P/00/008b 12/11/91
Section 29 (1)
Regulation 3.1 (2)

AUSTRALIA

Patents Act 1990 **640901**

NOTICE OF ENTITLEMENT

(To be filed before acceptance)

I, PER UDDEN of, Hofstrasse 1, CH-6064 Kerns, Switzerland being the applicant in respect of Application No. 52011/86 state the following:-

The Persons nominated for the grant of the patent: (i.e. PER UDDEN)

has entitlement from the actual inventors: JAN K. OBER of u. Brzechwy 6, PL-60-195 Poznan, Poland and PER UDDEN, of Hofstrasse 1, CH-6064 Kerns, Switzerland by assignment.

The person nominated for the grant of the patent:

has entitlement from the applicant of the application listed in the declaration under Article 8 of the PCT: by assignment.

The basic application listed on the request form:

is the first application made in a Convention country in respect of the invention

By my Patent Attorneys,
WATERMARK PATENT & TRADEMARK ATTORNEYS

.....

4 March 1993

L. C. Gebhardt
Registered Patent Attorney

AU8652011

(12) PATENT ABRIDGMENT (11) Document No. AU-B-52011/86
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 640901

(54) Title
EYE MOVEMENT MEASURING APPARATUS

International Patent Classification(s)
(51)[4] **A61B 003/02**

(21) Application No. : **52011/86** (22) Application Date : **18.11.85**

(87) PCT Publication Number : **WO86/03113**

(30) Priority Data

(31) Number	(32) Date	(33) Country
8405802	**19.11.84**	**SE SWEDEN**

(43) Publication Date : **18.06.86**

(44) Publication Date of Accepted Application : **09.09.93**

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(56) Prior Art Documents
US 4102564

(57) Claim

1. A device for measuring the movements of an eye, comprising at least two radiation sources (3, 4) located in front of the eye (8) and at least two radiation detectors (5, 6) adapted to detect the radiation reflected from the eye (8) and being located in a fixed spaced relationship to the radiation sources (3, 4), said radiation sources (3, 4) and said detectors (5, 6) being disposed in pairs so that one source-detector pair (3, 4; 5, 6) is arranged on each side of at least one symmetry plane through the centred eye (8), and electronic means being provided to process the signals generated by said detectors (5, 6) in response to the light incident thereon,

a diaphragm (1) provided with an aperture (2) arranged opposite the eye (8) and permitting the eye (8) to look through the aperture (2) within a certain viewing angle,

and a shielding member (7) disposed around said diaphragm (1) in order to prevent disturbing light from impinging onto the eye (8),

characterised in that the source-detector pairs (3, 4; 5, 6) are disposed on the side of the diaphragm (1) facing the eye (8) and located at a certain distance from the eye,

.../2

and in that said electronic means (11-20) are designed to adjust the radiation intensity from the sources (3, 4) in such a way that the radiation intensity detected by each detector is made substantially equal, whereby the difference in the emitted radiation intensity between the two radiation sources (3, 4) is a rough measure of the light reflected from the eye (8) and thus a coarse measure of the instantaneous position of the eye, which together with a fine measurement of an output of said radiation detectors, forms a high resolution measurement of the eye position.

AU-AI 52011/86

PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 : A61B 3/02 — A1

(11) International Publication Number: WO 86/03113

(43) International Publication Date: 5 June 1986 (05.06.86)

(21) International Application Number: PCT/SE85/00467

(22) International Filing Date: 18 November 1985 (18.11.85)

(31) Priority Application Number: 8405802-3

(32) Priority Date: 19 November 1984 (19.11.84)

