Docket Nos.: A0130.0113.C11
9591USC13

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Phillip Yee et al.

Application No.: Not yet assigned

Confirmation No.: Not yet assigned

Filed: April 2, 2021

Art Unit: Not yet assigned

For: ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR

Examiner: Not yet assigned

PRELIMINARY AMENDMENT

EFS Web
Commissioner for Patents

INTRODUCTORY COMMENTS

Prior to examination, please amend the application as follows:

Amendments to the Claims beginning on page 2 of this paper; and

Remarks beginning on page 9 of this paper.

DEXCOM
EXHIBIT 1002

ABSTRACT

An apparatus for insertion of a medical device in the skin of a subject is provided.

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	A0130.0113.C11
	Application Number	
Title of Invention	ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
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Residence Information (Select One) ● US Residency Non US Residency Active US Military Service

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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	A0130.0113.C11
	Application Number	
Title of Invention	ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR	

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Inventor 5 — Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	Michael	R.	Love	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Pleasanton	State/Province	CA	Country of Residence	US

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State/Province	CA
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Country	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. — Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	A0130.0113.C11
	Application Number	
Title of Invention	ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR	

Customer Number	95508		
Email Address	ipdocketing@onellp.com	Add Email	Remove Email

Application Information:

Title of the Invention	ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR		
Attorney Docket Number	A0130.0113.C11	**Small Entity Status Claimed**	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	29	**Suggested Figure for Publication (if any)**	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	● Customer Number	US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	95508		

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	A0130.0113.C11
	Application Number	
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Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)	
	Continuation of	17009647	2020-09-01	

Prior Application Status	Patented			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)	
17009647	Continuation of	16736728	2020-01-07	

Prior Application Status	Abandoned			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)	
16736728	Continuation of	15994129	2018-05-31	

Prior Application Status	Patented			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)	
15994129	Continuation of	15475647	2017-03-31	

Prior Application Status	Patented			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)	
15475647	Continuation of	15192531	2016-06-24	

Prior Application Status	Patented			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)	
15192531	Continuation of	12698129	2010-02-01	

Prior Application Status	Expired			Remove
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)	
12698129	Claims benefit of provisional	61149639	2009-02-03	

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	A0130.0113.C11
	Application Number	
Title of Invention	ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR	

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

Application Number	Country[i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	A0130.0113.C11
	Application Number	
Title of Invention	ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

PTO/AIA/14 (02-18)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	A0130.0113.C11
	Application Number	
Title of Invention	ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR	

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Applicant 1 — Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

● Assignee	Legal Representative under 35 U.S.C. 117	Joint Inventor
Person to whom the inventor is obligated to assign.	Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor:

If the Applicant is an Organization check here. ☒

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Country	US	Postal Code	94502
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Approved for use through 11/30/2020. OMB 0651-0032
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	A0130.0113.C11
	Application Number	
Title of Invention	ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR	

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

Remove

If the Assignee or Non-Applicant Assignee is an Organization check here. ☐

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information For Assignee including Non-Applicant Assignee:

Address 1			
Address 2			
City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee or Non-Applicant Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

Remove

NOTE: This Application Data Sheet must be signed in accordance with 37 CFR 1.33(b). **However, if this Application Data Sheet is submitted with the INITIAL filing of the application and either box A or B is not checked in subsection 2 of the "Authorization or Opt-Out of Authorization to Permit Access" section, then this form must also be signed in accordance with 37 CFR 1.14(c).**

This Application Data Sheet **must** be signed by a patent practitioner if one or more of the applicants is a **juristic entity** (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, **all** joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of **all** joint inventor-applicants.

See 37 CFR 1.4(d) for the manner of making signatures and certifications.

Signature	/Glen Liu/			Date (YYYY-MM-DD)	2021-04-02
First Name	Glen	Last Name	Liu	Registration Number	75058

Additional Signature may be generated within this form by selecting the Add button. Add

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	A0130.0113.C11
	Application Number	
Title of Invention	ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR	

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1 The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.

2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3 A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent CooperationTreaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

AMENDMENTS TO THE CLAIMS

This listing of claims replaces all previous versions of the claims in the application.

1-20. (Canceled)

21. (New) An insertion assembly, comprising:

(a) an on-body unit, comprising:

a housing comprising a top surface and a bottom surface, wherein the top surface comprises an opening of the top surface, wherein the bottom surface comprises an opening of the bottom surface, and wherein a longitudinal axis extends through the opening of the top surface and the opening of the bottom surface;

a glucose sensor; and

sensor electronics disposed within the housing and coupled with the glucose sensor; and

(b) an inserter, comprising:

a proximal end, a distal end, and an interior; and

a sharp,

wherein the on-body unit and the sharp are entirely disposed in the interior of the inserter,

wherein at least a portion of the glucose sensor is disposed in the sharp,

wherein the inserter is configured to advance the on-body unit and the sharp in a linear direction from a first position to a second position such that the sharp pierces skin of a user and the housing of the on-body unit is secured to the skin of the user in the second position,

wherein the sharp extends through the opening of the top surface and the opening of the bottom surface along the longitudinal axis when the on-body unit is in the first position,

wherein the distal end of the inserter is configured to be positioned on the skin of the user before advancement of the on-body unit and the sharp,

wherein the inserter is further configured to automatically retract the sharp from within the user and entirely into the interior of the inserter and leave a part of the glucose sensor in the skin of the user, and

wherein the distal end of the inserter is further configured to be removed from the skin of the user after automatic retraction of the sharp from within the user.

22. (New) The insertion assembly of claim 21, further comprising an adhesive portion configured to secure the housing to the skin of the user, wherein the adhesive portion is further configured to extend outwardly beyond the bottom surface of the housing along the skin in all directions when the housing is secured to the skin of the user.

23. (New) The insertion assembly of claim 22, wherein a distance between the housing when the on-body unit is in the first position and the housing when the on-body unit is in the second position is greater than a maximum height of the housing.

24. (New) The insertion assembly of claim 23, wherein the sensor electronics comprise a processor, a power source, an analog interface, a data storage unit, and wireless communication circuitry configured to communicate data indicative of a glucose level.

25. (New) The insertion assembly of claim 23, wherein the sharp is configured to pierce the skin of the user at an angle substantially perpendicular to the skin of the user.

26. (New) The insertion assembly of claim 23, wherein the on-body unit further comprises a side wall of the housing, wherein the side wall is located between the top surface and the bottom surface, wherein the side wall comprises a first portion and a second portion, and wherein the second portion of the side wall defines a non-orthogonal angle relative to both the first portion of the side wall and the top surface of the housing.

27. (New) The insertion assembly of claim 23, wherein the sensor electronics are in a sleep mode or an idle mode when the on-body unit is in the first position.

28. (New) The insertion assembly of claim 23, wherein the sensor electronics are configured to be activated when the on-body unit is at or near the second position.

29. (New) The insertion assembly of claim 23, wherein the sensor electronics further comprise an opening of the sensor electronics along the longitudinal axis, and wherein the sharp extends through the opening of the sensor electronics when the on-body unit is in the first position.

30. (New) The insertion assembly of claim 23, wherein the proximal end of the inserter comprises an inserter handle, wherein the distal end of the inserter comprises an inserter base, and wherein the inserter handle is configured to move in a downward direction toward the skin of the user relative to the inserter base in response to an application of force on the inserter handle.

31. (New) The insertion assembly of claim 30, wherein the inserter is configured to advance the on-body unit and the sharp from the first position to the second position after the application of force on the inserter handle.

32. (New) The insertion assembly of claim 23, further comprising a cap removably attached to a distal portion of the inserter by a plurality of threads, and wherein the cap comprises an interior space comprising a sterile environment.

33. (New) The insertion assembly of claim 32, wherein the cap further comprises a plurality of vertically extending grooves spaced apart around an outer perimeter surface of the cap.

34. (New) The insertion assembly of claim 23, wherein a height profile of the housing is less than or equal to approximately 10 millimeters.

35. (New) The insertion assembly of claim 23, further comprising a sensor hub,
wherein the glucose sensor comprises a distal sensor portion and a proximal sensor portion,
wherein the distal sensor portion is configured to sense a glucose level of the user,
wherein the proximal sensor portion is engaged with the sensor hub, and

wherein the distal sensor portion is substantially orthogonal to the proximal sensor portion.

36. (New) The insertion assembly of claim 23, wherein the distal end of the inserter defines a plane, and wherein the bottom surface of the housing is parallel to the plane when the on-body unit is in the first position.

37. (New) The insertion assembly of claim 22, wherein the opening of the top surface is a first opening of the top surface, wherein the top surface further comprises a second opening of the top surface, wherein the first opening of the top surface has a first maximum width, and wherein the second opening of the top surface has a second maximum width less than the first maximum width.

38. (New) The insertion assembly of claim 23, wherein the on-body unit is configured to be disposed after a single use.

39. (New) An insertion assembly, comprising:

(a) an on-body unit, comprising:

a housing comprising a top surface and a bottom surface, wherein the top surface comprises an opening of the top surface, wherein the bottom surface comprises an opening of the bottom surface, and wherein a longitudinal axis extends through the opening of the top surface and the opening of the bottom surface;

a glucose sensor; and

sensor electronics disposed within the housing and coupled with the glucose sensor, wherein the sensor electronics comprise a processor, a power source, an analog interface, a data storage unit, and wireless communication circuitry configured to communicate data indicative of a glucose level; and

(b) an inserter, comprising:

a proximal end, a distal end, and an interior; and

a sharp;

wherein the on-body unit and the sharp are entirely disposed in the interior of the inserter,

wherein at least a portion of the glucose sensor is disposed in the sharp,

wherein the inserter is configured to advance the on-body unit and the sharp in a linear direction from a first position to a second position such that the sharp pierces skin of a user and the housing of the on-body unit is secured to the skin of the user in the second position,

wherein a distance between the housing when the on-body unit is in the first position and the housing when the on-body unit is in the second position is greater than a maximum height of the housing,

wherein a height profile of the housing is less than or equal to approximately 10 millimeters,

wherein the sharp is configured to pierce the skin of the user at an angle substantially perpendicular to the skin of the user,

wherein the sharp extends through the opening of the top surface and the opening of the bottom surface along the longitudinal axis when the on-body unit is in the first position,

wherein the distal end of the inserter is configured to be positioned on the skin of the user before advancement of the on-body unit and the sharp,

wherein the inserter is further configured to automatically retract the sharp from within the user and entirely into the interior of the inserter and leave a part of the glucose sensor in the skin of the user, and

wherein the distal end of the inserter is further configured to be removed from the skin of the user after automatic retraction of the sharp from within the user.

