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(54) **Title:** OPTICAL COHERENCE TOMOGRAPHY APPARATUS, SETUP WITH SUCH AN APPARATUS, AND METHOD FOR CREATING AN OPTICAL COHERENCE TOMOGRAPHY IMAGE

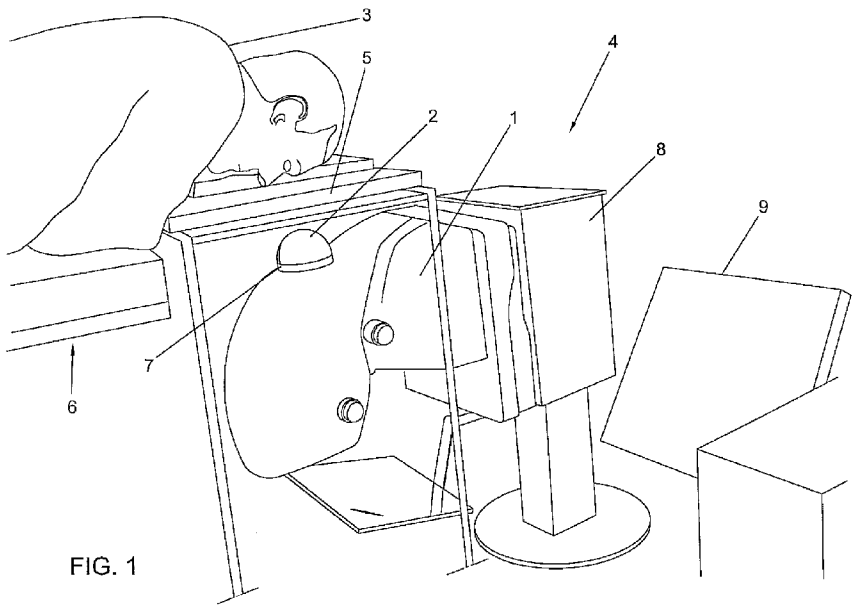

FIG. 1

(57) **Abstract:** Apparatus (1) for creating an optical coherence tomography image of the back of an eye, wherein a light beam operatively exiting from the apparatus has a main axis. The main axis of the exiting light beam has a substantially standing orientation. At least an exit unit of the apparatus is height adjustable along the main axis.

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Title: Optical coherence tomography apparatus, setup with such an apparatus, and method for creating an optical coherence tomography image

The invention relates to an apparatus for creating an optical coherence tomography image of the back of an eye, wherein a light beam operatively exiting from the apparatus has a main axis.

Such an apparatus is used in ophthalmology for obtaining an image of, for instance, the back of an eye. The exiting light beam of the optical coherence tomography apparatus (OCT apparatus) is reflected by the tissue of the eye. The delay of this reflected light is measured and on the basis thereof the image is set up.

Patent publication US 2003/0048540 describes an OCT apparatus of which a probe can be introduced into a body cavity, such as for instance an eye. The probe may be hand-operated and may be provided with a positioning unit for adjusting the position of an end of the probe.

Patent publication EP 0 697 611 describes an ophthalmologic surgical microscope which is combined internally with an OCT device, as well as a laser system which is combined internally with an OCT device. The exit beam of the OCT device is parallel to the exit direction of the microscope and the laser light, respectively.

Patent publication WO 2005/080912 describes a contrast measuring device in a Michelson interferometer which can be used in an OCT system.

A disadvantage of the known OCT apparatus is that after certain eye operations it cannot be verified whether a treatment performed during the operation has actually been successful. This is for instance the case with an operation in connection with macular degeneration, where during the operation *inter alia* an air bubble is placed in the eye.

An object of the invention is to provide an OCT apparatus which obviates the disadvantages mentioned.

To this end, the invention provides an apparatus for creating an optical coherence tomography image of the back of an eye, wherein a light beam operatively exiting from the apparatus has a main axis, characterized in that the main axis of the exiting light beam has a substantially standing orientation.

