and odd orders will cancel, and that opposite signs can be used to ensure reinforcement rather than cancellation.

v) The appellant referred to the method disclosed in paragraph [0134] and Fig. 9 of the patent and submitted that this method constituted a trial-and-error method that potentially required an infinite number of tries because the different coefficients $P_{xt}(n)$ needed to be varied independently from each other from $-\infty$ to $+\infty$, implying an infinite number of combinations to be tried in order to handle the plurality of orders of aberration. This amounted to an

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undue burden and merely to an invitation to perform a research programme.

The respondent submitted that these arguments constituted an inadmissible amendment to the appellant's case.

The board notes on the one hand that the appellant's submissions relate to issues already addressed during the first-instance oral proceedings and that they only constitute counter-arguments - in particular, the further elaboration of previous arguments on the basis of specific facts already considered during the first-instance proceedings contesting the reasons given by the opposition division in the decision under appeal. For this reason, the appellant's submissions do not constitute an amendment to the appellant's case within the meaning of Article 12 (4) RPBA, but only arguments substantiating the appeal and based on facts previously addressed in the proceedings and the board considers that, contrary to the respondent's submissions, it has no discretion - in particular not under Article 12 (4) RPBA - not to consider these submissions in appeal. On the other hand, the appellant's arguments are in the board's view not persuasive because the skilled person in this specific technical field is in a position to determine the aberrations present in an optical system to be compensated or corrected (paragraphs [0124] to [0127] of the patent specification) and, as submitted by the respondent, the patent gives sufficient guidance in paragraphs [0062] and [0133] to [0137] for enabling the person skilled in this technical field to iteratively modify the Taylor coefficients of the drive signals if needed, one by one as submitted by the respondent so as to correct or compensate, at least to some extent, at least some aberrations of the optical system. Therefore, contrary to the appellant's

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submissions the patent does not disclose a mere trial-and-error method, but a specific iterative method to be followed for determining the Taylor coefficients. In addition, there is no evidence of an undue burden and, in particular, of the iterative method of the patent not converging relatively quickly as submitted by the respondent, and the appellant's submissions in this respect are not sufficient to discharge the burden of proof of the appellant and to shift it to the respondent.

7.1.3 Variant (b) of claim 1

The appellant's submissions concerning variant (b) of claim 1 essentially correspond to those submitted in respect of variant (a) when considering not the aberrations of an associated optical system, but the aberrations introduced by a specimen, with further submissions based on them and relating in particular to an inadvertent movement of the focused spot (see point 7.1.2 above, paragraph iii)) which would cause the electromagnetic beam being focused on different locations of the specimen.

However, the submissions concerning variant (a) are, as concluded in point 7.1.2 above, either not admitted or not persuasive, and the same applies to the appellant's submissions relating to the correction of aberrations induced by the specimen being examined according to variant (b). Furthermore, the further submissions relating to the movement of the focused spot are based on Table 1 of document 03 and they are not admitted into the proceedings (see point 7.1.2 above, paragraph iii)). In addition, although the aberrations arising in a specimen such as a tissue are – as stated by the opposition division in its decision – of a more

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unpredictable nature than those of an optical system, the section of the description already referred to in point 7.1.2 above, paragraphs ii) and v) (see paragraphs [0123] to [0137]), together with the dynamic aberration control disclosed in paragraphs [0138] to [0143] of the patent by reference to Fig. 10 - in particular, the modelling of the aberrations of the specimen disclosed in paragraphs [0139] to [0141] - would in the board's view enable the skilled person to perform variant (b) of claim 1 without undue burden.

7.1.4 Variant (c) of claim 1

i) The appellant submitted that, contrary to the opposition division's view, variant (c) did not merely require that the focused point smoothly travelled, but that it defined a scanner and required that the user could determine where the focused point was travelling. In addition, there was no enabling disclosure for a scanner if the skilled person could not control the movement of the focused point. Furthermore, the sole formula in the patent specification relating to axial scanning, in paragraph [0162], was erroneous because of the missing definition of the quantity V and because of the dimensional incompatibility between the quantity $P_{\rm xt}(3)$ in this formula and in the functions of paragraph [0122], and it was not apparent how the formula could be corrected.