40. (New) The insertion assembly of claim 39, further comprising an adhesive portion configured to secure the housing to the skin of the user, wherein the adhesive portion is configured to extend outwardly beyond the bottom surface of the housing along the skin in all directions when the housing is secured to the skin of the user.

41. (New) The insertion assembly of claim 40, wherein the opening of the top surface is a first opening of the top surface, wherein the top surface further comprises a second opening of the

top surface, wherein the first opening of the top surface has a first maximum width, and wherein the second opening of the top surface has a second maximum width less than the first maximum width.

42. (New) The insertion assembly of claim 41, wherein the sensor electronics further comprise an opening of the sensor electronics along the longitudinal axis, and wherein the sharp extends through the opening of the sensor electronics when the on-body unit is in the first position.

43. (New) The insertion assembly of claim 42, wherein the distal end of the inserter defines a plane, and wherein the bottom surface of the housing is parallel to the plane when the on-body unit is in the first position.

44. (New) The insertion assembly of claim 43, wherein the proximal end of the inserter comprises an inserter handle, wherein the distal end of the inserter comprises an inserter base, wherein the inserter handle is configured to move in a downward direction toward the skin of the user relative to the inserter base in response to an application of force on the inserter handle, and wherein the inserter is configured to advance the on-body unit and the sharp from the first position to the second position after the application of force on the inserter handle.

45. (New) The insertion assembly of claim 43, wherein the sensor electronics are in a sleep mode or an idle mode when the on-body unit is in the first position.

46. (New) The insertion assembly of claim 43, wherein the sensor electronics are configured to be activated when the on-body unit is at or near the second position.

47. (New) The insertion assembly of claim 43, wherein the on-body unit further comprises a side wall of the housing, wherein the side wall is located between the top surface and the bottom surface, wherein the side wall comprises a first portion and a second portion, and wherein the second portion of the side wall defines a non-orthogonal angle relative to both the first portion of the side wall and the top surface of the housing.

48. (New) The insertion assembly of claim 43, further comprising a sensor hub,
wherein the glucose sensor comprises a distal sensor portion and a proximal sensor portion,
wherein the distal sensor portion is configured to sense a glucose level of the user,
wherein the proximal sensor portion is engaged with the sensor hub, and
wherein the distal sensor portion is substantially orthogonal to the proximal sensor portion.

49. (New) The insertion assembly of claim 43, further comprising a cap removably attached to a distal portion of the inserter by a plurality of threads, and wherein the cap comprises an interior space comprising a sterile environment.

50. (New) The insertion assembly of claim 49, wherein the cap further comprises a plurality of vertically extending grooves spaced apart around an outer perimeter surface of the cap.

WHAT IS CLAIMED IS:

1. A sensor comprising:

a body having a proximal section, a distal section longitudinally aligned with the proximal section, and an intermediate section,

wherein the intermediate section is laterally displaced from at least the distal member and a notch is defined between the laterally displaced intermediate section and a portion of the distal section.

2. The sensor of claim 1, wherein the intermediate section is laterally displaced from at least a portion of the proximal section of the sensor body.

3. The sensor of claim 2, wherein a gap is defined between the laterally displaced intermediate section and the proximal section of the sensor body.

4. The sensor of claim 1, wherein the intermediate section has a distal end and a proximal end, and further wherein the proximal section is coupled to the proximal section and the distal section is coupled to the distal section of the sensor body.

5. The sensor of claim 4, wherein the intermediate section is a longitudinal member.

6. The sensor of claim 1, wherein the distal section has a proximal end and a distal end.

7. The sensor of claim 6, wherein the proximal end is proximate to the notch defined between the distal member and the intermediate member.

8. The sensor of claim 7, wherein the proximal end is received within a needle seat to create an anchor region to allow the sensor body to slide into a slot defined in the insertion needle but prevent the sensor body from slipping out of the insertion needle.

9. The sensor of claim 8, wherein a width of the distal section of the sensor body has a width sized to fit within the slot of the insertion sharp having a diameter less than about 22 to about 26 gauge.

10. The sensor of claim 1, wherein the intermediate member includes a bendable portion.

11. The sensor of claim 10 wherein the bendable portion allows the proximal section of the sensor body to be in a plane different than the distal section of the sensor body.

12. The sensor of claim 11, wherein the proximal section and the distal section are in planes perpendicular to each other.

13. The sensor of claim 1, wherein the proximal section has a curved portion.

14. The sensor of claim 1, wherein sensor is configured in a bent configuration.

15. The sensor of claim 1, wherein the sensor body includes conductive material disposed on a surface thereto to define one or more electrodes.

16. The sensor of claim 1, wherein the sensor body 15 includes conductive material defining traces disposed on a surface of the sensor body.

17. The sensor of claim 16, wherein the traces are in communication with the one or more electrodes.

18. The sensor of claim 16, wherein the traces are disposed on at least surface of the proximal section of the sensor body.

19. The sensor of claim 17, wherein the one or more electrodes are disposed on the distal section of the sensor body.

20. The sensor of claim 17, wherein at least one of the traces or electrodes comprise gold.

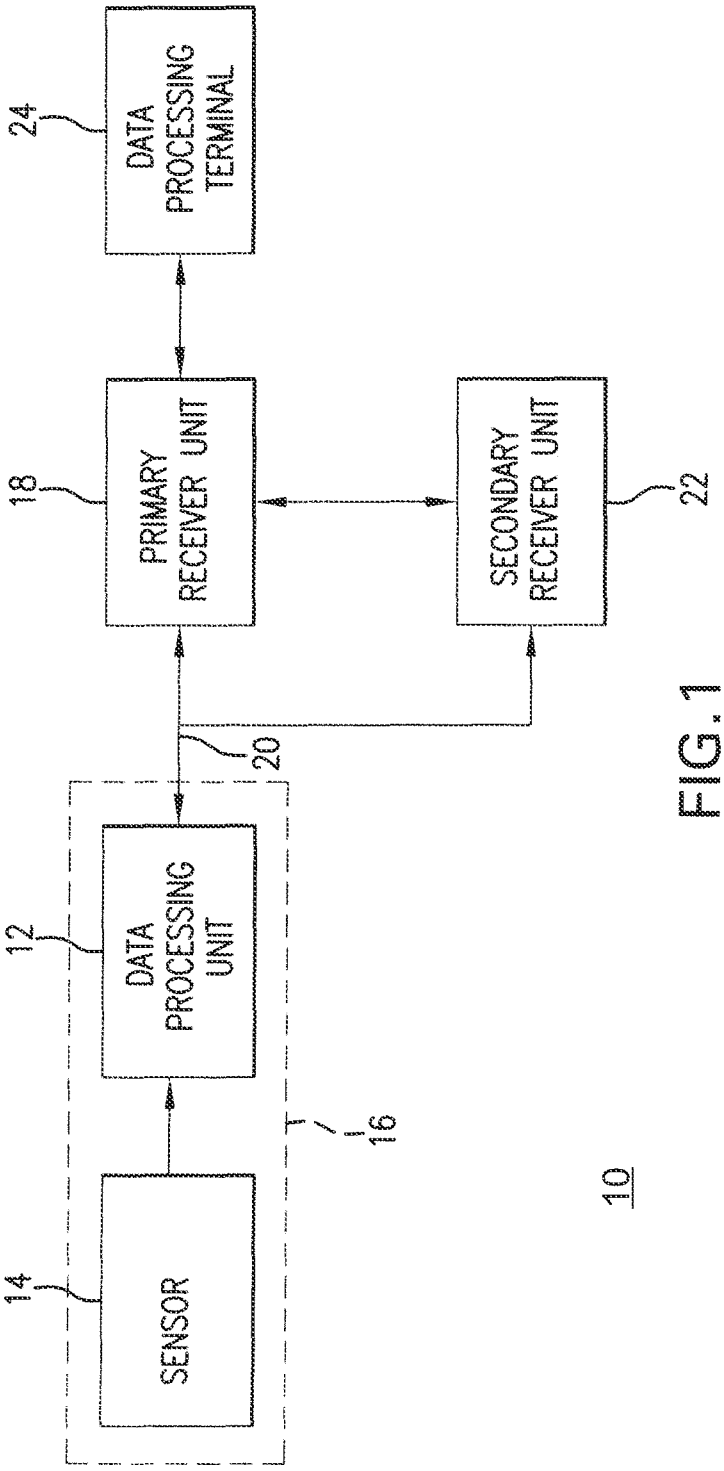

DATA PROCESSING TERMINAL
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PRIMARY RECEIVER UNIT
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SECONDARY RECEIVER UNIT
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DATA PROCESSING UNIT
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16
SENSOR
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FIG. 1

