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Case Number: T 1480/10 - 3.4.02

Application Number: 06000753.1

Publication Number: 1684064

IPC: G01N21/64, G01N21/21

Language of the proceedings: EN

Title of invention:
Quantum resonance analytical instrument

Applicant:
McGrew, Stephen P.

Relevant legal provisions:
EPC Art. 83

Keyword:
Sufficiency of disclosure (yes)
Remittal for further prosecution

Decisions cited:
T 0792/00

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European Patent Office
D-80298 MUNICH
GERMANY
Tel. +49 (0) 89 2399-0
Fax +49 (0) 89 2399-4465

Case Number: T 1480/10 - 3.4.02

D E C I S I O N
of Technical Board of Appeal 3.4.02
of 15 September 2014

Appellant: (Applicant)	McGrew, Stephen P. 9715 West Sunset Highway Spokane, Washington 99224 (US)
Representative:	Grünecker, Kinkeldey, Stockmair & Schwanhäusser Leopoldstraße 4 80802 München (DE)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 19 January 2010 refusing European patent application No. 06000753.1 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	A. G. Klein
Members:	F. J. Narganes-Quijano
	D. Rogers

Summary of Facts and Submissions

I. The appellant (applicant) lodged an appeal against the decision of the examining division refusing European patent application No. 06000753.1 (publication No. 1684064).

In its decision the examining division held that the invention defined in the sets of claims of the main and the first to fifth auxiliary requests then on file was not sufficiently disclosed in the application within the meaning of Article 83 EPC. The examining division referred to the following documents in support of its finding:

D4: "Optimal quantum control with multi-polarization fields", R. Wu *et al.*; Chemical Physics Letters (NL), Vol. 400 (2004), pages 469 to 475

D6: "Femtosecond shaping of transverse and longitudinal light polarization", T. Brixner *et al.*; Optics Letters (US), Vol. 29 (2004), pages 2187 to 2189

D7: "Phase, amplitude, and polarization shaping with a pulse shaper in a Mach-Zehnder interferometer", M. Plewicki *et al.*; Applied Optics (US), Vol. 45 (2006), pages 8354 to 8359.

II. With the statement setting out the grounds of appeal the appellant submitted six sets of claims as main and first to fifth auxiliary requests, the sets of claims being identical to the sets of claims considered by the examining division in the decision under appeal. The appellant requested that the decision under appeal be

set aside and a patent be granted. In support of its submissions the appellant filed document

DA: "Femtosecond polarization interferometry tolerances", R. Chipman, College of Optical Sciences, University of Arizona (US), 2010.

Claim 1 of the main request filed under cover of a letter dated 31 May 2010 reads as follows:

"A microscope for detecting a distribution of a component substance in a specimen, comprising:

a plurality of pulse shapers (1510, 1520, 1530, 1540) configured to re-shape an initial pulse of radiation emitted from a radiation source into a first re-shaped pulse that is linearly polarized, and a second re-shaped pulse that has combined polarization;

an illuminating assembly configured to simultaneously illuminate the specimen with the first and second re-shaped pulses so that the first and second re-shaped pulses intersect at an angle of at least 45 degrees on the specimen to form a combined pulse having at least three mutually orthogonal electric fields; and

objective optics (830) configured to focus radiation emitted from the specimen when the specimen is illuminated with the re-shaped pulses into an image representing a distribution of the component substance in the specimen, wherein

the specimen is mounted on or beneath a horizontal surface of a prism (1690) and the first and second re-shaped pulses enter the prism through first and second surfaces (1695), orthogonally to the first and second surfaces, or mounted on or beneath the bottom of a single block of glass (1710) configured such that the reshaped pulses are totally internally reflected at the

bottom face of the block of glass (1710) using appropriate mirrors (1720, 1730) or coatings so that the specimen is illuminated by an evanescent field of the reflected reshaped pulses, wherein the mirrors or coatings are incorporated into the solid block of glass."

The main request includes dependent claims 2 to 8 all referring back to claim 1. The wording of the claims of the first to fifth auxiliary requests is not relevant for the present decision.

Reasons for the Decision

1. The appeal is admissible.

Sufficiency of disclosure - Main request

2. Claim 1 of the main request is directed to a microscope for detecting the distribution of a component substance in a specimen. According to the claimed subject-matter, the specimen is illuminated with two polarized pulses the shape of which has been modified so that the combined pulse has three mutually orthogonal electric fields such that the image obtained by focusing the radiation emitted from the specimen represents the distribution of the component substance in the specimen.