The respondent submitted that the appellant's arguments constituted an inadmissible amendment to their case in appeal.

The board notes that the appellant's submissions constitute - contrary to the respondent's submissions - only counter-arguments based on facts already considered in the proceedings and contesting the reasons given by the opposition division in its

decision. Therefore, the board considers that it has no discretion - in particular not under Article 12 (4) RPBA - not to consider these submissions in the appeal proceedings. As regards the appellant's submissions that the formula in paragraph [0162] was erroneous, the board notes that variant (c) only requires "form[ing] a focused point that smoothly travels with at least a component in the -Z or Z direction" by using drive signals "phase-modulated to the third order", without requiring - as emphasized by the opposition division in its decision and contrary to the appellant's submissions - a precise control of the Z-movement of the focused point, at least not to the degree that the formula in paragraph [0162] would allow. In addition, the invention defined in variant (c) of claim 1 is in the board's view already sufficiently disclosed in paragraphs [0145] and [0152] to [0161] of the patent specification, i.e. without consideration of paragraph [0162] and the corresponding formula. Therefore, even assuming that the formula is erroneous or that the skilled person would encounter difficulties in using the mentioned formula, these difficulties would not prevent the skilled person from performing the invention actually defined in variant (c) of claim 1. In any case, the errors in the formula in paragraph [0162] alleged by the appellant, in particular by reference to document 019, do not affect the disclosure in the patent according to which the value of the Zdisplacement (δZ) of the focused point is linearly proportional to $P_{xt}(3)$ and also linear in time (Fig. 14), and this disclosure already enables a predetermined level of control of the claimed Zdisplacement of the focused point.

ii) The appellant also submitted that variant (c)
("[...] focused point that smoothly travels with at

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least a component in the -Z or Z direction" [emphasis added]) covered general 3-dimensional scanning and that the patent merely referred to document 02, without teaching lateral scanning. Furthermore, document 02 relied on a formalism different from, and incompatible with the formalism used in the patent; in particular, the purely third-order Taylor term became a mixed expression of zero-, first- and second-order terms when the frequency was written in a polynomial form as in document 02, with the consequence that the focused spot would - contrary to the teaching of the patent relating to the XY-plane movement being attributable to the second order coefficient - be moving in the XY-plane. In addition, document O3 disclosed in Table 1 how to choose the values of $P_{xt}(n)$ in order to achieve the desired beam deflection and the corresponding information was missing in the patent specification.

The board first notes that the mere fact that postpublished document 03 might present a more detailed description of the invention does not per se prejudice sufficiency of disclosure of the invention defined in variant (c) of claim 1, and that the patent discloses a way of determining the third-order coefficients in order to achieve a smooth movement of the focused point in the Z-direction (paragraphs [0029] and [0145], together with paragraphs [0152] to [0155]). In addition, variant (c) of claim 1 does not require XYscanning, i.e. lateral deflection of the light beam, at least not a precise control of the lateral deflection together with a precise control of the Z-movement of the focused point. In any case, the claimed invention constitutes a further development of the acousto-optic lens disclosed in document O2 cited in the patent in suit (see patent specification, paragraphs [0012] to [0015], [0099] and [0119]), the document discloses - as submitted by the respondent - how to move the focal

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point in the lateral direction and how to step the focal point in the Z-direction (document O2, Fig. 8, together with the corresponding description), and the patent specification discloses by reference to document 02 the technical meaning of the zero- to the thirdorder terms of the Taylor series and how to achieve a smooth movement of the focal point in the Z-direction (paragraphs [0147] to [0153]). In addition, the board cannot see any incompatibility between the formalism of document 02 based on a frequency linearly varying with time (document 02, page 26, lines 20 to 27) and of the formalism of the patent based on phase modulation, because in both formalisms the frequency is given by the derivative of the phase (patent specification, page 12, lines 6 to 8) and the skilled person in this technical field is in a position to bring both formalisms into correspondence with each other and to accommodate the presence of the third-order term of the Taylor series of the invention in the formalism of document 02 (see patent specification, paragraphs [0150] to [0154]).

iii) The appellant also submitted that the burden of proof should, in view of their arguments, be shifted to the respondent. However, the appellant's arguments are, as concluded in paragraphs i) and ii) above, not persuasive, and therefore the board sees no reason justifying shifting the burden of the proof to the respondent.