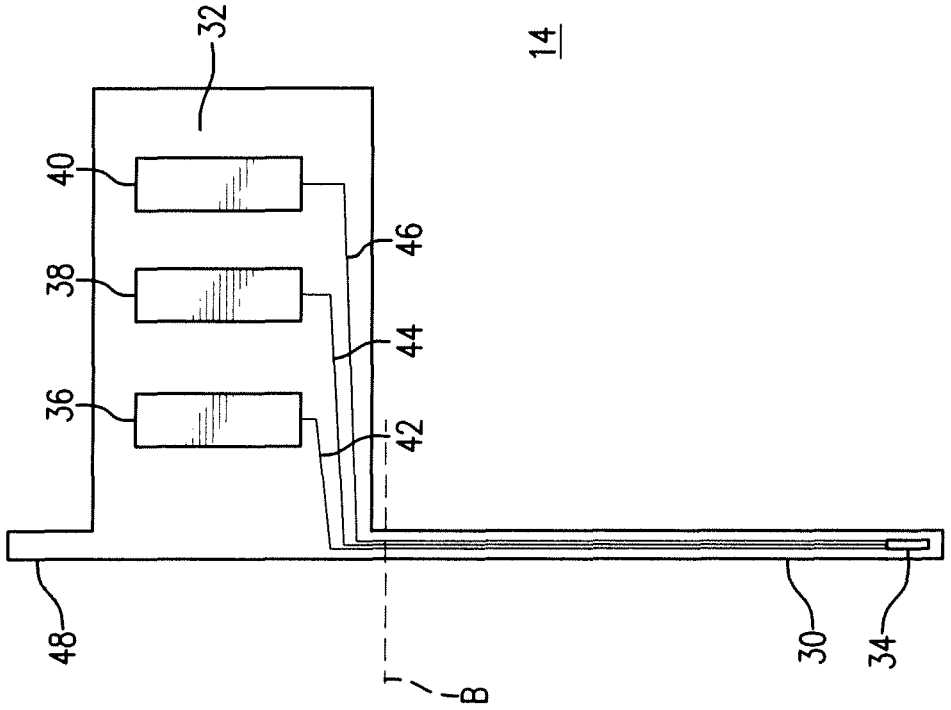


FIG.2

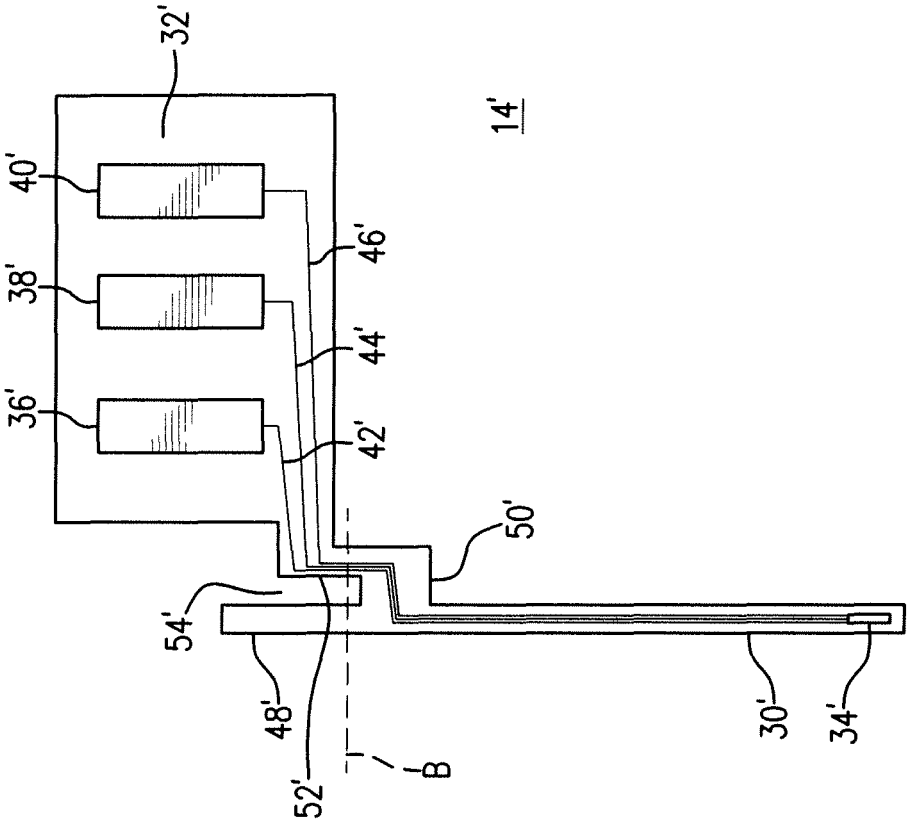


FIG.3

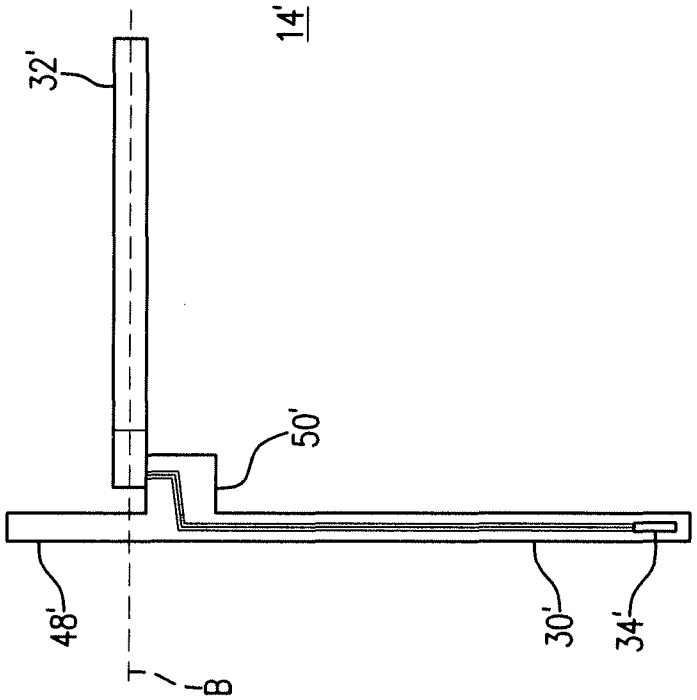


FIG.4

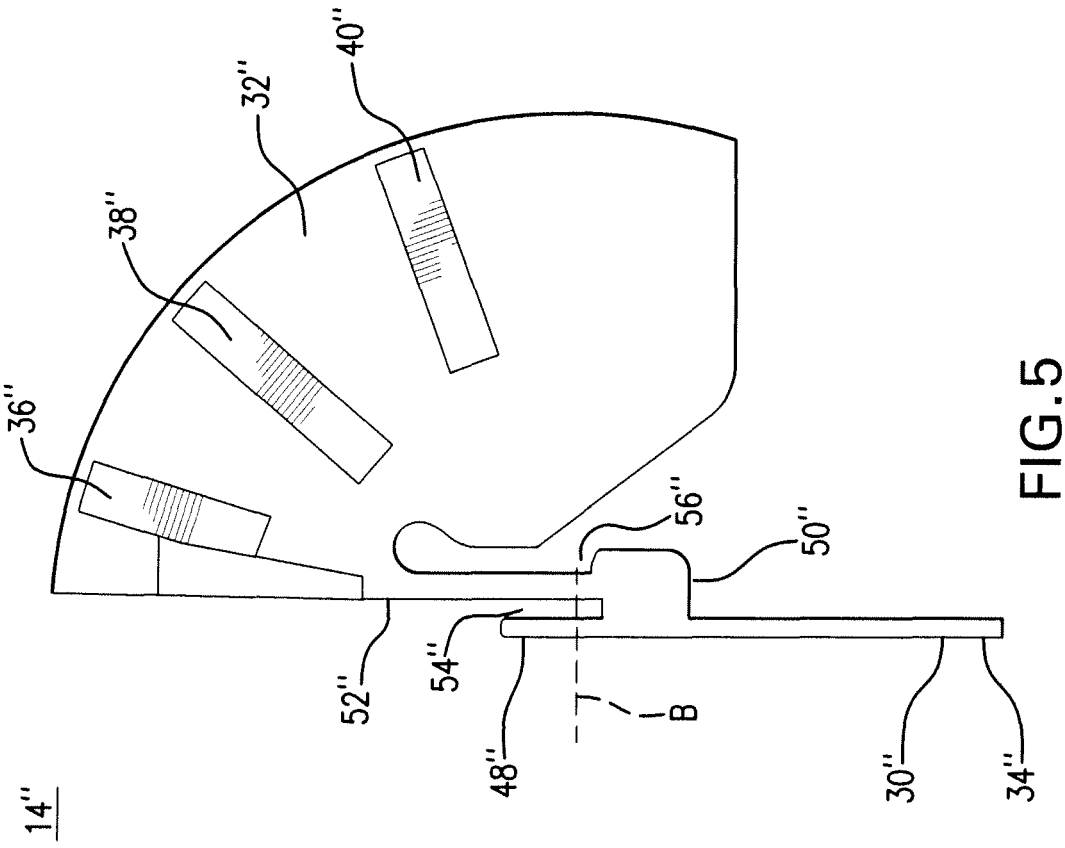


FIG.5

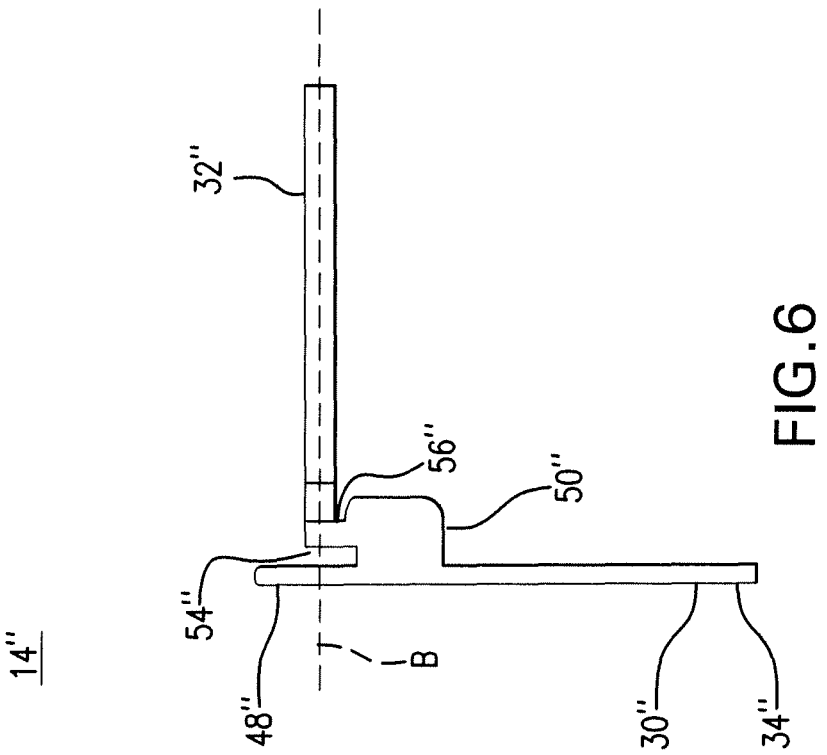


FIG.6

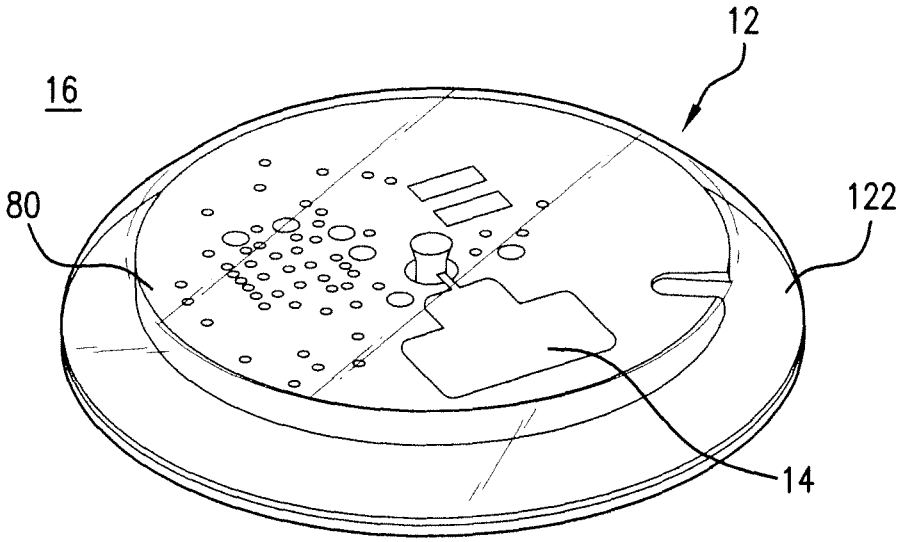


FIG.7

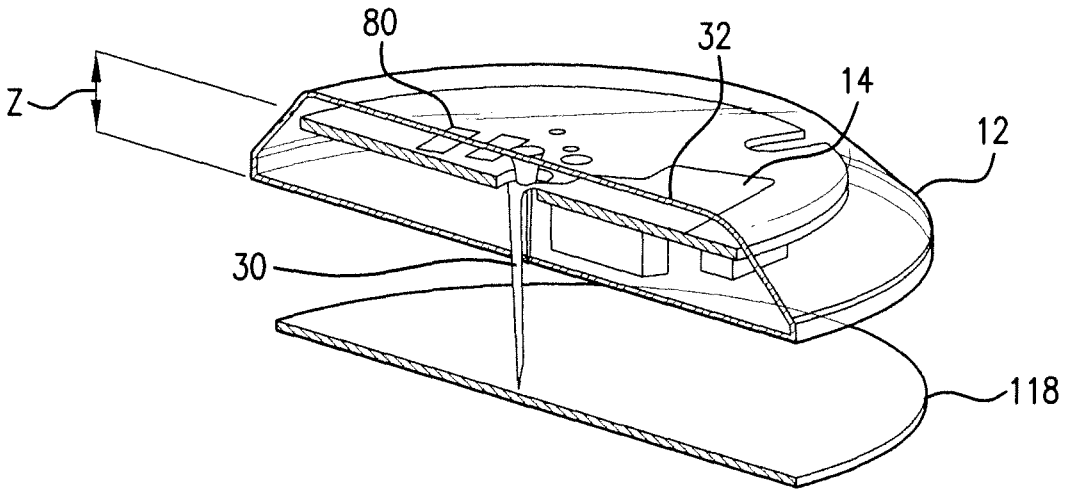