The physical mechanism underlying the claimed formation of an image representing the distribution of the

component substance in the specimen is based on the generation of an electromagnetic pulse within (Figure 16) or in the vicinity of the specimen (Figure 17) resulting from the coherent combination of two polarized pulses the optical characteristics of which (phase and/or amplitude and/or polarization) have been appropriately reshaped (page 12, lines 10 to 19, together with Figure 15 and the corresponding disclosure on page 19, line 19 to page 21, line 5). The optical characteristics of the combined pulse, and in particular the three-dimensional configuration of its electric field, are tailored to the specific quantum spectral response of the component substance to be detected by selectively reshaping the two polarized pulses in such a way that the electric field of the combined pulse induces a quantum state transition between predetermined energy levels of the energy band structure of the component substance. The component substance subsequently emits radiation of a specific wavelength within the fluorescence emission spectrum characteristic of the substance, and the radiation is then focused into an image as claimed (page 6, lines 7 to 15, page 18, lines 14 to 22, and page 22, lines 20 to 24).

It is first noted that the claimed invention does not properly focus on the physical mechanism underlying the formation of the image, but on the optical arrangement constituted by the pulse shapers configured to reshape an initial pulse of radiation into the two reshaped polarized pulses, the illuminating assembly configured to recombine the two pulses at or close to the specimen, and the objective optics configured to focus the radiation emitted from the specimen into the image. In addition, the examining division has questioned neither the technical feasibility of the two

alternative optical arrangements defined in the claim and disclosed in the description with reference to Figures 16 and 17 (page 22, line 10 to page 23,line 9), nor the physical mechanism underlying the formation of the claimed image *per se*. The objection of lack of sufficiency of disclosure raised by the examining division rather concerns two particular aspects of the technical implementation of the aforementioned mechanism underlying the formation of the image, namely the phase stability between the two polarized reshaped pulses, and the spatial uniformity of the polarization of the recombined pulse on the plane of the specimen.

2.1 As regards the stability of the relative phase of the two reshaped pulses incident on the specimen, the examining division held that the description failed to disclose sufficient information on how to achieve a sufficient phase stability for the aforementioned mechanism to work.

This problem is already acknowledged in the paragraph bridging pages 21 and 22 of the description of the application where the optical arrangement is required to be interferometrically stable within a variance substantially less than one wavelength, and in particular lens than 1/10th or 1/20th of the radiation wavelength. In addition, the same paragraph already specifies concrete technical measures to be taken in order to preserve the required interferometric stability. In particular, it is proposed in the mentioned paragraph to machine the pulse shaping and recombining means "into a single block of metal [...] surrounded by a temperature-stabilized enclosure mounted on a vibration isolation table to prevent dimensional changes". In addition, it is stated in the

same paragraph that the required degree of stability "is maintained as a matter of course in systems known in the art, for example, in holographic systems provided by New Light Industries, (Spokane, WA)". In the previous paragraph of the description it is also proposed to use path length adjusters for compensating possible variations in the relative path lengths of the pulses (page 21, lines 20 to 26). The description therefore contains technical information on how to correct, at least to a predetermined degree, possible interferometric instabilities caused by variations in the relative phase of the pulses.

In the decision under appeal the examining division held all these technical measures to be insufficient and speculative and referred to documents D4, D6 and D7 in support of its view in this respect. However, the Board does not find the arguments of the examining division persuasive for the following reasons:

2.1.1 Document D4 explores, following an analytical and simulation approach, the control of quantum systems subject to the interference by multi-polarization shaped pulses (abstract). As noted by the examining division, the document acknowledges that "full 3-D shaped control has not been achieved. Good optical stability will be needed to maintain the relative timing and structure of the beams" (page 470, second column, first paragraph), and in the final, concluding remarks the authors of the document state that "the practical creation of the shaped pulses is presently not a routine operation". These statements, however, are made in document D4 in a specific context, namely in the context of the so-called "3-D" control of the shape of each of three linearly polarized pulses independently of each other (abstract, Figure 1

together with the paragraph bridging the two columns on page 470); in contrast thereto, the claimed invention only requires reshaping a single initial pulse of radiation emitted from a radiation source by splitting it into a first linearly polarized pulse and a second pulse with combined polarization and then reshaping and recombining the two pulses, and document D4 itself already reports on known techniques for "arbitrarily shaping two polarization components in a single beam" (page 470, second column, lines 9 to 11).