7.1.5 Additional objections

i) The appellant also raised objections in respect of the approach followed in the claimed invention and based on Taylor series (paragraph [0026] of the patent specification). In particular, the appellant noted that

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the Taylor series of a smooth and continuous function could be developed at point 0 but also at any other point, and that the coefficients of the respective Taylor series were different, so that the technical meaning attributed in the patent to the Taylor coefficients was not consistent. The question of whether a phase modulation could achieve a predetermined technical effect - in particular, the correction of aberrations or the movement of the focused spot in the Z-direction - could not depend on the choice of the point (in particular, of the time point for the functions of the patent) at which the Taylor series was developed. In addition, the patent was based on varying the Taylor coefficients of a Taylor series to achieve predetermined technical effects, but the n-order Taylor coefficients of a function were related to the n-derivative of the function (document 027) and they could not be arbitrarily varied.

However, none of these arguments are in the board's view convincing. The Taylor series of a predetermined smooth and continuous function f(z) can be expressed at the point z=0 in the form Σ C_nz^n and also at any other point "a" within the domain of definition of the function in the form Σ $D_n(z-a)^n$, where the coefficients $C_{\rm n}$ and $D_{\rm n}$ are respectively defined as the value of the n-derivative of the function at the corresponding point $(f^{(n)}(0))$ and $f^{(n)}(a)$, respectively) multiplied by a factor of 1/n!. However, the function remains the same and, therefore, the sets of coefficients $\{C_n\}$ and $\{D_n\}$ are related to each other and the technical meaning attributed to a specific coefficient C_k is then shared by the set of coefficients $\{D_n\}$. In addition, the patent relies - as emphasized by the respondent - on building order term by order term a specific Taylor series in such a way that each Taylor coefficient

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achieves a specific technical effect - in particular, in such a way that the third-order coefficient achieves a smooth movement of the focused point in the Zdirection (variant (c) of claim 1, dependent claim 6, and paragraphs [0144] to [0158]). In this context, the question of the specific technical meaning of the Taylor coefficients of another Taylor series expressing the same function at a different point is of no relevance to the issue of the reproducibility of the claimed invention following the disclosure of the invention in the description of the patent specification. It is also noted that the coefficients of the Taylor series of a specific function are - as submitted by the appellant - related to each other by the values of the derivatives of the function, but that they can be varied to obtain new functions, and working with Taylor series simplifies in the context of the patent the task of finding functions having predetermined characteristics. As an example, the korder Taylor coefficient C_k of the Taylor series Σ C_nz^n at the point 0 of a specific function f(z) - such as the sin function (see point 3.1 above, first paragraph) or a polynomial function of the form $\Sigma \ {C_m} z^m$ which constitutes its own Taylor series at the point 0 - can be arbitrarily varied $(C_k + \Delta_k)$ to obtain a different Taylor series defining a new function, namely the function $\Delta_k z^k + f(z)$.

ii) The appellant also submitted by reference to the established case law that the patent monopoly should be justified by the actual technical contribution to the prior art and that the disclosure of the patent should allow the invention to be performed in the whole claimed range. This was not the case in the patent in suit in respect of the correction

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of aberrations and of the Z-movement of the focused point.

The board, however, is not persuaded by this argument because the patent specification discloses in detail the interplay and the function of the different terms of the Taylor series in respect of the correction of aberrations and also the specific function of the third-order Taylor term in achieving a smooth Z-displacement of the focused point (see patent specification, paragraphs [0134], [0135], [0141], [0145] to [0159] and [0163]), it being noted that variant (c) of claim 1 specifically requires phase modulation "to the third order so that" the focused point smoothly travels with a component in the Z-direction.