FIG.8

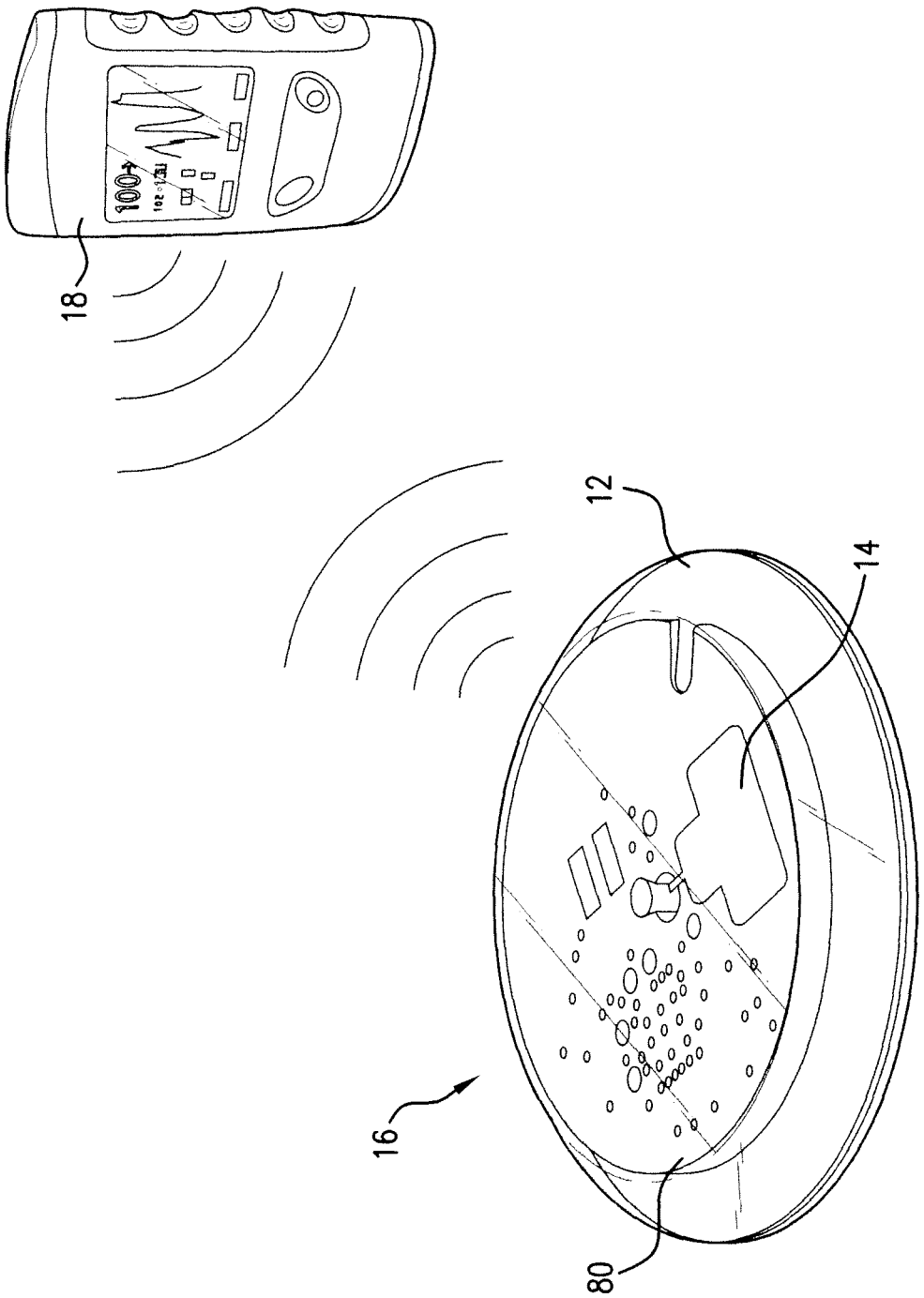


FIG.9

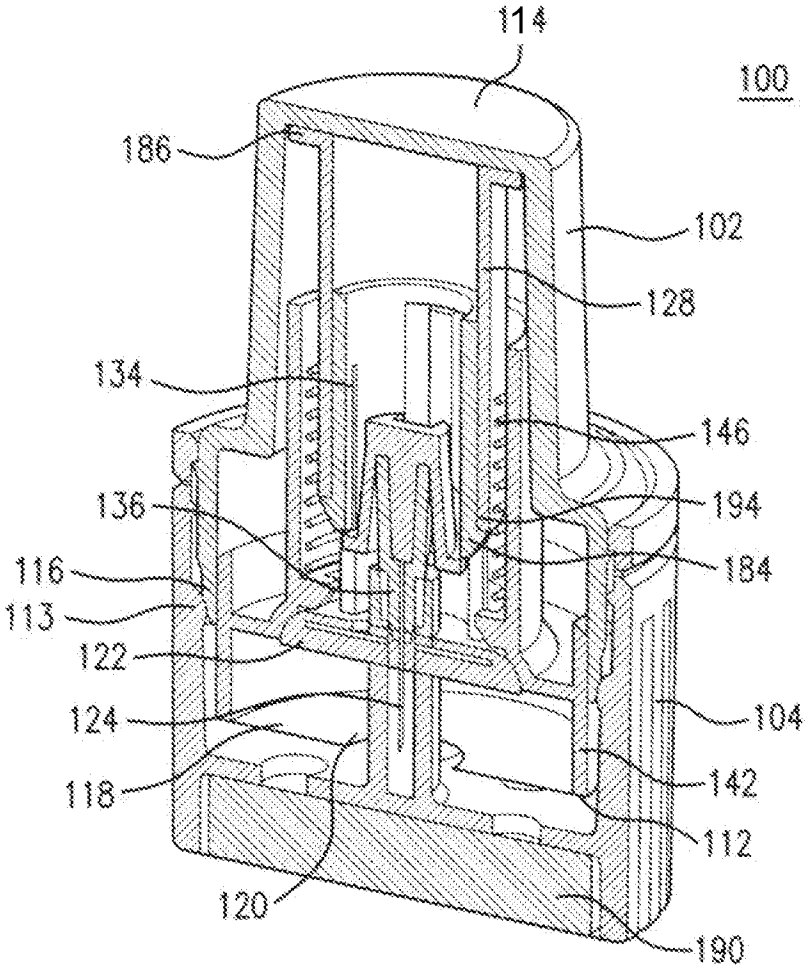

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FIG. 10

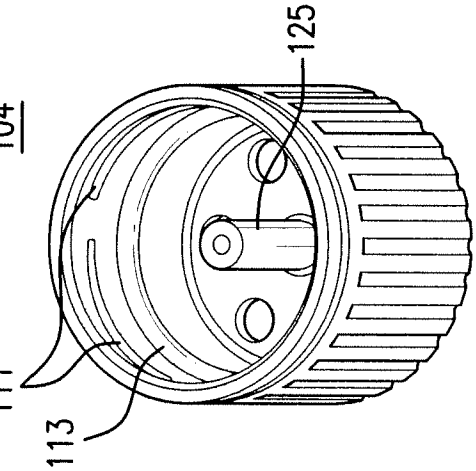


FIG. 12

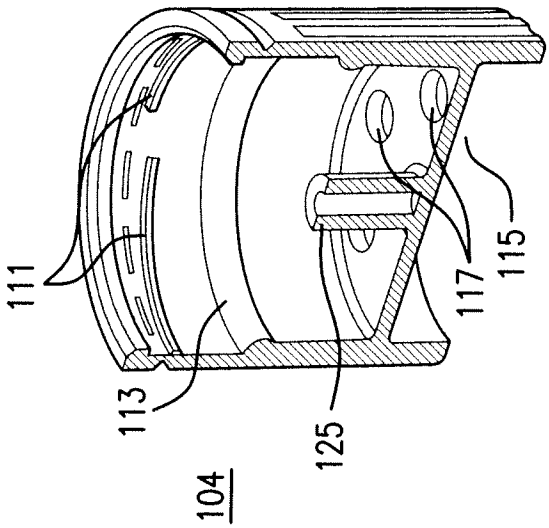


FIG. 13

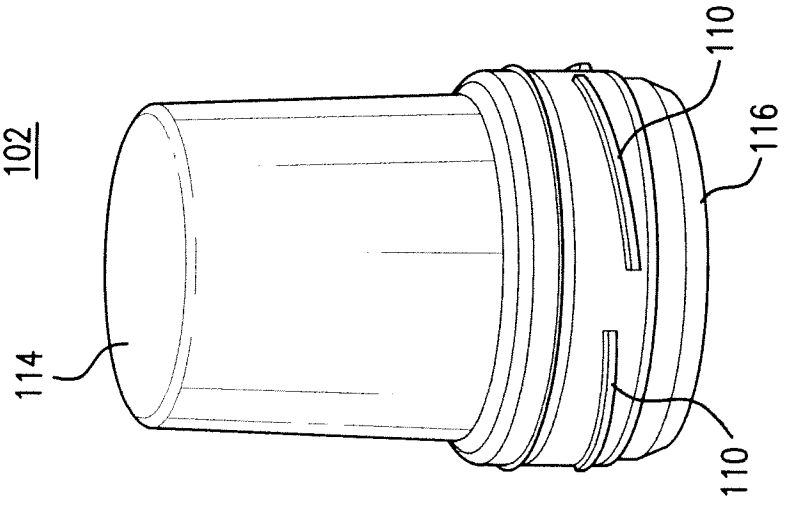


FIG. 11

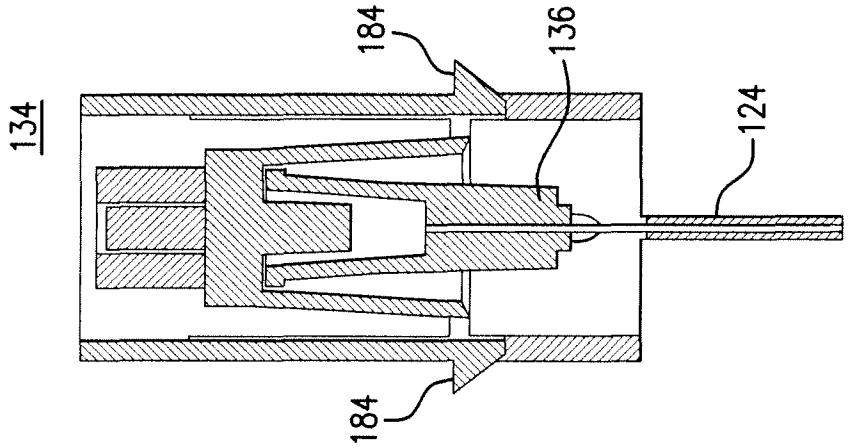