In addition, as repeatedly emphasized in document D4 (see for instance title, abstract, section "Introduction", and the concluding section), the problem addressed in the document is the optimization of the control of the quantum system excited by the pulses by means of a full, optimal control of the shape of three independent polarization pulses. The present invention, however, only requires a reshaping of the pulses sufficiently stable during a time period sufficiently long to excite the quantum energy levels of the component substance to be detected, and this mechanism does not require the level of optimization addressed in document D4. On the contrary, while the approach disclosed in document D4 requires the analytical determination of the optimal shapes of the pulses (page 472, second column, central paragraph) and full control of the same, it is explicitly stated in the present application (page 8, lines 3 to 6) that in the claimed invention there is even no need to know the specific shape of the pulses as these are reshaped according to parameters fed into the shapers and the specific values of the parameters are previously empirically determined by an optimization algorithm of the evolutionary type (page 7, lines 4 to 7 together

with Figure 3 and the corresponding description on page 8, lines 7 to 24).

Consequently, contrary to the examining division's findings, document D4 does not provide evidence that the disclosure of the application is sufficient to enable the claimed invention to be put into practice.

2.1.2 Document D6 addresses the problem of locally shaping in the near-field of a scanning tunnelling microscope tip the longitudinal and the two transverse components of the electric field of an incident polarized light pulse, wherein the incident pulse has a transverse polarization state that has previously been shaped in two orthogonal directions (abstract together with Figure 1 and the corresponding disclosure). The document discusses the behaviour of the electric field and the possibilities of reshaping the same (page 2189, first column, second paragraph), and in a comparison of the approach followed in the document with that generally based on transversely polarization-shaped fields it is stated that in the latter approach "full controllability requires three independently phase-and-amplitude-shaped beams from different spatial directions and nontrivial mutual phase stabilization" (page 2189, first column, third paragraph). However, as already concluded in the former paragraph, the claimed invention relies on one single initial pulse split into a first linearly polarized pulse and a second pulse with combined polarization, and not on three independent pulses and, in addition, the invention does not require full controllability of the shaping process. Furthermore, the approach proposed in document D6 relies on reshaping one single initial pulse and the authors state in the same passage mentioned above that "our scheme employs only one

external source and therefore requires no phase stabilization".

Therefore, document D6 does not call into question that the claimed invention can be implemented; on the contrary, the document rather supports that shaping pulse components originating from one single initial pulse and recombining them solves, or at least reduces, the problem associated with the instabilities in the relative phase of the pulse components.

2.1.3 The examining division also referred to the disclosure of document D7 published after the priority date of the application in suit. This document discloses a pulse shaper arrangement integrated in both arms of an interferometer of the Mach-Zehnder type and according to the document the arrangement allows for a full control of the phase, the amplitude and the polarization of a radiation pulse (abstract and Figure 1 together with the corresponding description). The document states that "to keep the same polarization is crucial to maintain a stable relative phase between the polarization components" (page 8355, first column, last paragraph). Thus, the document addresses the stability problem under consideration, and it is in this context that the document proposes the use of one single shaper in both arms of the interferometer because this feature "provides more stability compared with two independent [...] shaper layouts. Any possible vibration or thermal deformation from these components will have the same effect on both paths and consequently have minimal influence on the relative phase stability". It follows from this disclosure that the effect of the use of one common shaper for both pulse components is an improved stability in the relative phase of the pulses, but, contrary to the examining division's view, it cannot be

inferred therefrom that the use - as claimed - of a plurality of shapers would considerably undermine the relative phase stability, at least not to the extent of rendering impossible the claimed effect of obtaining an image representing a distribution of the component substance in the specimen. Furthermore, the disclosure of the document pertains to a technical context requiring that the relative phase shift is, as mentioned in the last paragraph on page 8358, maintained constant "over long periods of time", and such a condition is not required by the claimed invention because, as already mentioned above, the invention only requires a reshaping of the pulses sufficiently stable during a time period sufficiently long to induce transitions between the quantum energy levels of the component substance to be detected.