7.2 Dependent claim 2

i) The appellant submitted that dependent claim 2 gave a precise lower limit of the value of the Taylor coefficients greater than second order. However, claims 1 and 2 did not state that the Taylor coefficients should be measured in units of waves of aberration (2π radians) and, in addition, the coefficients $P_{xt}(n)$ of the formula in paragraph [0122] of the patent specification were - as submitted by the respondent normalised to the time unit $\tau/2$, with the consequence that a factor of $1/(\tau/2)^n$ had been incorporated in each of the coefficients $P_{xt}(n)$. The skilled person was not instructed whether the Taylor coefficients should be measured in units of waves $(1/2\pi)$ and units of $(\tau/2)^n$. Therefore, the skilled person was unable to decide whether or not the claimed value of 3.2/n! had to be multiplied by 2π and divided by $1/(\tau/2)^n$ to perform the invention defined in dependent claim 2.

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The board refers to the comments in point 6.2.1 above concerning the units of the coefficients mentioned in dependent claim 2 and also notes that the normalization factor $1/(\tau/2)^n$ of the Taylor coefficients submitted by the respondent concerns the Taylor coefficients of the mathematical description of the acoustic waves travelling through the AODs (patent specification, paragraph [0122]) when the coefficients are specifically "measured at $t-x/V_{ac} = \tau/2$ " (page 12, line 56), and not the Taylor coefficients considered in claims 1 and 2, i.e. the Taylor coefficients used in the mathematical description of the drive signal synthesized by the driver and applied to the AODs for generating the mentioned acoustic waves travelling within the AODs, the mentioned drive signals being a function of the time variable considered in the Taylor series, but - contrary to the acoustic waves - not of x. The board also notes by reference to the comments in point 6.1.2 above that dependent claim 2 is broad. Yet, even if this dependent claim were unclear - and in particular ambiguous as to the definition of the Taylor coefficients -, the same objection would concern dependent claim 2 as granted, and no objection of lack of clarity within the meaning of Article 84 EPC can be considered by the board in this respect because Article 84 EPC is not a ground for opposition under Article 100 EPC and the appellant's objection does not arise from an amendment to the patent (see decision G 3/14 (OJ EPO 2015, A102)). In addition, the skilled person would have no difficulties in synthesising a drive signal as claimed with a Taylor term constituted by the magnitude 3.2/n! multiplied by the n-power of the corresponding time variable selected for expressing the function describing the corresponding drive signal.

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ii) During the oral proceedings the appellant submitted that dependent claim 2 imposed a limitation on the value of the Taylor coefficients of the Taylor series of claim 1 and, therefore, a limitation on the way the coefficients could be varied in order to achieve the technical effects defined in variants (a) to (c) of claim 1. The nature of the limitation was such that it was not possible to achieve these effects.

The board notes that dependent claim 2 only imposes - as submitted by the respondent - a minimum value for at least one of the Taylor coefficients greater than second order, and that the appellant has not substantiated with technical arguments or evidence that this limitation would be detrimental to the considerations in paragraph i) above to the extent that the skilled person would be confronted with difficulties when implementing the claimed invention. In these circumstances, the board considers that the appellant's objection is not persuasive - and in any case not sufficiently substantiated to justify shifting the burden of proof to the respondent.

7.3 Dependent claim 3

i) The appellant submitted that the wave functions defined in dependent claim 3 represented the acoustic waves and they were different from the functions representing the corresponding drive signals mentioned in claim 1, and that the skilled person could not derive from the patent specification - even under consideration of document 04 if it was considered as representing common general knowledge in this field - how to relate the mentioned functions to each other and in particular how to choose the Taylor coefficients of the drive signal functions required to obtain the

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acoustic waves of dependent claim 3. The pertinent information was disclosed in document 03, but not in the patent specification.

The board, however, is not convinced by the appellant's arguments essentially for the reasons already given in point 7.1.1 above, second paragraph. As regards the reference to document 03, the corresponding submissions are not admitted into the proceedings for the same reasons given in point 7.1.2 above, paragraph iii).

ii) The appellant also submitted that the feature "t = time measured from centre of wave function" of dependent claim 3 was obscure and could be interpreted in several ways, in particular as referring to the centre of the AOD, thus meaning that the source of the acoustic waves was - as a physically incorrect description - at the centre of the AOD. Furthermore, the further feature " $P_{xt}(n)$ = Coefficient n of Taylor series measured at $t-x/V_{ac} = \tau/2$ " was ambiguous and it would imply that the Taylor series should include a term $(t-\tau/2)^n$ as the multiplying factor of the Taylor coefficients, and not the term $(t-x/V_{ac})^n$ as it was the case in dependent claim 3.