FIG.16

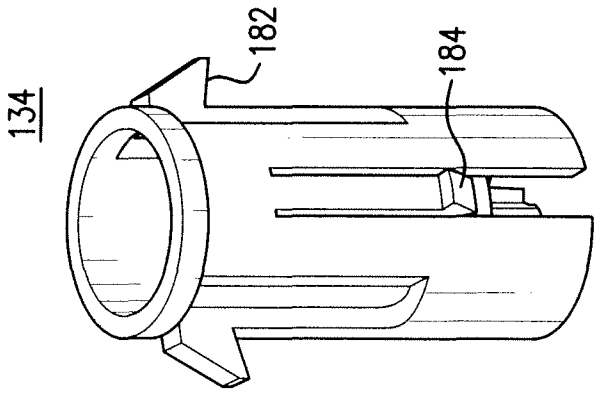


FIG.15

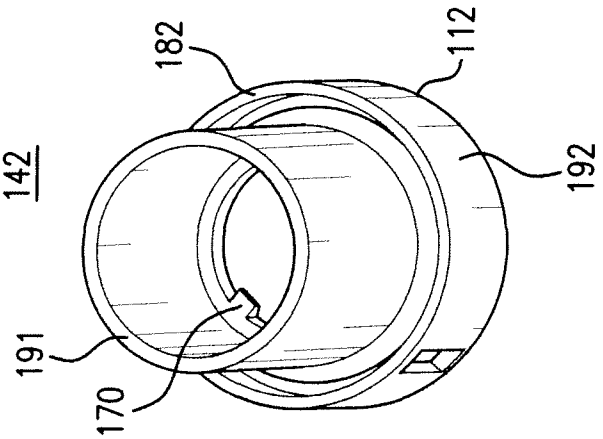


FIG.14

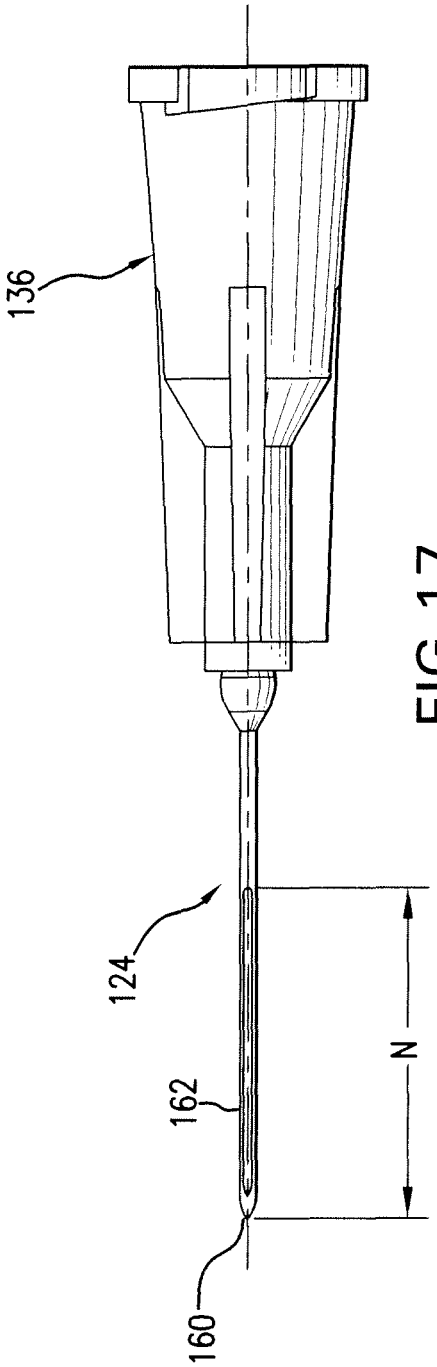


FIG. 17

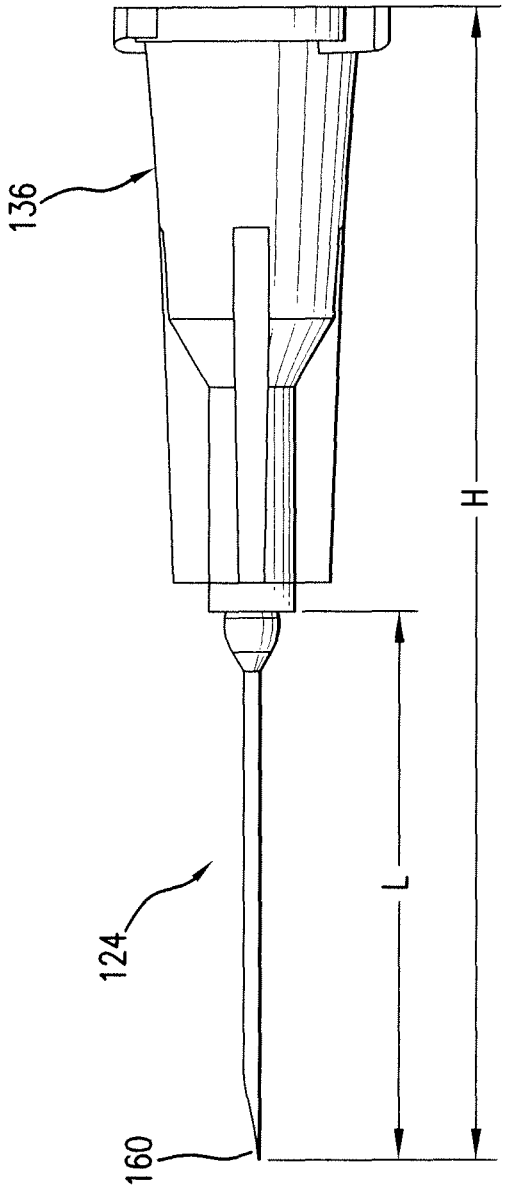


FIG. 18

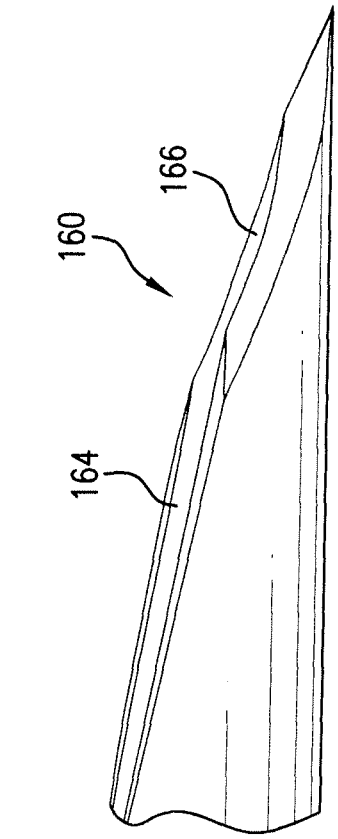


FIG.20

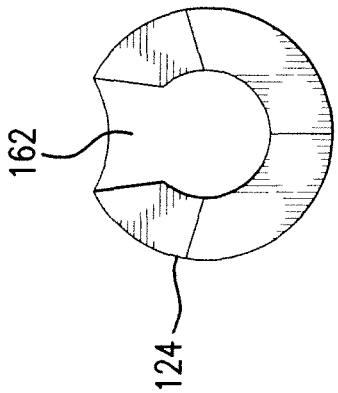


FIG.19

