

(19)



(11)

EP 1 748 292 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
31.01.2007 Bulletin 2007/05

(51) Int Cl.:
G01N 21/53 (2006.01)

(21) Application number: **06014112.4**

(22) Date of filing: **18.12.2003**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IT LI LU MC NL PT RO SE SI SK TR

- **Dahlström, Anna**
582 30 Linköping (SE)
- **Petterson, Hans**
590 62 Linghem (SE)

(30) Priority: **20.12.2002 SE 0203868**
20.12.2002 SE 0203869

(74) Representative: **Berglund, Erik Wilhelm**
Berglunds Patentbyrå AB
Aspebraten
590 55 Sturefors (SE)

(62) Document number(s) of the earlier application(s) in accordance with Art. 76 EPC:
03768470.1 / 1 579 196

(71) Applicant: **Optoq AB**
58112 Linköping (SE)

Remarks:
This application was filed on 07-07-2006 as a divisional application to the application mentioned under INID code 62.

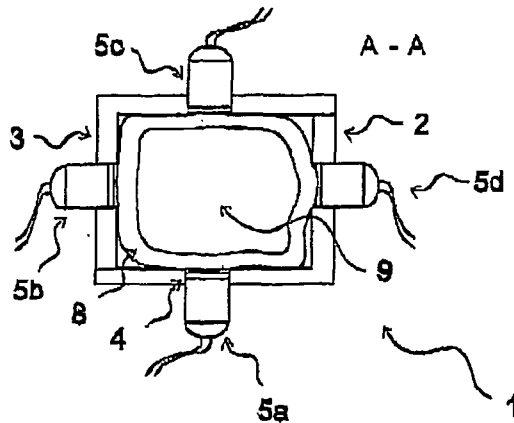
(72) Inventors:
• **Petterson, Magnus**
589 41 Linköping (SE)

(54) Device for measurements in blood

(57) Probe or detector arrangement comprising two essentially V-shaped profiles in the walls of which led's and sensors are arranged. A tubing clamped in the V-shaped profiles receives a square cross section. Light sources and sensors are arranged at the flat surfaces so

that the walls of the tubing becomes essentially flat where led's and sensors are located. A sensor device suitable for measuring the density of blood cells in blood in which light emitters and detectors are provided some of whose sense sectors do not intersect the incident light beam from a source.

Fig. 1



EP 1 748 292 A1

Description

Background of the invention

[0001] Hematocrit is the concentration of red blood cells (RBC) in blood. The measurement of hematocrit values is of great importance in the assessment of the condition of a patient. The established method of measuring hematocrit is by drawing blood from the subject (patient). Various methods to optically measure hematocrit by optical or ultrasonic means have been attempted, e.g., during a dialysis treatment of a patient. In these situations, not only the level of hematocrit is of high importance but also the relative variation of this parameter. In order to provide an optimized but still safe dialysis treatment the change of the hematocrit or relative blood volume has to be monitored during the treatment. The attempts to monitor this have so far not resulted in any product that can measure the hematocrit without a special cuvette integrated in the transport tubing. The methods used so far have therefore increased the cost of every dialysis treatments since the transport tubing must be equipped with this single-use cuvette. The invention presented here does not require any special cuvette, instead it provides the possibility to measure the hematocrit, or monitor the change of relative blood volume directly on any standard dialysis transport tubing on the market without increasing the cost of each treatment.

Technical field

[0002] The invention relates to measuring various blood constituents with optical means. Blood is irradiated with - preferably - near infrared or infrared light. Light scattering and attenuation of the light is measured and novel compensations for optical variations in the receptacle walls, flow etc. is used to calculate blood constituents such as hematocrit. The invention makes it possible to add the feature of hematocrit measurement without major alterations into any dialysis system. The addition of this feature makes blood volume measurements at hand.

Prior art

[0003] Hematocrit has been measured with various methods since the early hood of medical diagnosis. Continuous measurement is particularly useful during dialysis treatment. During the process of dialysis, liquids are extracted from the blood stream. As a result, hematocrit increases during me process. For the assurance or good quality in the dialysis treatment, the hematocrit value should be monitored, as this provides the care provider with essential information regarding the rate of extraction of fluids from the patient's bloodstream.

[0004] Various techniques have been presented in the field of optical measurements of hematocrit in blood. Several make use of the scattering effect RBC has on light

passing trough blood in a vessel, cuvette or the like. Openheimer presents in patent US 5,601,080 a method to measure the degree of scatter to derive blood constituents.