(33) Priority Country: SE

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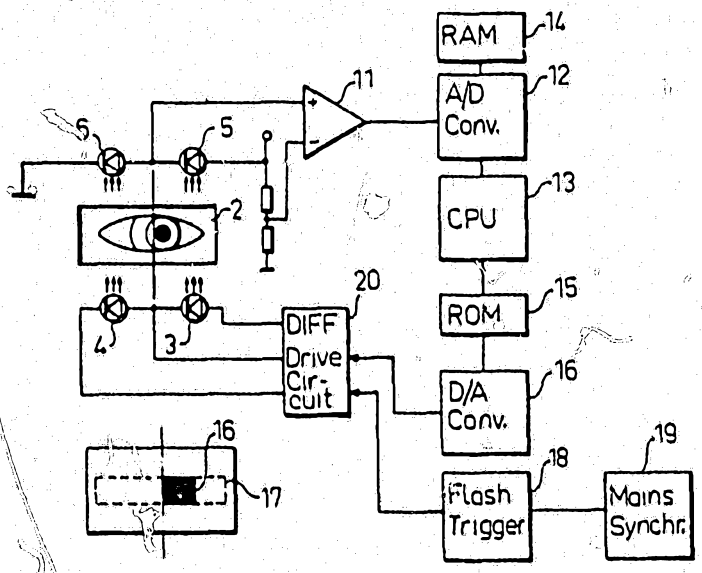
(81) Designated States: AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), US.

Published 640901
With international search report.

(54) Title: EYE MOVEMENT MEASURING APPARATUS

(57) Abstract

Device for measuring eye movements. At least two radiation sources are located in front of the eyes and at least two radiation detectors are adapted to detect the radiation reflected from the eye, whereby the detectors are located in connection with the radiation sources. In accordance with the invention the radiation sources (3, 4) and the detectors (5, 6) are disposed in pairs so that one pair is arranged on each side of at least one symmetry plane through the centered eye. The at least two pairs are disposed on a diaphragm (1) which is located at a certain distance from the eye (8) and which is provided with an aperture (2) straight opposite to the eye having a certain form and size thereby to permit the eye to look through the aperture within a certain space angle. A shielding member (7) is disposed around the diaphragm and the eye in order to prevent disturbing light from impinging into the eye beyond the light falling through the aperture. Electronic means (11-20) are arranged to detect the radiation which is reflected from the eye and incident against the detector to adjust the radiation from the sources in such a way that the radiation intensity detected by each detector will be substantially equal. The difference in the emitted radiation intensity between the two radiation sources is a rough measure of the light reflection from the eye and thus a coarse measurement of the instantaneous position of the eye which together with a fine measurement of the photodetector output forms a high resolution measurement of the eye position.



Eye movement measuring apparatus

The present invention relates to a device for measuring eye movements, comprising at least two and in front of the eyes located radiation sources and at least two radiation detectors adapted to detect the radiation reflected from the eye and being located in connection with the radiation sources.

It is previously known to measure eye movements by means of light emitters and light detectors which are placed in front of the eye and are adapted to sense the changing reflection characteristics of each eye due to the different positions, for instance when following a text line or other kind of information which causes the eye to move.

The drawbacks with these known arrangements for measuring eye movements are above all their complexity and the difficulty to adjust them properly and correctly in positions around the eye in order to obtain accurate read-out from the apparatus. Since there is an increasing demand for such apparatus specifically in order to diagnose different degrees of dyslexia among children it should be appreciated that the apparatus hitherto known can only be used under laboratory conditions and require extreme accurateness both from the operator and from the patient in order to obtain any useful results. Such apparatus can therefore hardly be used under normal working conditions, for instance in schools or offices since neither of these environments are sufficiently controlled for instance as to the illumination from the light sources normally used in such rooms.

The main object of the present invention is to provide a measuring device in which all these deficencies of the prior art measuring apparatus have been eliminated. Thus, the invention provides a device which can give extremely accurate measurements and which can be used under normal working conditions, for instance in schools or offices. Moreover, the device according to the invention is far cheaper than any of the prior art measuring apparatus which can only be used in controlled environments as can be obtained in a laboratory.

The object of the invention is realized substantially by the fact that the radiation sources and the detectors are disposed in pairs so that one pair is arranged on each side of at least one symmetry plane through the centered eye, and that the at least two pairs are disposed on a diaphragm which is located at a certain distance from the eye and which is provided with an aperture straight opposite to the eye having a certain form and size to thereby permit the eye to look through the aperture within a certain space angle, and that a shielding member is disposed around the diaphragm and the eye in order to prevent disturbing ligh from impinging into the eye beyond the light falling through the aperature, and that electronic means are arranged to detect the radiation which

is reflected from the eye and incident against the detector and to adjust the radition from the sources in such a way that the radiation intensity detected by each detector will be made substantially equal, whereby the difference in the emitted radiation intensity between the two radiation sources is a rough measure of the light reflection from the eye and thus a coarse measurement of the instantaneous position of the eye which together with a fine measurement of the photodetector output, forms a high resolution measurement of the eye position.