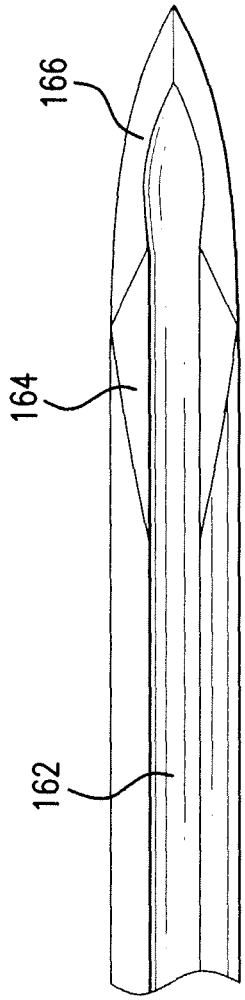


FIG.21

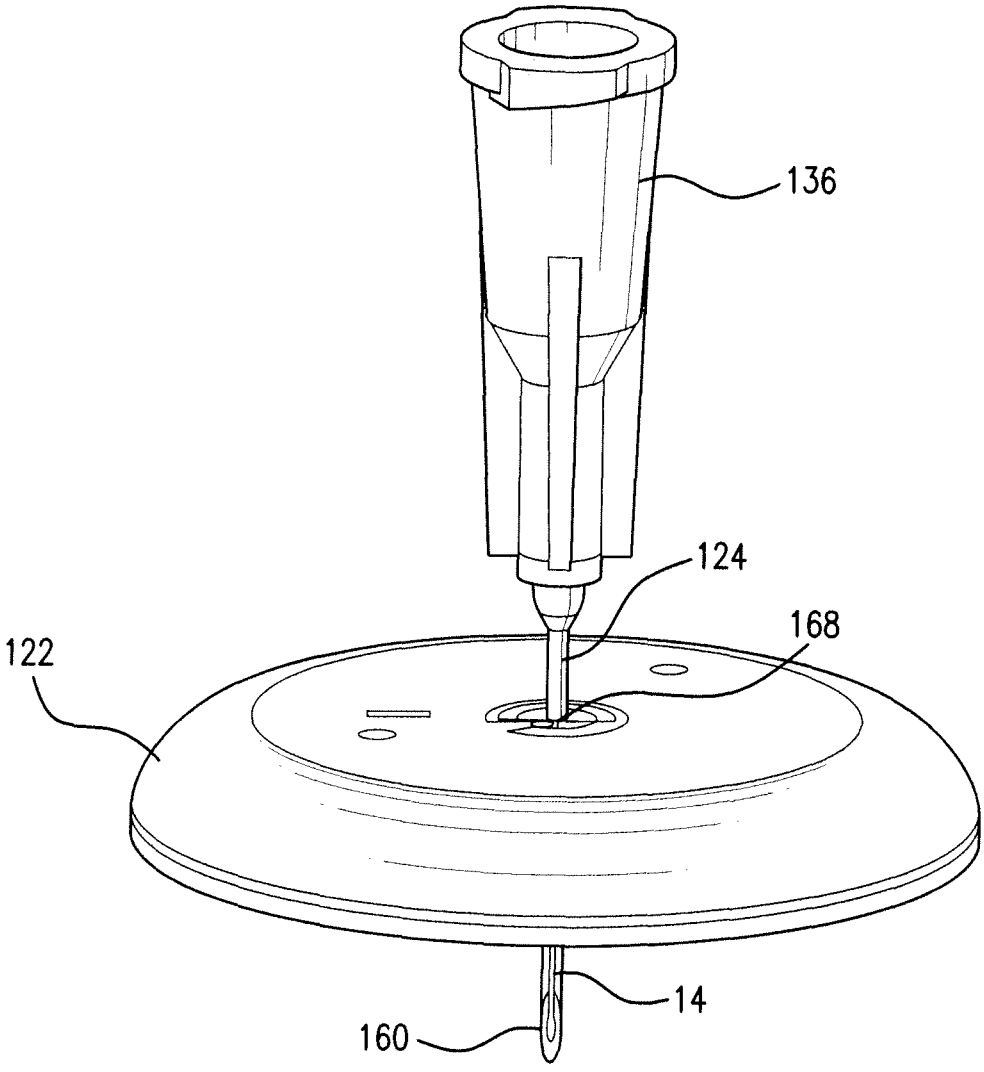


FIG.22

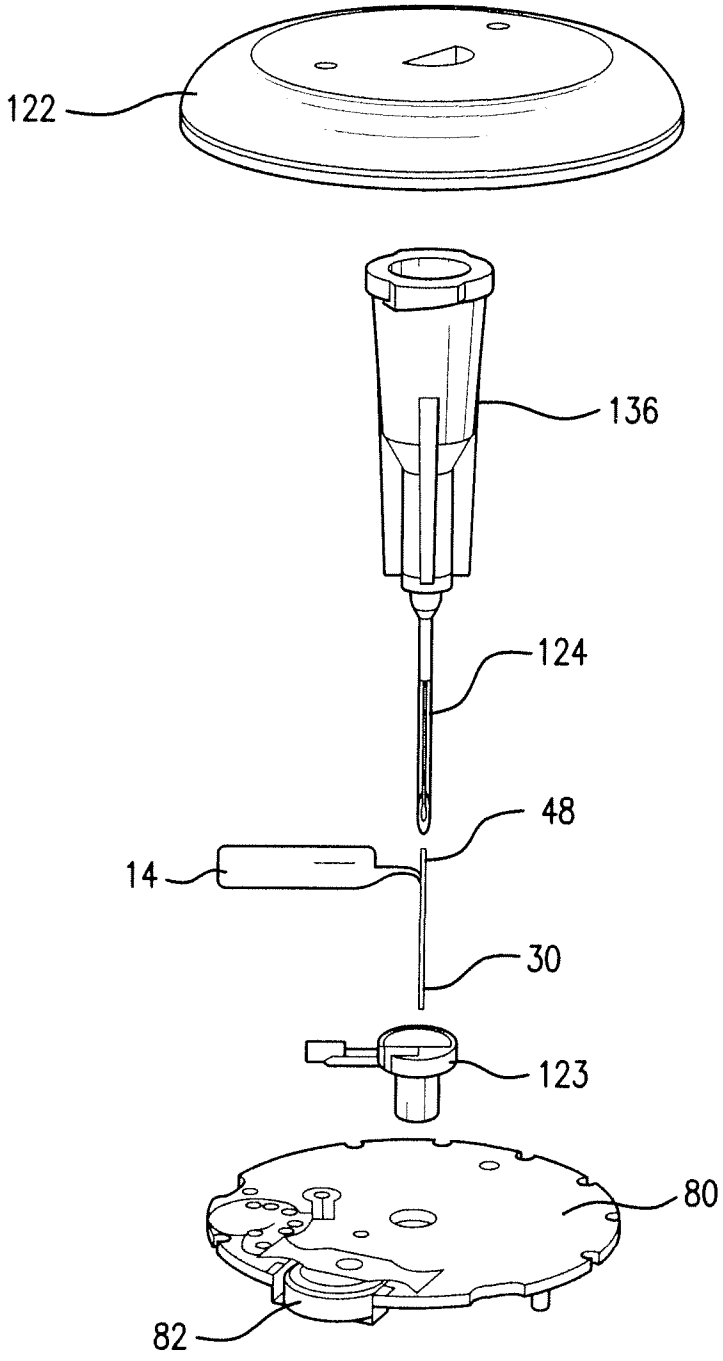


FIG.23

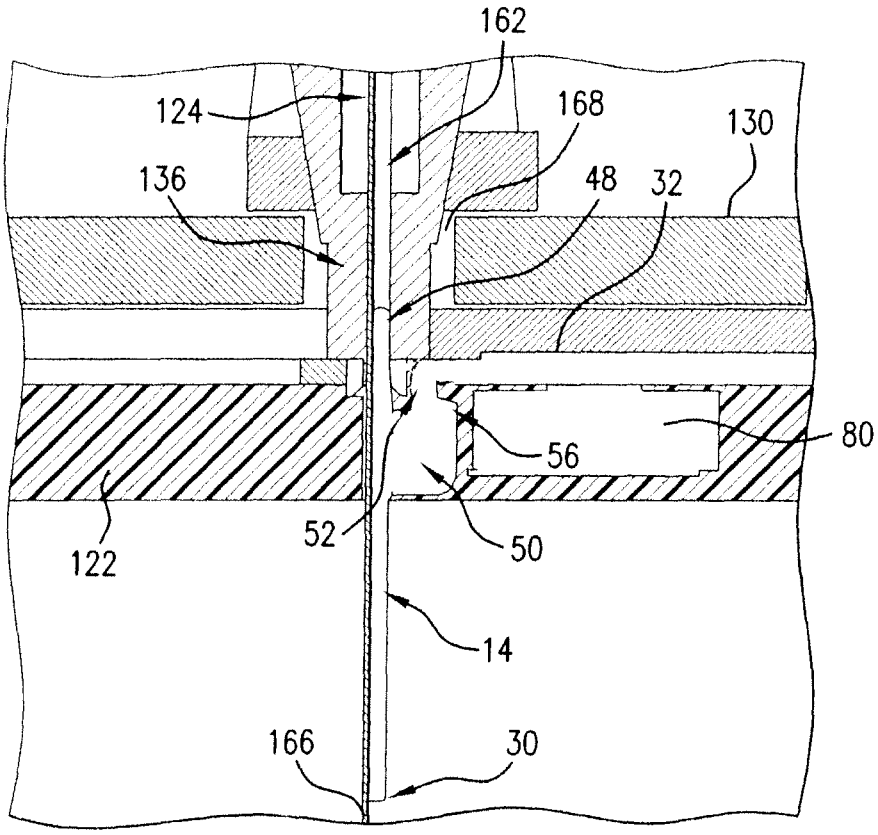


FIG.24

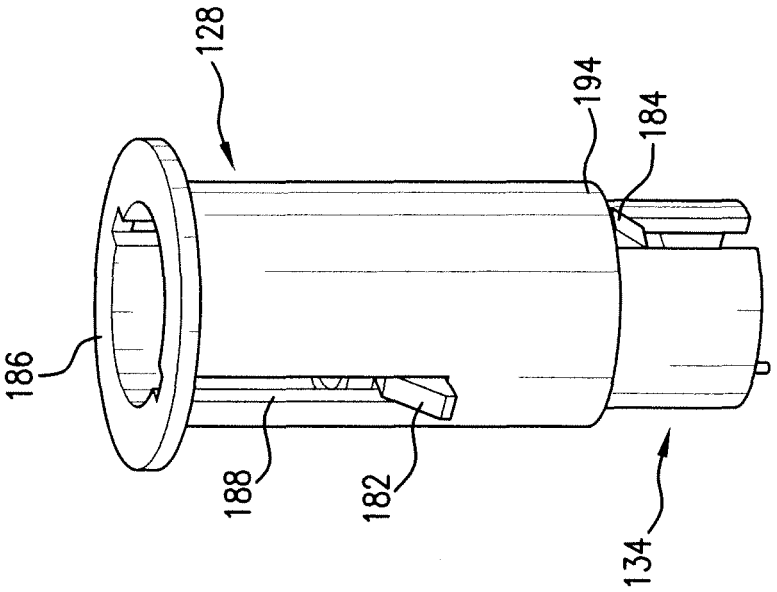


FIG.26

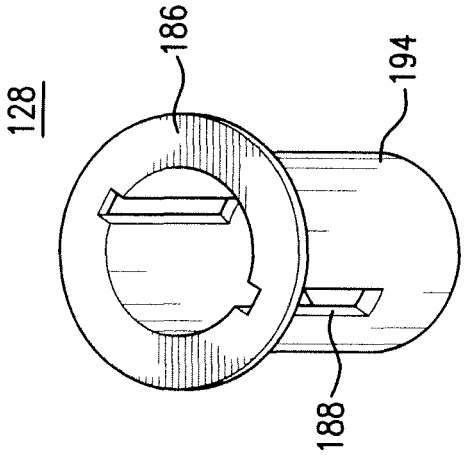


FIG.25

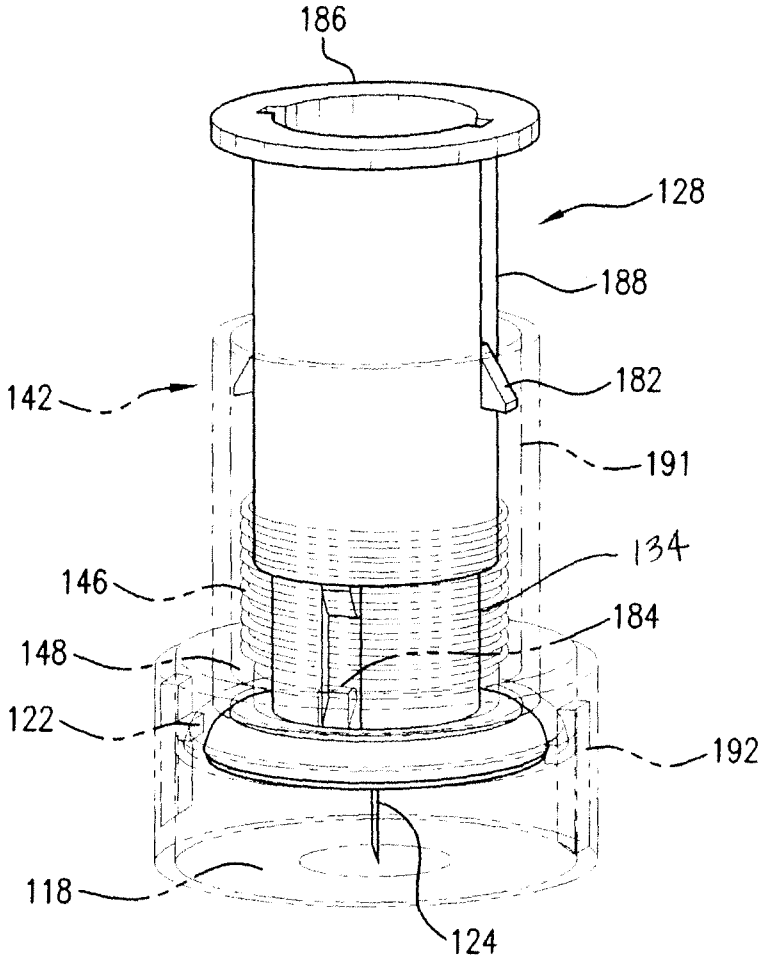