5 [0005] Other patents are US 4,745,279 to Karkar, describing scattering effect of blood in a cuvette. US 6,493,567 to Krivitski et al. describes a measuring instrument using one light emitting diode and one sensor. US 6,064,474 to Wylie et al is another description of a hematocrit measuring method using the scattering effect RBC has on light. However the known methods and devices do not provide a satisfactory precision.

The invention

15 [0006] The above objects are in accordance with the invention achieved by emitting light into the blood and then two detectors placed opposite each other are used to execute the measuring.

20 [0007] In accordance with the present invention, a novel apparatus is presented to measure blood properties with a procedure comprising a new optical probe arrangement that overcomes the problem of the prior art, as for instance optical variations, such as optical density, refractions etc. The invention may even take the shape of a clamp that with great ease can be applied on a transparent tubing such as transport tubing in dialysis. The new probe makes hematocrit values available with unsurpassed precision in the art, in spite of the fact that it measures trough transparent tubing that vary in thickness and shape.

25 [0008] In the practical embodiment of the invention the blood is measured as it flows through a transparent tubing. A beam of light, for instance from a laser is direct perpendicular into the tube and two sensors opposed to each other and perpendicular to the light beam pick up light and the sensor signals are used for the evaluation. The light source and the sensors may lie in the same plane but the plane of the sensors may also be slightly offset in relation to the light beam, for instance along the tubing. One can also consider using several pairs of sensors offset along the tubing and upstream as well as downstream in order to increase precision. Also a third sensor may be added to each pair, this third sensor being placed close to the light source.

30 [0009] In this solution the sensor offset in relation to the light source may advantageously be so large that the sensing sectors of the two sensors do not intersect the light beam. With increasing offset the sensitivity to relative changes is increased, whereas a smaller offset will provide a more accurate absolute measurement of the hematocrit value. It is thus possible to use one set of sensors to establish an absolute value and then use a set of more offset placed sensors for the monitoring and controlling of the level during dialysis.

35 [0010] Further preferable developments are apparent from the claims and the following description of a preferred embodiment of the invention.

Brief description of the drawings

[0011]

Fig. 1 is a cross section of an optical probe arrangement 1, accommodating light emitting diodes 5 in holes 4 in a framework comprising two halves 2 and 3 suited to fit a receptacle 8 such as tubing for blood 9.

Fig. 2 is a cross section of an optical probe arrangement 1, accommodating light detectors 6 in holes 4 in a framework comprising two halves 2 and 3 suited to fit a receptacle 8 such as tubing for blood 9.

Fig. 3 depicts the arrangement of the array of light detectors 5 and light emitting diodes 6 on the optical probe arrangement 1. This is a suggestion where the arrays according to Fig. 1 and Fig. 2 are located with indication "A - A" for the light emitting diodes, and "B - B" for the light detectors.

Fig. 4 depicts the arrangement of a second array of light detectors 7.

Fig. 5 depicts the optical probe arrangement 1 with the further embodiment of light emitting diodes 9, and photo detectors 8.

Fig. 6 depicts the resulting hematocrit values with reference to measurements performed at an accredited clinical laboratory.

Description

[0012] We have achieved very good results by using the following arrangement of light - emitting diodes (LED's) and photo detectors, when assessing hematocrit values. These values correlate very well with laboratory reference values.

[0013] Four LED's are arranged in a preferably - but not limited to - perpendicular fashion to each other around a receptacle, such as tubing, for the blood as apparent in Fig. 1. The light detectors are arranged in a fashion where they similarly are preferably perpendicular to each other according to Fig 2, but at a distance longitudinally away from the encirclement by the LED's, as exhibited in Fig. 3. In a further embodiment, a second encirclement of light detectors is fitted. The arrangement is apparent in Fig. 4.

[0014] The LED and photo detector arrangement should for best understanding be viewed as groups of LED's and photo detectors: For instance, LED 5 a, and photo detector 6 b is one group. Another group can be LED 5 b, and photo detector 6 a and 6 c. Note that no LED's and photo detectors are aligned to achieve direct transmitted light. The invention does not make use of directly transmitted light, as often is the case in prior art.