Arranging for the main axis of the exiting light beam to have a substantially standing orientation makes it possible, with the eyes of the patient directed downward, to form a proper image of the back of the eye. In particular, it can be seen whether after an operation in connection with macular degeneration the air bubble introduced into the eye during the operation has ended up in the correct place in the eye. The main axis of the exiting light beam has a substantially standing orientation with respect to the "fixed world". Preferably, the exiting light beam operatively has an upward orientation, thus to be able to enter into eyes of a person whose eyes are in downward orientation. In a stable manner, an image can thus be formed of the back of, for instance, a downward-oriented eye.

As at least an exit unit of the apparatus is height-adjustable along the main axis, the distance between the eye and the apparatus can be set. Preferably, at least the exit unit of the OCT apparatus also has a standing orientation with respect to the fixed world.

As at least the exit unit of the apparatus is adjustable in a direction substantially transverse to the main axis, the position of the apparatus with respect to the eye can be optimally set to enable a best possible image to be formed of the back of the eye.

As the apparatus is attached to a standing guide for height adjustment, the distance between the eye and the apparatus can be set in a simple manner.

The invention also relates to a setup for creating an optical coherence tomography image of the back of an eye of a person, comprising an apparatus for creating an optical coherence tomography image of the back of an eye, wherein a light beam operatively exiting from the apparatus has a main axis, wherein the main axis of the exiting light beam has a substantially standing orientation, and further comprising means for supporting a facial part surrounding the eye, wherein the means have a substantially lying orientation so that the eyes of the person are oriented downward. Optionally, the OCT apparatus may be set up such that the main axis of the exiting light beam has a standing orientation.

By additionally providing, in the setup with an OCT apparatus, means for supporting a facial part surrounding the eye, with the means having a substantially lying orientation so that the eyes of the person are oriented downward, the facial part of the person can be supported in a stable manner. Thus, an optimum image can be obtained of the back of the eye. An exiting light beam of the OCT apparatus has a standing orientation with respect to the fixed world, so that the light beam can operatively be directed upward to be able to enter into downwardly directed eyes of a person. Preferably, also the exit unit of the OCT apparatus has a standing orientation.

The invention further relates to a method for creating an optical coherence tomography image of the back of an eye of a person, utilizing an apparatus for creating an optical coherence tomography image of the back of the eye with a main axis of a light beam exiting from the apparatus having a substantially standing orientation and wherein the eyes of the person are oriented substantially downward.

Further advantageous embodiments are represented in the dependent claims.

The invention will be further elucidated with reference to an exemplary embodiment represented in a drawing. In the drawing:

Fig. 1 shows a schematic perspective view of a setup according to the invention.

It is noted that the drawing figure is only a schematic representation of a preferred embodiment of the invention which is described by way of non-limitative exemplary embodiment.

In Fig. 1 there is shown an apparatus 1 for creating an optical coherence tomography image of the back of an eye (OCT apparatus). In the apparatus 1 is a light source emitting light of various wavelengths. The exiting light beam leaves the apparatus along an exit opening 2. The main axis of the exiting light beam has a substantially standing orientation with respect to the fixed world. In this exemplary embodiment, the OCT apparatus is set up such that the main axis of the exiting light beam has a standing orientation.

Optionally, the OCT apparatus 1 may be designed with an integrated base and/or stand, by which the OCT apparatus can be placed on the ground or on a table.

The light beam exiting from the OCT apparatus 1 along the main axis falls into the eye of the person 3 and is there reflected by the tissue of the eye. The reflected light beam passes along the exit opening 2 to reenter the apparatus 1, where the delay is analyzed. Based on the delay of the reflected light, an image is composed of the back of the eye. By making use of a light source emitting light over a wide range of frequencies, what can be achieved is that the light penetrates into the tissue of the back of the eye only over a short distance. As a result, an image can be formed of substantially the retina of the eye. The light source may for instance be designed as a superluminescent diode or as a laser with an extremely short pulse. A white light source also emits light over a wide range of frequencies. An OCT apparatus is generally available and is well known to the skilled person.