FIG.27

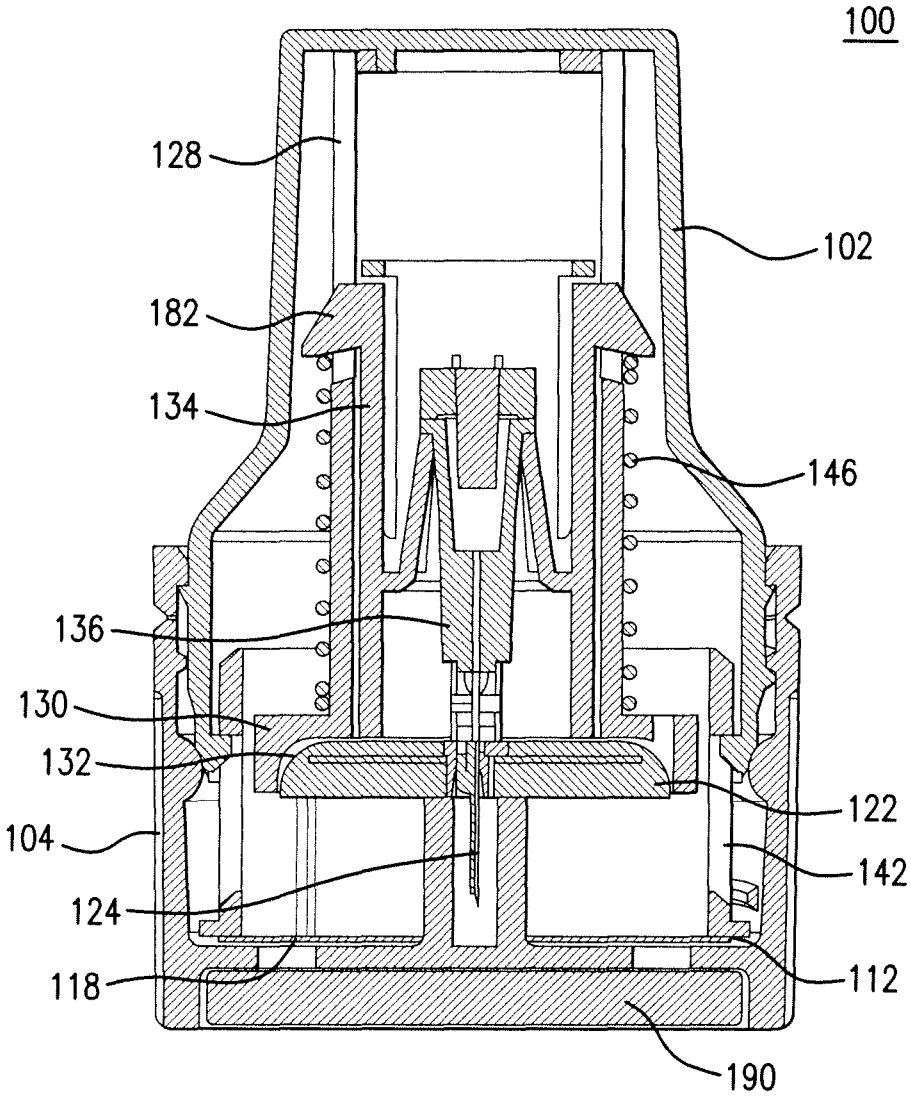


FIG.28

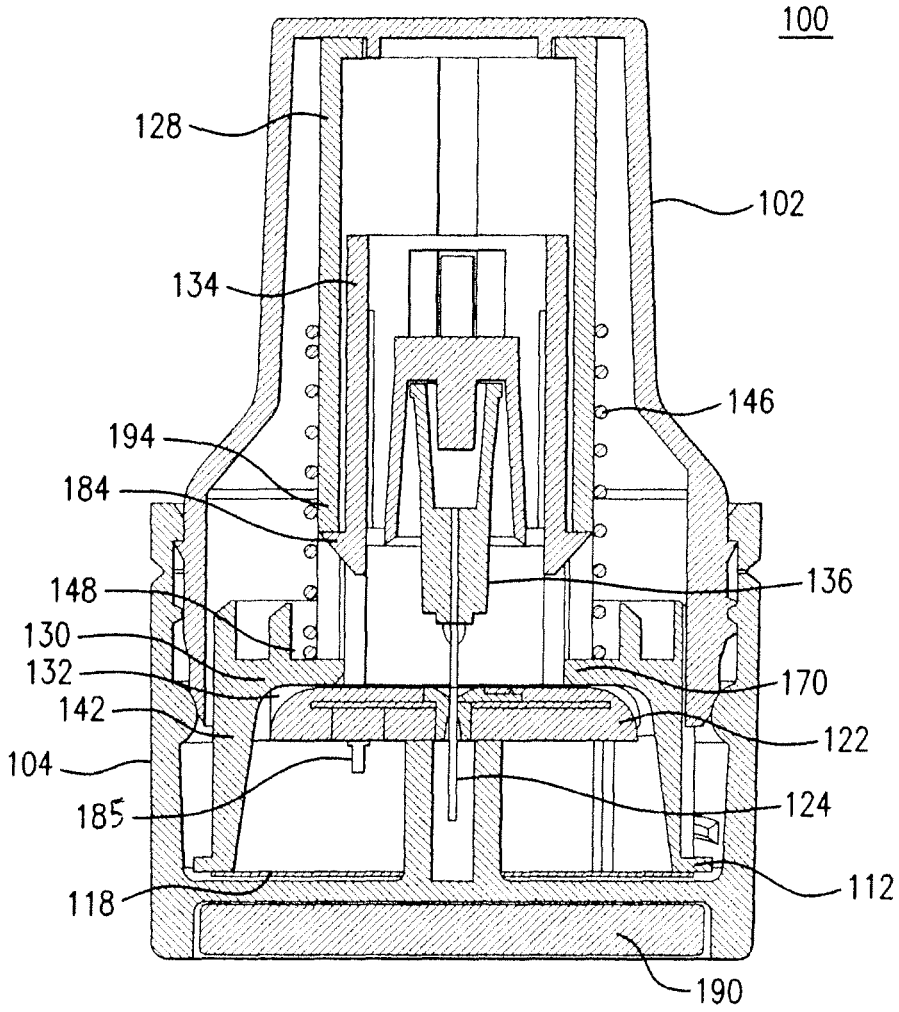

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FIG.29

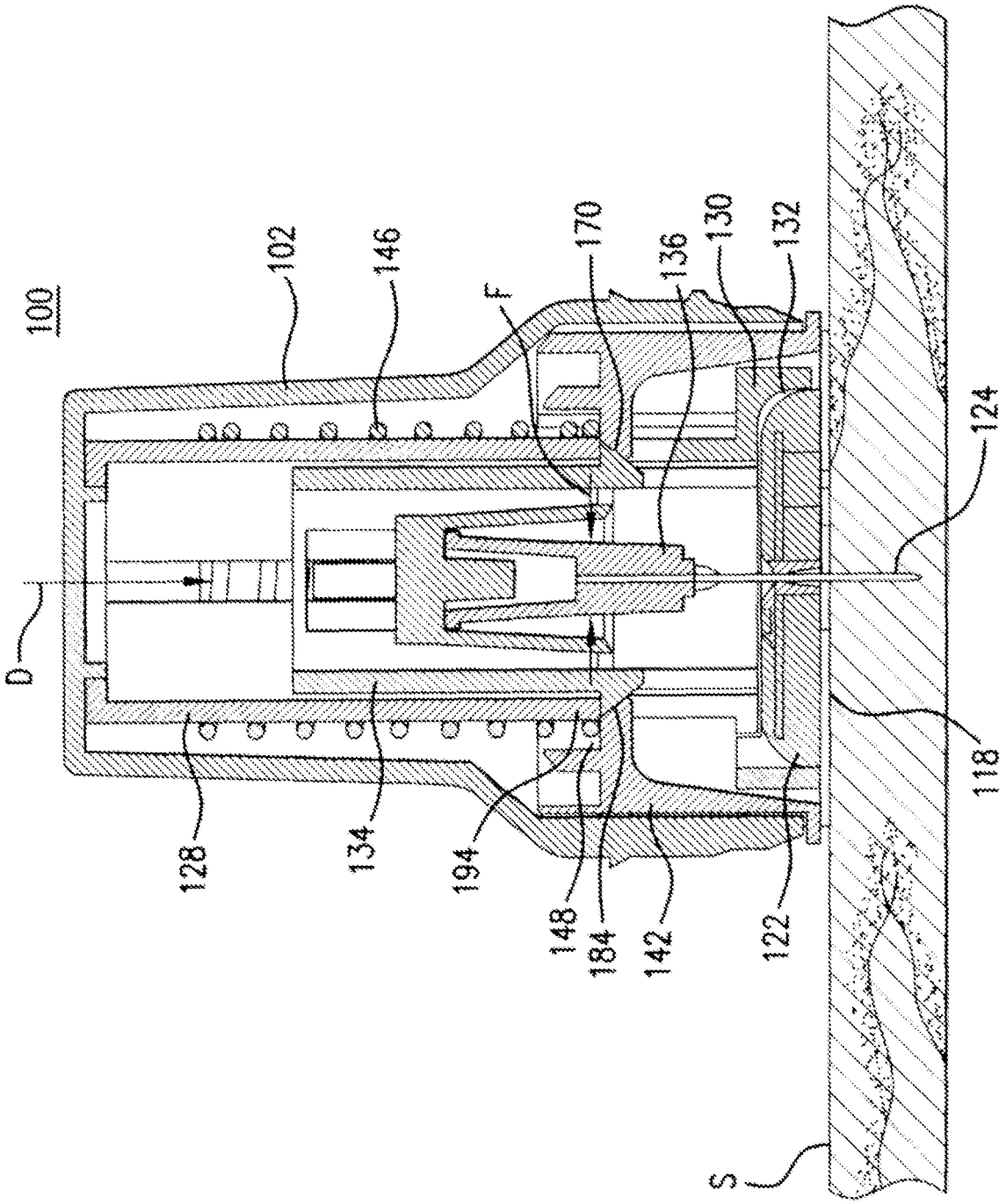

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FIG.30

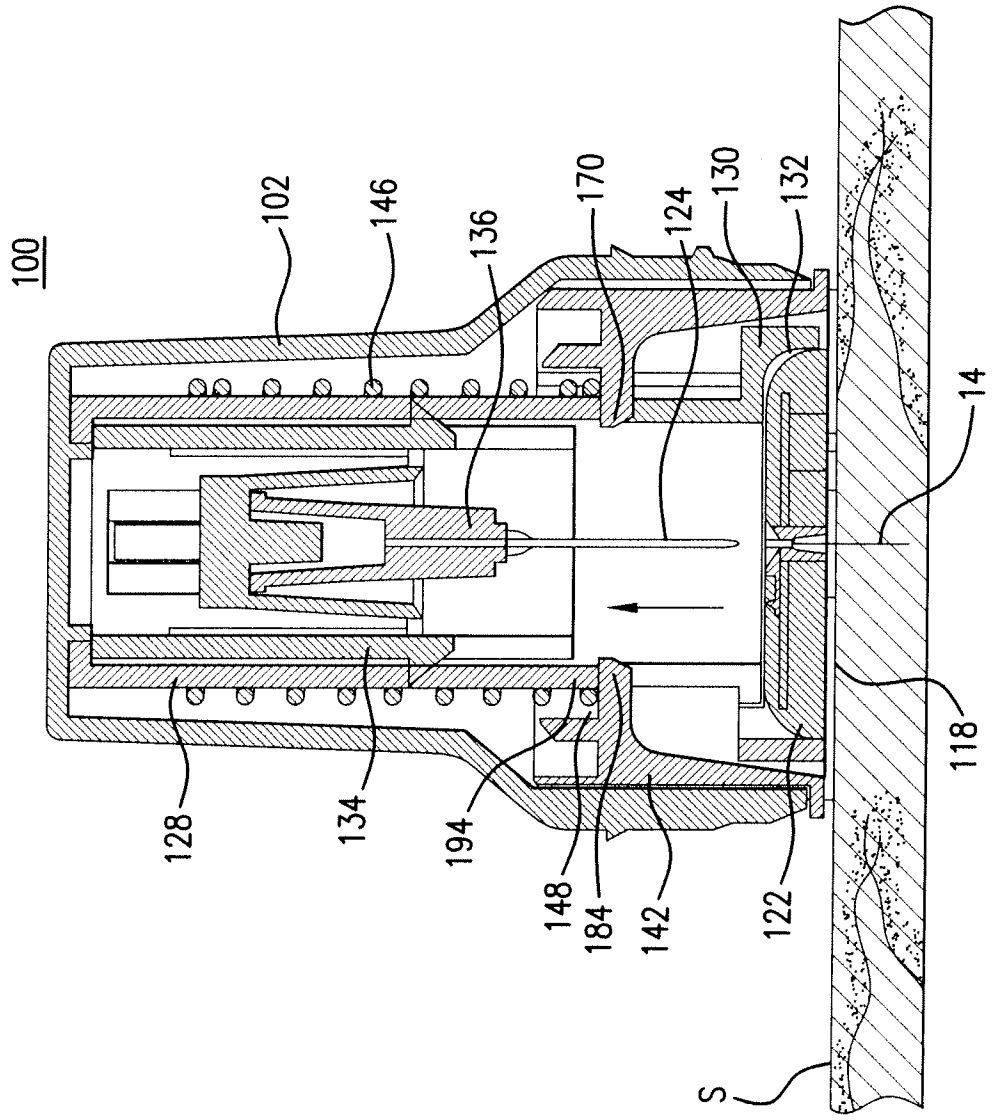