[0015] A sample of light detected from a group of one or several photo detectors can be taken at any one short instance in time. Another sample can be taken from the same or another group as a second sample. Preferably, a first sample is taken from a first group comprising LED

5 a, and light detectors 6 b and 6 d, a second sample is taken from a second group comprising LED 5 b, and light detectors 6 a and 6 c, a third sample is taken from a third group comprising LED 5 c, and light detectors 6 b and 6 d, and finally a forth sample is taken from a fourth group comprising LED 5 d, and light detectors 6 a and 6 c. A first result is derived from these four sequentially acquired samples being signal processed. The process can include variations of amplification factors for the signals from the detectors, and also correlation factors between these signals, to further enhance the detection of the blood constituent to be measured. The results make a first result for blood constituents, such as hematocrit. In this process, the error occurring from variations in the cross section of the flow pattern in the vessel is reduced. Furthermore averaging may reduce the effect the vessel wall has on the measurement. This is highly beneficial if the vessel is the extracorporeal circuit of a dialysis system. One of the major advancements in the disclosed invention resides in the new possibility to measure hematocrit through the walls of dialysis extracorporeal circuit, namely the so-called transport tubing of the circuit. It is highly advantageous that no special cuvettes or dedicated arrangements to the disposable bloodlines are necessary. Our process even makes it unnecessary to fit dedicated tubing to the extracorporeal circuit. This feature is considerably cost saving for the health care provider. Fitting the hereby disclosed probe on the transport tubing also has the advantage that the probe is not interfering with the ordinary functions of the dialysis system. Also, it furnishes the highly beneficial possibility to upgrade any already existing dialysis system with measurement of hematocrit, even if it is not prepared for such purpose. Subsequently blood volume changes can be calculated and displayed.

[0016] In one embodiment of the invention, two arrays of detectors are employed. Downstream (or upstream) a blood flow in a vessel such as tubing, a second array of detectors is fitted. This is apparent in Fig 4. The mathematical signal processing can further enhance the results by including this "second order" of detectors in the process.

[0017] In another embodiment of the invention, a second arrangement of LED's and photo detectors, including a second array of detectors is fitted. This is exhibited in Fig 5. In this embodiment, the LED's emits a different wavelength. This allows limited spectral analysis for further calculation of blood constituents, such as saturation of hemoglobin as known in the art. The results derived from this second array, can beneficially be incorporated in a signaling process with the values derived from the aforementioned first array. Such process makes it possible not only to output all parameters from blood constituents, but also let the saturation value influence the input of signals from the first array to the signaling process. This is beneficial, as blood saturation may influence the first results of blood constituents from the first process from the first array.

[0018] In the drawings and the above description a transparent blood transporting tubing is shown clamped between two essentially V-shaped profiles in the walls of which the led and sensors are arranged. In an alternative embodiment V-shaped groves in blocks may be used to clamp and shape the tubing so that its walls become essentially flat at LEDs and sensors.

[0019] In a further embodiment the sensors may be arranged in small holes with even smaller openings serving as collimators towards the tubing.

[0020] It is not today clear why the invented measuring method and device are so superior in relation to the prior art, one theory could be the offset between sensors and light source. Only light that has been dispersed from the volume of the blood in the path of the light and into the sense sector of the sensor and from this into the sensor will be registered. In other word only light that has been dispersed at least twice will reach the sensor. By arranging source and sensor perpendicularly blood cells in a major part of the tube cross section will have the opportunity to contribute so that the signals from the sensors become a function of the hematocrite value.

Claims

1. Sensor device for the measuring of the density of blood cells in blood **characterized in** comprising vessel or tubing, a light beam emitter facing the tubing, and one or several sensor(s) also facing the vessel and so arranged that its or their sense sectors do not intersect the beam of the light source in the vessel or tubing.
 2. Sensor device according to claim 1, **characterized in that** the locations of the light source and sensor (s) respectively are separated lengthwise of the vessel or tubing.
 3. Sensor device according to claim 1 or 2, **characterized in that** two sensors are arranged with their sensing directions perpendicular to the light beam.
 4. An optical probe arrangement that surrounds blood in a receptacle, said optical probe arrangement comprising at least two sets of light emitters and light detectors, each set comprising one light emitter and at least one detector, each set arranged to transilluminate the blood at a preferred angle between said light emitter and said light detector - or detectors - of each set, where said angle is at least sufficient to avert direct light from said light emitter to said light detector, for the detection of blood constituents.
 5. An optical probe arrangement according to claim 4, comprising four sets of light emitters and two or three light detectors in each set, wherein a light detector may represent a detector incorporated in an adjacent
- set.
 6. An optical probe arrangement according to claim, 4 or 5, wherein the light emitters are arranged as an array to encircle an elongated receptacle at longitudinally one location around said receptacle's circumference, and the light detector are arranged to encircle the receptacle at a different circumferential location.
 7. An optical probe arrangement according to any of the claims 4-6, wherein a second array of light detectors are longitudinally located at a third location around said receptacle's circumference, and the light detector are arranged to encircle the receptacle at that circumferential location.
 8. An optical detector or probe arrangement according to any of the claims 1-7, where a third array of light detectors are longitudinally located at a fourth location around said receptacle's circumference, and the light detector are arranged to encircle the receptacle at that circumferential location and an second array of light emitting diodes longitudinally located at a fifth location around said receptacle's circumference, and the light detectors are arranged to encircle the receptacle at that circumferential location.
 9. An apparatus according to any of the claims 1-7 claims, comprising a system to calculate hematocrit values from blood, and presenting the data to a display, and/or transferring data to another application.
 10. An apparatus according to any of the claims 1-7, comprising a system to calculate hematocrit values and oxygen saturation values from blood, and presenting the data to a display, and/or transferring data to another application.
 11. Probe or detector arrangement according to any of the claims 1-10 or 19-20, **characterized in that** the measuring takes place in a tubing that is clamped in a holder with V-shaped recesses so that tube is given a square cross section and that light sources and sensors are arranged at the flat surfaces.