The setup 4 as shown in Fig. 1 further comprises means 5 for supporting a facial part which surrounds the eye of the person 3, so that the eyes of the person 3 are oriented downward. These means 5 are here designed as a table in which there is a hole, but the means 5 may also be designed as a support which is attached to the OCT apparatus 1, or as a support which is attached to a chair or bed.

In the setup 4 of Fig. 1, it can also be seen that the body of the person 3 is supported. The means 6 for supporting the body of the person 3 are here designed as a bed set up in a substantially lying orientation, but may also be designed, for instance, as a chair.

Through the means 5 for supporting the facial part of the person 3, or the means 6 for supporting the body of the person 3, the eyes of the person can be oriented substantially downward.

Optionally, an exit unit 7 along which the exiting light beam exits has a standing orientation with respect to the fixed world. Optionally, the whole OCT apparatus may be set up such that the main axis of the exiting light beam has a standing orientation with respect to the fixed world.

To enable obtaining as optimal an image as possible of the back of the eye, at least the exit unit 7 of the OCT apparatus 1 is height adjustable along the main axis. In this way, the distance between the eye and the exit opening 2 can be changed. Advantageously, at least the exit unit 7 of the OCT apparatus 1 is also adjustable in a direction substantially transverse to the main axis. The exit unit 7 of the OCT apparatus 1 may thus be adjustable in three translation directions. A proper position of the exit opening 2 with respect to the eye can be set. As the eyes of the person 3 are oriented downward, for instance the air bubble introduced into the eye during an operation in connection with macular degeneration will move upwards towards the back of the eye.

As at least the exit unit 7 of the OCT apparatus 1 is set up adjustably, the exit unit 7 can be positioned such that the standing exiting

light beam can fall optimally into the eye to form an optical coherence tomography image of the back of the eye. In an advantageous embodiment, the exit unit 7 has a standing orientation with respect to the fixed world and is adjustable with respect to the OCT apparatus in, for instance, three translation directions. In an embodiment, the whole exit unit 7 is coupled to the OCT apparatus via an adjusting device. The adjusting device may for instance comprise rails of standing orientation along which the whole exit unit 7 is adjustable in height. Also, the adjusting device may comprise rails oriented in a direction transverse to the rails of standing orientation, for adjustment of the exit unit 7 in directions transverse to the standing direction, so that the exit unit 7 may be adjustable in three translation directions.

Optionally, the exit unit 7 is fixedly connected with the OCT apparatus 1, and the whole OCT apparatus 1 is set up such that, as shown in Fig. 1, the main axis of the exiting light beam has a standing orientation with respect to the fixed world. In this exemplary embodiment, the exiting light beam is oriented upward.

The OCT apparatus 1 is attached to a standing guide 8 for adjustment of the OCT apparatus 1. The standing guide 8 is configured so that the OCT apparatus 1 is adjustable in the direction of the main axis, hence in standing direction, and preferably is also adjustable in directions substantially transverse to the main axis. Optionally, the OCT apparatus 1 is also rotatably attached to the standard guide 8. As the OCT apparatus 1 may be translatably and rotatably attached to the standing guide 8, an optimum position of the exit opening 2 with respect to the eye can be set in a simple manner. By adjustment of the OCT apparatus 1, the exit opening 2 of the exit unit 7 can be positioned such that the exiting light beam of standing orientation can enter a downward-oriented eye of a person in an optimum manner.

For instance, a standing guide 8 may be designed as a column in which guides are arranged. In the guide a slide may reciprocate in height direction. On the slide proper, a guide could be arranged in a direction substantially transverse to the height direction, for adjustment of the OCT apparatus 1 in the other two translation directions. The OCT apparatus 1 could then be attached to the slide. Optionally, the connection between slide and column and between OCT apparatus and slide may be provided with one and/or two rotation degrees of freedom. Thus, the OCT apparatus could be adjustable in three translation and three rotation directions. If the OCT apparatus is designed with an integrated base and/or stand, the guide may optionally be integrated in the base and/or stand.