The position of the eye is measured in two steps, first in a coarse measurement, then in a fine measurement. The coarse measurement is carried out when positioning the sensitivity window as close as possible to the actual eye position. The fine measurement is performed within the sensitivity window.

In a suitable embodiment of the invention the arrangement is made in the form of goggles having a device according to the invention for each eye in order to make it possible to study the movements of two eyes simultaneously.

One embodiment of the invention will now be described more in detail with reference to the accompanying drawings in which

Fig. 1 is a schematical view of a device according to the invention as viewed from the eye,

Fig. 2 is a schematical and sectional view of a device according to the invention placed around an eye which observes a text,

Fig. 3 is an electric block diagram of a device according to the invention including all the different electrical circuits which are necessary to measure and store the eye movements.

Fig. 1 shows the device according to the invention in which a diaphragm 1 is provided with an aperture 2 through which the eye can read a text or any other kind of information. Below the aperture there are two IR-illuminators 3 and 4 and above the same there are two photodetectors 5 and 6. The illuminators and the detectors are arranged in pairs and one pair is disposed on each side of a symmetry plane through the centered eye, in this embodiment being the vertical plane to the centered eye and dividing the rectangular aperture into two substantially equal portions.

As shown in Fig. 2 the two IR-illuminators emit light within a rather wide angle which can be in the size of about 60^{o}. A shield 7 is disposed around the diaphragm 1 and also around the eye 8 in order to form a closed space 9 into which no disturbing light can enter from the out-side beyond the light which is incident through the rectangular aperture 2. This means that the reflection from the eye will be diffused and the detectors 5 and 6 will sense this diffused light reflected from that portion of the eye which corresponds to

the position of the illuminator 3 or 4. In the figure the eye is shown in centered position with the optical axis passing through the centre of the iris.

If the eye changes position, as indicated in Fig. 3, the photodetector 5 will receive less reflected light from the eye due to the altered reflection characteristics in the right half of the aperture 2. This will cause an unbalance between the two photodetectors 5 and 6 and result in a certain voltage input to the amplifier 11 which is connected to an analogue-digital converter 12 from which the now digital value of the unbalance voltage is supplied to a CPU 13 which compares the unbalance value with the stored values in a ROM 15 and in case this value is above or below the allowed range the CPU 13 establishes how much the illumination from illuminator 3 has to be increased or to be decreased from illuminator 4 in order to re-establish the balance between the two photodetectors 5 and 6. As indicated above the balance between the two detectors 5 and 6 is re-established when the command values i transferred to the illuminators 3, 4 via a digital-analogue converter 16 and a differential drive circuit 20. Moreover, the CPU compares the digital unbalance value with stored values in a ROM 15 and in case it is within the allowed range, sends it to the RAM as the value representing the eye position within the sensitivity window (fine measure of the eye position). This information is stored in the RAM along with the value sent to the D/A converter (used for correct placement of sensitivity window) as the value representing the coarse position of the eye. Both the rough and fine measure of the eye position stored in the RAM are used to construct the high resolution plot of the eye movement trajectory.

The eye position is measured within the sensitivity window (16) with 8 bits resolution of A/D. As the result of permanent re-establishing of balance by readjusting the illumination, the sensitivity window displaces along the whole dynamic range (17), that is the sensitivity window follows the current position of the eye. The positioning of the sensitivity window is the coarse (rough) measurement of the eye position and is performed with 8 bits resolution of D/A. The fine measurement of the eye position within the sensitivity window is the amplified output from the photodetectors and is carried out with 8 bits resolution of A/D. The possibility to adjust the position of the sensitivity window automatically excludes the necessity of fine placement of measuring system on the subject head and the correct measurement can be taken without any adjustment at all.

The illuminators 3 and 4 do preferably not emit light constantly but in light flashes of a duration of about 0.5 ms for detecting the position of the eye. This has great advantage since the eye can be considered stationary during

such a short time period of the flash and moreover, the flash can be synchronized with the mains voltage in order to always obtain the same lighting conditions at the measurement instant. The flash is supplied from a trigger circuit 18 and is synchronized with the mains voltage through a controller 19.