Fig. 1

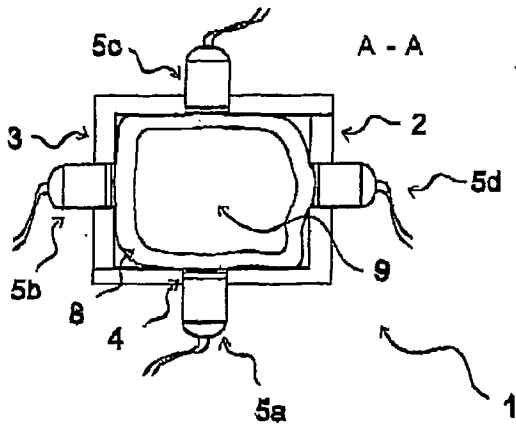


Fig. 2

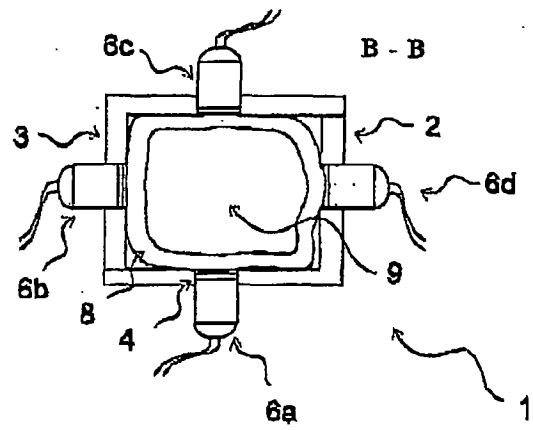


Fig. 3