By arranging for the exiting light beam to have a standing, preferably upward, orientation, an image of the back of a downward-oriented eye can be formed in a stable manner. By adjustably coupling the exit unit 7 to the OCT apparatus and/or attaching the OCT apparatus adjustably to for instance a standing guide, the OCT apparatus and/or the exit unit can be set up stably, so that in a simple manner an optimum image can be formed of, for instance, the back of an eye.

In the setup 4 shown in Fig. 1, also a monitor 9 is present. The image of the back of the eye created by the OCT apparatus 1 can be displayed on the monitor 9. In this exemplary embodiment, the monitor 9 is set up separately from the standing guide 8 or the OCT apparatus 1. Optionally, the monitor 9 may also be attached to a standing guide 8 or to the OCT apparatus 1.

It will be clear that the invention is not limited to the exemplary embodiment represented here. Many variants will be clear to those skilled in the art and are understood to be within the scope of the invention as set forth in the following claims.

CLAIMS

1. An apparatus for creating an optical coherence tomography image of the back of an eye, wherein a light beam operatively exiting from the apparatus has a main axis, characterized in that the main axis of the exiting light beam has a substantially standing orientation.

2. An apparatus according to claim 1, wherein at least an exit unit of the apparatus is height-adjustable along the main axis.

3. An apparatus according to claim 1 or 2, wherein at least the exit unit of the apparatus is adjustable in a direction substantially transverse to the main axis.

4. An apparatus according to any one of the preceding claims, wherein the apparatus is attached to a standing guide for height adjustment.

5. An apparatus according to any one of the preceding claims, wherein the apparatus is attached to the standing guide for adjustment in a direction substantially transverse to the main axis.

6. An apparatus according to any one of the preceding claims, wherein the apparatus is rotatably attached to the standing guide.

7. An apparatus according to any one of the preceding claims, wherein the created image is displayed on a monitor.

8. A setup for creating an optical coherence tomography image of the back of an eye of a person, comprising an apparatus according to any one of claims 1 to 6 and means for supporting a facial part surrounding the eye, wherein the means have a substantially lying orientation so that the eyes of the person are oriented downward.

9. A setup for creating an optical coherence tomography image of the back of an eye of a person, comprising an apparatus according to any one of claims 1 to 7 or according to claim 8, furthermore comprising means for

supporting the body of the person, wherein the means are set up in substantially lying orientation so that the eyes of the person are oriented downward.

10. A method for creating an optical coherence tomography image of the back of an eye of a person, utilizing an apparatus for creating an optical coherence tomography image of the back of the eye with a main axis of a light beam exiting from the apparatus having a substantially standing orientation and wherein the eyes of the person are oriented downward.