The board first notes that dependent claim 3 corresponds to granted dependent claim 3 and that no objection of lack of clarity under Article 84 EPC can be considered by the board for reasons analogous to those given in point 7.2 above, paragraph i), second sub-paragraph, in respect of dependent claim 2. In addition, any lack of clarity that the person skilled in the specific technical field under consideration would encounter when reading the two features of dependent claim 3 mentioned by the appellant would not be detrimental to the issue of insufficiency of disclosure in view of the corresponding disclosure in

the description of the patent. The board notes in particular that the wave functions describing the acoustic waves mathematically depend on t±x - thus implying, as submitted by the respondent, a correspondence between the wave functions at x=0measured over time and the wave functions at t=0measured over x (see in this respect Fig. 11 of the patent specification) -, where the variables x and t defined in dependent claim 3 are only mathematical variables; in addition, according to the patent specification "the waves start to be propagated by the AODs at some negative time and each AOD is arranged to be just full of an acoustic wave at time t=0" (paragraph [0127]). Therefore, the skilled person would understand - as explained by the opposition division in its decision and as submitted by the respondent - that the acoustic wave starts propagating at one side (x=-L/2) of the AOD at a predetermined time point $(t=-\tau)$ and reaches the other side (x=+L/2) at a predetermined subsequent time point (t=0) at which the acoustic wave fills the whole AOD. In addition, a substitution of the expression $(t-x/V_{ac})$ by $\tau/2$ in the Taylor series of paragraph [0122] leads - as submitted by the respondent - to the coefficients $P_{xt}(n)$ "measured at $t-x/V_{ac}=\tau/2$ " as claimed and, therefore, the board is not convinced that the Taylor series should be expressed in terms of powers of $(t-\tau/2)$ as submitted by the appellant.

- 7.4 Dependent claims 4 to 6
- 7.4.1 The features of dependent claims 4 to 6 are the same as the features of variants (a) to (c) defined in claim 1, respectively. Therefore, the considerations in points 7.1.2 to 7.1.4 above relating to variants (a) to (c) of

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claim 1 also apply to the objections raised by the appellant in respect of dependent claims 4 to 6.

7.4.2 The appellant also objected that dependent claim 6, when referring to dependent claim 4 or 5 or to any of variants (a) and (b) of claim 1, required at the same time scanning and aberration correction, and that Table 1 of document 03 disclosed that any aberration correction was accompanied by an axial and/or lateral acceleration of the focal spot. This effect was not mentioned in the patent specification and rendered scanning along a desired trajectory impossible.

The board notes that the appellant's arguments in this respect are based on Table 1 of document O3. For reasons analogous to those given in point 7.1.2 above, paragraph iii), the board decided not to admit these submissions into the appeal proceedings (Article 12 (4) and/or Article 12 (6) RPBA).

- 7.5 Claims 7 to 11 and 14 to 16
- 7.5.1 The objections raised by the appellant under Article 83 EPC in respect of dependent claims 7 to 9, of claim 10 directed to a microscope comprising the acousto-optic lens of any one of claims 1 to 9, of claim 11 directed to a method of determining drive signals of the acousto-optic lens according to claim 1, and of dependent claims 14 to 16 all refer to the objections raised in respect of claims 1 to 6 and these objection have already been addressed in points 7.1 to 7.4 above. The corresponding submissions are either not admissible or not persuasive for the reasons given in points 7.1 to 7.4 above.

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7.5.2 The appellant also noted that the features of dependent claim 8 were obviously impossible to carry out when dependent on dependent claim 7.

However, dependent claim 8 only refers back to any of claims 1 to 6 and, therefore, there is no basis for the objection raised by the appellant.