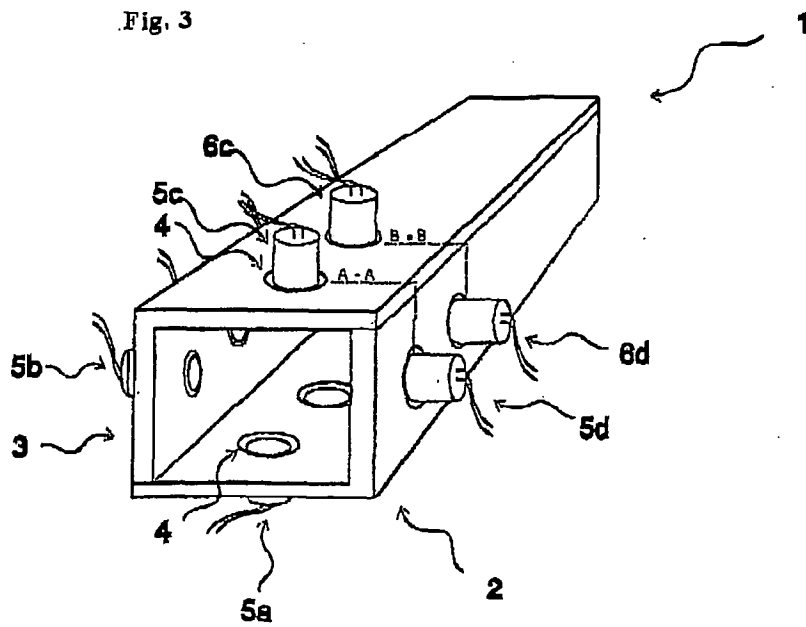


Fig. 4

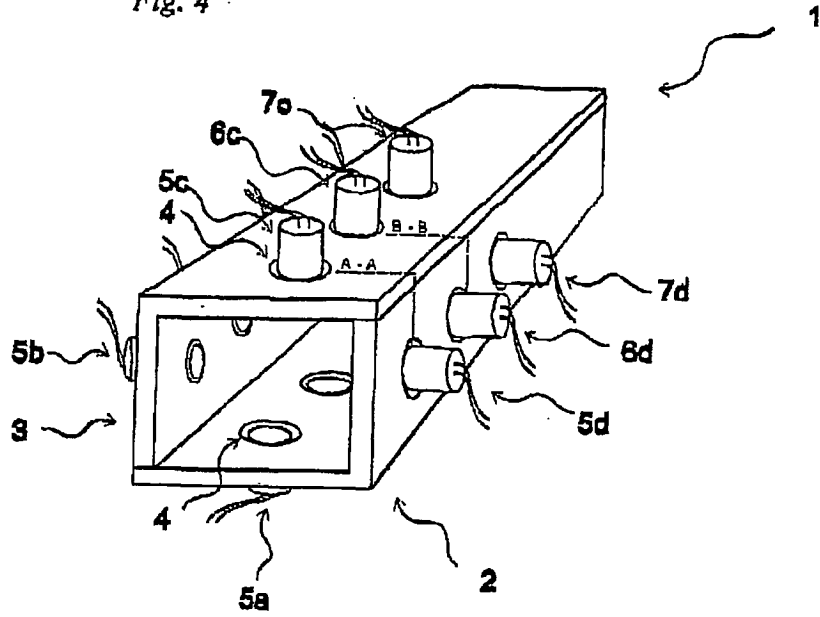
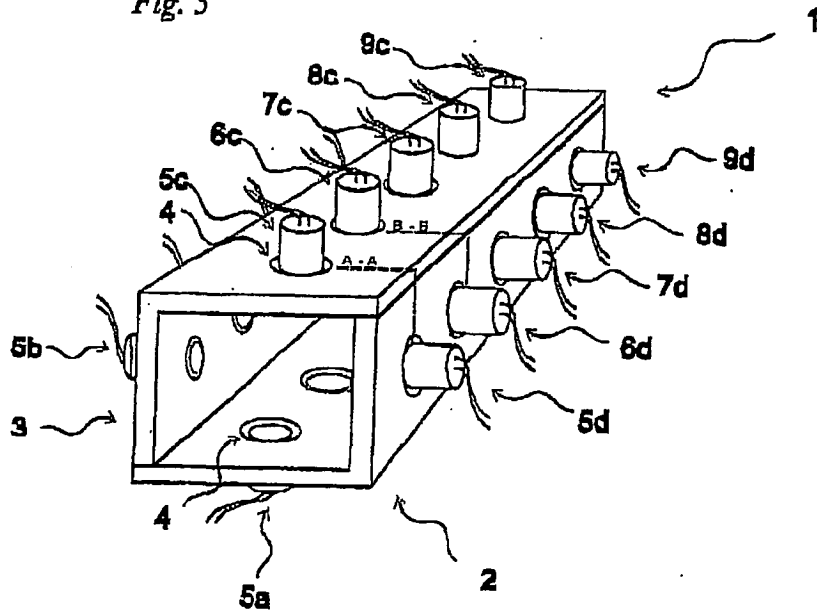