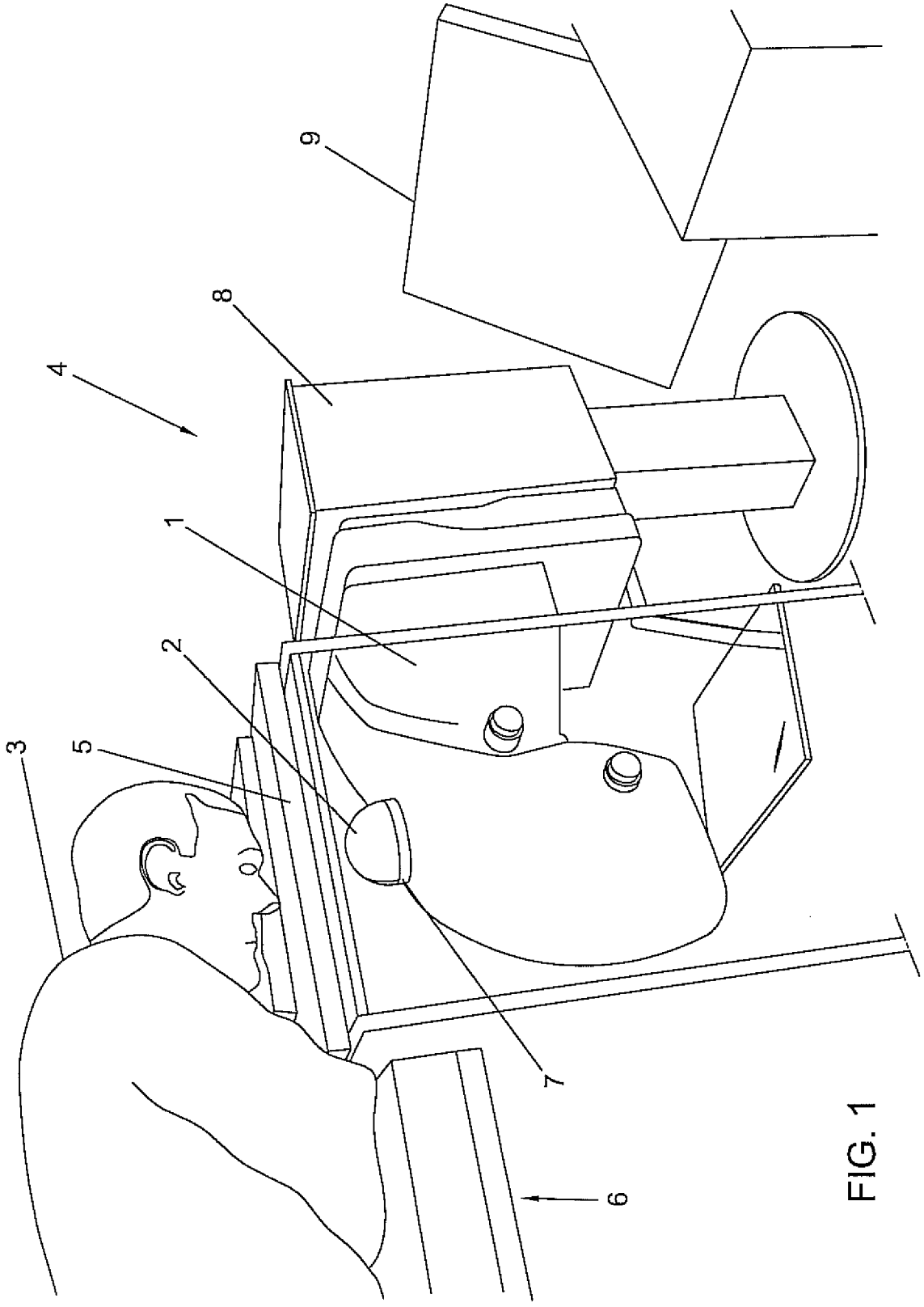

FIG. 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2009/050015

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B3/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	ANONYMOUS: "Retinal detachment repair" ADAM HEALTH ILLUSTRATED ENCYCLOPEDIA, [Online] 7 July 2007 (2007-07-07), XP002488414 Retrieved from the Internet: URL:http://web.archive.org/web/20070707030747/http://adam.about.com/encyclopedia/Retinal-detachment-repair.htm> [retrieved on 2008-07-15] pages 1,4	1-10
X	US 2003/048540 A1 (XIE TIANYU [JP] ET AL) 13 March 2003 (2003-03-13)	1-5,7-9
Y	paragraphs [0005], [0188], [0195], [0197], [0198]; figures 1,2,6,15	1-10

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
7 May 2009	15/05/2009

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2009/050015

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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A	column 10, lines 8,9,23,24,29; figures 1,6 column 11, lines 18,26,27	6
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A	EP 0 941 692 A (SCHWIND GMBH & CO KG HERBERT [DE] SCHWIND EYE TECH SOLUTIONS GMB [DE]) 15 September 1999 (1999-09-15) paragraph [0007]; figure 2	2-6
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Information on patent family members

International application No
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