The above embodiment of the invention has been described in connection with a device for measuring eye movements substantially in the horizontal direction but it can of course also be used in a device for measuring both horizontal and vertical movements of the eye. In that case, however, the aperture has to be designed e.g. in the form of a circular opening which permits detection of horizontal as well as vertical eye movements.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A device for measuring the movements of an eye, comprising at least two radiation sources (3, 4) located in front of the eye (8) and at least two radiation detectors (5, 6) adapted to detect the radiation reflected from the eye (8) and being located in a fixed spaced relationship to the radiation sources (3, 4), said radiation sources (3, 4) and said detectors (5, 6) being disposed in pairs so that one source-detector pair (3, 4; 5, 6) is arranged on each side of at least one symmetry plane through the centred eye (8), and electronic means being provided to process the signals generated by said detectors (5, 6) in response to the light incident thereon,

a diaphragm (1) provided with an aperture (2) arranged opposite the eye (8) and permitting the eye (8) to look through the aperture (2) within a certain viewing angle,

and a shielding member (7) disposed around said diaphragm (1) in order to prevent disturbing light from impinging onto the eye (8),

characterised in that the source-detector pairs (3, 4; 5, 6) are disposed on the side of the diaphragm (1) facing the eye (8) and located at a certain distance from the eye,

and in that said electronic means (11-20) are designed to adjust the radiation intensity from the sources (3, 4) in such a way that the radiation intensity detected by each detector is made substantially equal, whereby the difference in the emitted radiation intensity between the two radiation sources (3, 4) is a rough measure of the light reflected from the eye (8) and thus a coarse measure of the instantaneous position of the eye, which together with a fine measurement of an output of said radiation detectors, forms a high resolution measurement of the eye position.

2. A device according to Claim 1, characterised in that the form of the aperture in the diaphragm, which restricts the visual field, is in accordance with the orientation of a sensitivity axis, and that sensing components are placed close to a limit of the aperture.

3. A device according to Claim 1 or 2, characterised in that the sources (3, 4) are pulsed, such that flash eye illumination is short enough to consider the eye to be stationary during the measurement, and that the sources (3, 4) are triggered synchronously with external light fluctuations as in the case of artificial illumination powered from mains, allowing to record the movement of the eye (8) under usual lighting conditions.