2.1.4 The examining division also referred in this regard to decision T 792/00. In this decision the corresponding Board addressed the issue of sufficiency of disclosure of an invention that went against the prevailing technical opinion at the priority date of the corresponding application (points 3 to 8 of the reasons). As shown in the former paragraphs, however, none of documents D4, D6 and D7 allow establishing a prevailing technical opinion that would be in conflict with the claimed invention. Consequently, the rationale behind decision T 792/00 is not relevant to the present case.

2.1.5 Finally, the appellant has submitted with the statement setting out the grounds of appeal document DA reporting on the results of an analysis of the degree of phase stabilization required by the claimed invention. According to the results of the analysis carried out on the basis of analytical and simulation methods, the

tolerances in phase stability required in the claimed microscope to place the three-dimensional electric field in a configuration guaranteeing a high transition probability in the component substance are in the range of λ/20 to λ/10 (document DA, Figures 7 to 10 and page 7, first paragraph) and are therefore of the same order of magnitude as the phase stability tolerances for standard optical interferometers conventionally used in optical testing (page 3, third paragraph). These results show that a sufficient degree of relative phase stability can be achieved in the claimed microscope by means of the conventional technical measures used in the stabilization of standard optical interferometers. In addition, these conventional technical measures correspond substantially to the technical measures already specified in the description of the application and mentioned in the second paragraph of point 2.1 above.

The Board concludes that the arguments given by the examining division and the evidence considered in support thereto cannot put into doubt that the technical measures disclosed in the description are sufficient to operate the claimed microscope with the sufficient degree of phase stability required to obtain the claimed image.

2.2 As regards the uniformity of the polarization of the recombined pulse on the plane of the specimen, the examining division held in its decision that in order to obtain an image as claimed the area of the specimen must be illuminated by radiation having substantially uniform polarization because, otherwise, it would be impossible to determine whether a spatial variation in the emitted radiation would be the result of a local

change in the amount of component substance or of a change in the illuminating polarization.

The Board, however, cannot follow this argument because the radiation emitted by the component substance would be uniquely characterized by a spectral radiation component having a specific wavelength associated with a predetermined quantum transition in the energy band structure of the substance, and it would therefore be clearly distinguishable from other radiation components emerging from the specimen, and in particular from those resulting from a change in the illumination polarization (see description, page 4, lines 5 to 13, page 6, lines 9 to 15, page 8, line 25 to page 9, line 2, and page 23, lines 20 to 28). In addition, local changes in the polarization state of the illumination field and spatial variations of the illumination field, such as that resulting from possible interference patterns or from the presence of an evanescent illumination field, would not be detrimental to the formation of an image as claimed. Indeed, contrary to what the examining division appears to have assumed, the claimed invention does not require illuminating the whole sample area with a uniform polarization illumination field, and claim 1 does not even require the formation of a full, continuous image of the spatial distribution of the component substance in the specimen with a predetermined resolution. Rather, claim 1 only requires the focusing of the radiation emitted from the specimen "into an image representing a distribution of the component substance in the specimen". For the implementation of the claimed invention it is therefore sufficient to focus an image, the information content of which is representative of the distribution of the substance at predetermined spatial regions of the specimen, such as the fringes of

an interference pattern projected on the specimen. Whether a full, continuous image of the spatial distribution of the component substance can subsequently be obtained from the claimed image - for instance, by means of techniques mentioned by the appellant as being conventional such as filtering of image data, scanning of the specimen with the recombined pulse, combining and/or averaging images, etc. - goes beyond the invention actually claimed and is therefore not pertinent for the issue under consideration.

2.3 Having regard to all the considerations and conclusions above, the Board does not see any reason to doubt that the claimed invention is sufficiently disclosed in the application for a skilled person to put it into practice without undue burden or experimentation. The Board concludes that the invention defined in the set of claims of the main request is sufficiently disclosed in the application within the meaning of Article 83 EPC.

3. In view of the above, the decision under appeal is to be set aside. The issue of the further request for grant of a patent, however, requires further examination as to whether the application documents amended according to the main request and the invention to which they relate satisfy the remaining requirements of the EPC. For these reasons, the Board considers it appropriate to exercise its power under Article 111(1) EPC and to remit the case to the examining division for further prosecution upon the basis of the main request.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the department of first instance for further prosecution upon the basis of the main request filed under cover of a letter dated 31 May 2010.

The Registrar: The Chairman:

M. Kiehl A. G. Klein

Decision electronically authenticated