Fig. 5



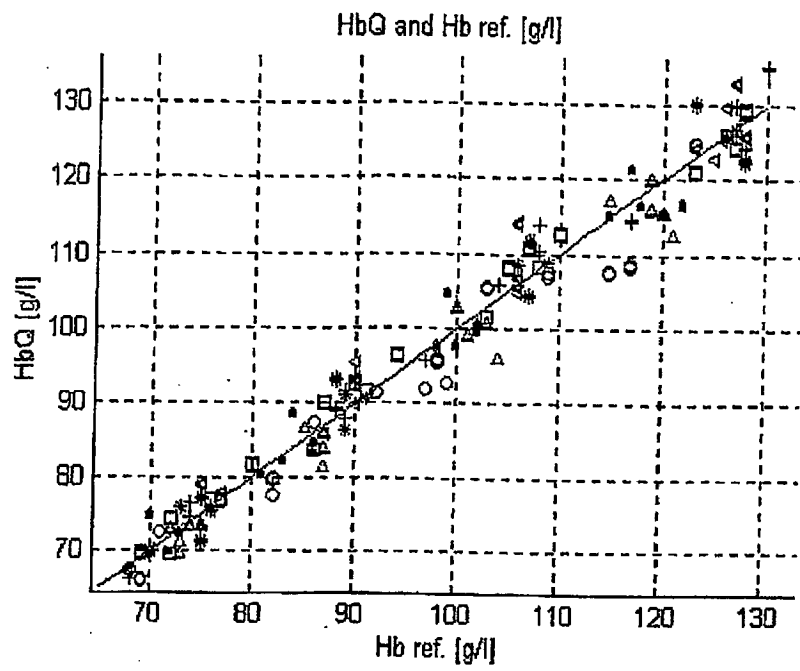


Fig. 6



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 720 013 A2 (CORETECH MEDICAL TECHNOLOGIES [CA]) 3 July 1996 (1996-07-03) * claim 3; figures 2,3 *	1-11	INV. G01N21/53
A	WO 98/59233 A (LUMINEX CORP [US]) 30 December 1998 (1998-12-30) * figures 1,2 *	1-11	
A	US 6 315 955 B1 (KLEIN CORNELIS [NZ]) 13 November 2001 (2001-11-13) * figures 1,2,8,10-13 *	1-11	
A	US 5 757 014 A (BRUNO ALFREDO EMILIO [CH] ET AL) 26 May 1998 (1998-05-26) * figure 6 *	1-11	
A	WO 97/19340 A (CME TELEMATRIX INC [CA]; CADELL THEODORE E [CA]; SAMSOONDAR JAMES [CA]) 29 May 1997 (1997-05-29) * figures 1,2 *	1-11	
A	GB 2 141 553 A (STANDARD TELEPHONES CABLES LTD) 19 December 1984 (1984-12-19) * figures 1-4 *	1-11	TECHNICAL FIELDS SEARCHED (IPC) G01N
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 5 December 2006	Examiner Mason, William
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 06 01 4112

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

05-12-2006

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
EP 0720013	A2	03-07-1996	US	5601080 A	11-02-1997
WO 9859233	A	30-12-1998	AU	8148898 A	04-01-1999
US 6315955	B1	13-11-2001	AT	339680 T	15-10-2006
			AU	719048 B2	04-05-2000
			AU	5293596 A	23-10-1996
			EP	0871858 A1	21-10-1998
			JP	11503236 T	23-03-1999
			NO	974597 A	03-12-1997
			RU	2205382 C2	27-05-2003
			WO	9631764 A1	10-10-1996
US 5757014	A	26-05-1998	CA	2173552 A1	08-10-1996
			EP	0736767 A1	09-10-1996
			JP	8285775 A	01-11-1996
WO 9719340	A	29-05-1997	JP	2000500578 T	18-01-2000
GB 2141553	A	19-12-1984	AU	573254 B2	02-06-1988
			AU	3293984 A	20-03-1986
			CH	670511 A5	15-06-1989
			NO	843551 A	10-03-1986

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 5601080 A [0004]
- US 4745279 A, Karkar [0005]
- US 6493567 B, Krivitski [0005]
- US 6064474 A, Wylie [0005]

专利名称(译)	用于血液测量的装置		
公开(公告)号	EP1748292A1	公开(公告)日	2007-01-31
申请号	EP2006014112	申请日	2003-12-18
[标]申请(专利权)人(译)	OPTOQ		
申请(专利权)人(译)	OPTOQ AB		
当前申请(专利权)人(译)	OPTOQ AB		
[标]发明人	PETTERSON MAGNUS DAHLSTROM ANNA PETTERSON HANS		
发明人	PETTERSON, MAGNUS DAHLSTRÖM, ANNA PETTERSON, HANS		
IPC分类号	G01N21/53 A61B5/00 G01N15/00 G01N15/02 G01N21/05		
CPC分类号	A61B5/14535 A61B5/14557 G01N15/0211 G01N21/05 G01N21/53 G01N2015/0065		
优先权	0203868 2002-12-20 SE 0203869 2002-12-20 SE		
外部链接	Espacenet		

摘要(译)

探针或探测器装置包括两个基本上为V形的型材，在其壁中布置有引线和传感器。夹在V形型材中的管子接收方形横截面。光源和传感器布置在平坦表面上，使得管的壁变得基本平坦，其中LED和传感器位于其中。一种适于测量血液中血细胞密度的传感器装置，其中提供光发射器和检测器，其中一些感测扇区不与来自光源的入射光束相交。

Fig. 1