Dated this 6th April 1993

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Fig. 1

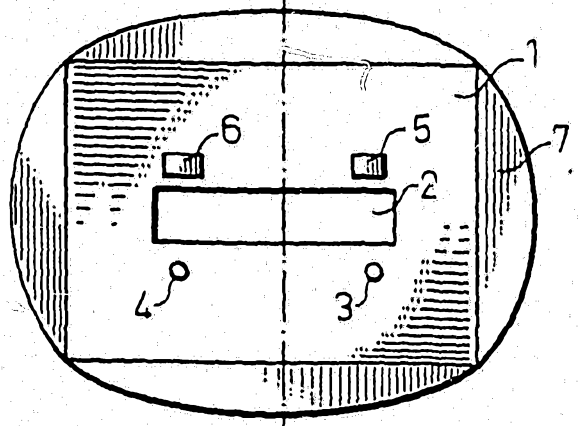


Fig. 2

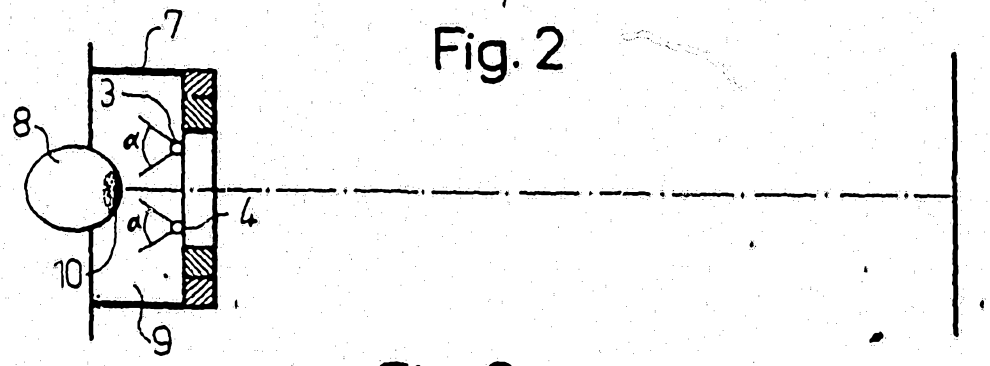
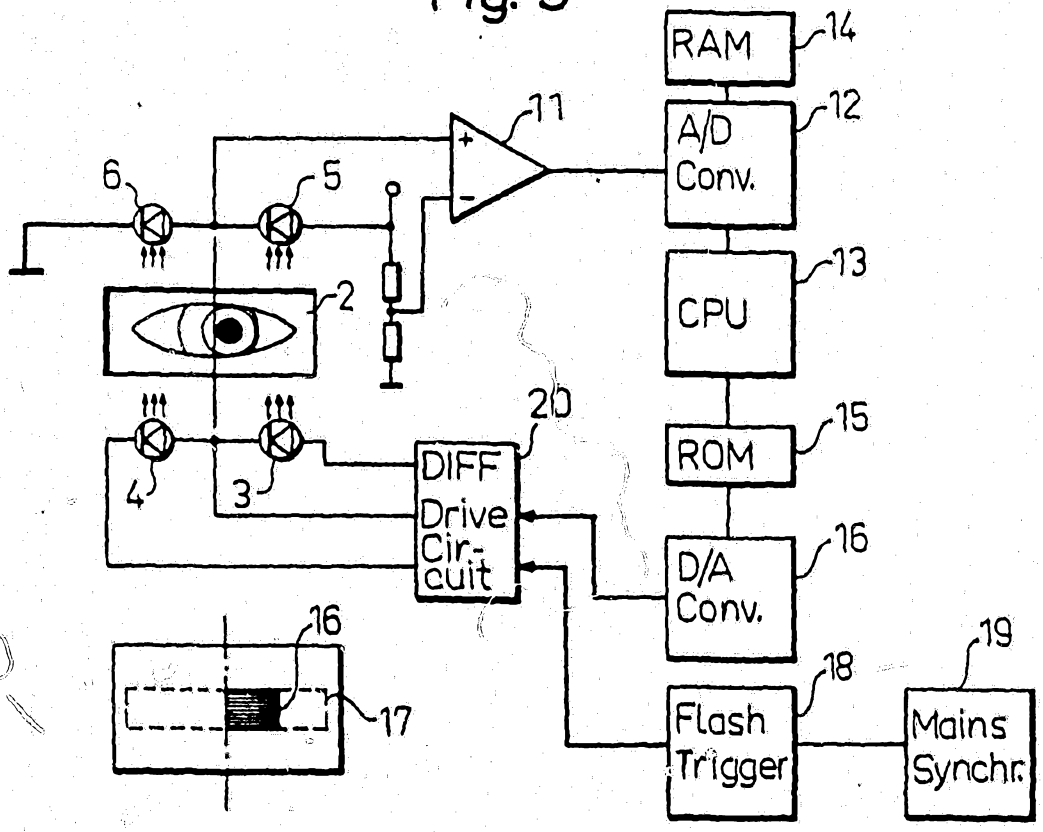


Fig. 3



INTERNATIONAL SEARCH REPORT

International Application No PCT/SE85/00467

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC 4

A 61 B 3/02

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC 4	A 61 B 3/00, /02, /10
US Cl	351:1, 2, 7, 23, 24, 39, 200, 203, 209, 210

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [8]

SE, NO, DK, FI Classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [10]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	US, A, 4 102 564 (MICHAEL) 25 July 1978	
A	US, A, 3 689 135 (YOUNG ET AL) 5 September 1972	
A	US, A, 3 450 466 (E. STREISINGER) 17 June 1969	
A	US, A, 4 255 023 (HOUSE) 10 March 1981	
A	GB, A, 2 096 791 (DANIEL KLIGLER ET AL) 20 October 1982	

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
1986-01-28	1986 -02- 03
International Searching Authority	**Signature of Authorized Officer**
Swedish Patent Office	Gunnar Hilderoth

L.E