- 7.5.3 The appellant also objected that the features of dependent claim 9 involving a third and a fourth AOD were not limited to the correction of aberrations and/ or to Z-scanning as it was the case for the AODs defined in claim 1. The board notes, however, that the same objection concerns dependent claim 9 as granted which referred back to dependent claims 4 to 6 as granted. Therefore, to the extent that this objection concerns clarity within the meaning of Article 84 EPC, the appellant's objection cannot be considered by the board for reasons analogous to those given in point 7.2 above, paragraph i), second sub-paragraph, in respect of dependent claim 2. In addition, to the extent that the objection concerns the issue of sufficiency of disclosure under Articles 100 b) and 83 EPC, the board notes that the objection could have been raised earlier during the proceedings, but that it was raised for the first time during the oral proceedings before the board, and that, therefore, the objection constituted an amendment to the appellant's case in appeal within the meaning of Article 13 RPBA. In the absence of any apparent exceptional circumstance within the meaning of Article 13 (2) RPBA, the board decided not to take into account the appellant's objection (Article 13 (2) RPBA).
- 7.5.4 During the oral proceedings the appellant emphasized in respect of the microscope defined in claim 10 that its

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operation required a precise control of the position of the focus point and that document O2 cited in the patent specification was based, as already submitted in respect of variant (c) of claim 1 (point 7.1.4 above, paragraph ii)), on a different formalism. However, as submitted by the respondent, the patent specification discloses sufficient information enabling the skilled person to achieve a predetermined level of control of the Z-displacement of the focused point and therefore of the Z-scanning, and the appellant's arguments are not convincing for the reasons already given in point 7.1.4 above, paragraphs i) and ii).

7.6 Dependent claims 12 and 13

The appellant submitted in respect of dependent claim 12 that the skilled person was not presented with any information on how to determine the Taylor coefficients in order to achieve the claimed feature "for focusing an incoming beam of electromagnetic radiation", without the use of an objective lens and without consideration of the diffraction components - in particular, of the 0-order diffraction component - of the diffracted light. Dependent claim 13 required objective optics, but the objection mentioned above in respect of the missing consideration of the diffraction components of the diffracted light was maintained.

The board notes that these objections were presented for the first time with the statement of grounds of appeal and that they constitute - as submitted by the respondent - new arguments based on new facts. In these circumstances, and for reasons analogous to those given in point 7.1.2 above, paragraph iii), the board decided not to admit these submissions in the appeal proceedings (Article 12 (4) and 12 (6) RPBA).

7.7 The board concludes that the appellant's submissions in support of the objections under Article 83 EPC are either not admitted or not persuasive. Therefore, the board sees no reason to question that the claims according to the third auxiliary request comply with the requirements of Article 83 EPC.

8. Further prosecution

On the one hand, as concluded in point 3 above, the ground for opposition of lack of inventive step prejudices - contrary to the opposition division's view - the maintenance of the patent as granted. Already for this reason, the decision under appeal cannot stand and must be set aside. The appeal is thus allowable within the meaning of Article 111 (1), first sentence, EPC.

On the other hand, the question arises whether the patent can be maintained in amended form. It follows from Article 111 (1), second sentence, EPC that the board may either examine this question or remit the case to the opposition division. As concluded in point 4 above, none of the first and the second auxiliary requests are allowable. As regards the third auxiliary request, the board sees no reason to question that this request complies with the requirements of Articles 83, 84 and 123 (2) EPC (points 5 to 7 above). However, during the oral proceedings before the board the discussion on the question of novelty and inventive step of the subject-matter of claim 1 of the third auxiliary request raised various different new substantive issues which had not been addressed during the first-instance proceedings. Addressing all these new substantive issues on appeal would have required the board to go beyond the primary object of the appeal - 55 - T 0762/21

proceedings to review the appealed decision in a judicial manner (Article 12 (2) RPBA). In the board's view, this constitutes a special reason within the meaning of Article 11 RPBA that justifies the remittal of the case to the opposition division for further prosecution. For these reasons, the board considers it appropriate in the exercise of its discretion under Article 111 (1), second sentence, EPC, together with Article 11 RPBA, to remit the case to the opposition division for further prosecution.

Order

For these reasons it is decided that:

- 1. The decision under appeal is set aside.
- 2. The case is remitted to the opposition division for further prosecution.

The Registrar:

The Chairman:



C. Moser R. Bekkering

Decision electronically authenticated