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FIG.31

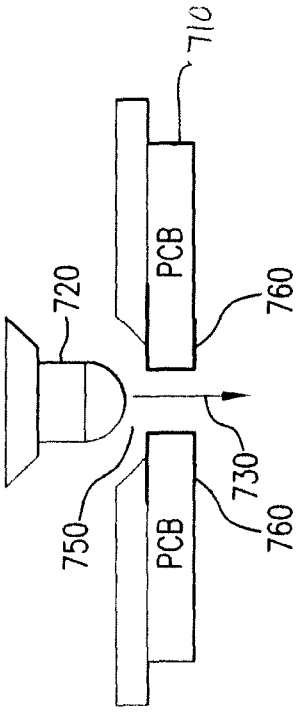


FIG.32

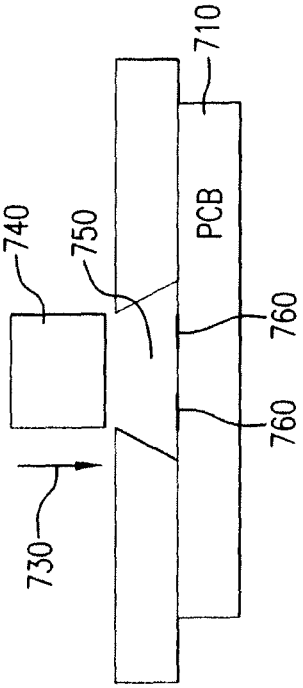


FIG.33

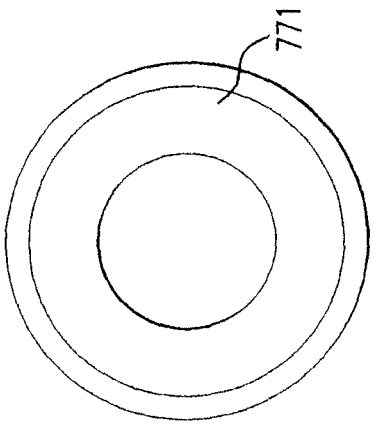


FIG.35A

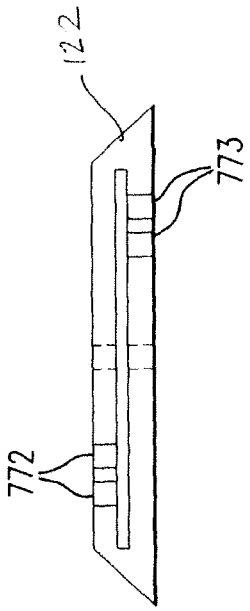


FIG.35B

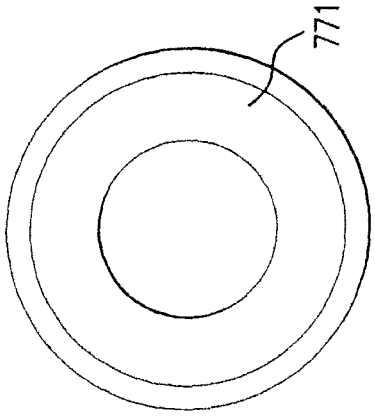


FIG.34A

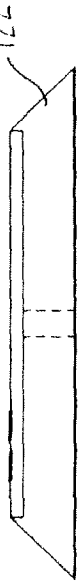


FIG.34B

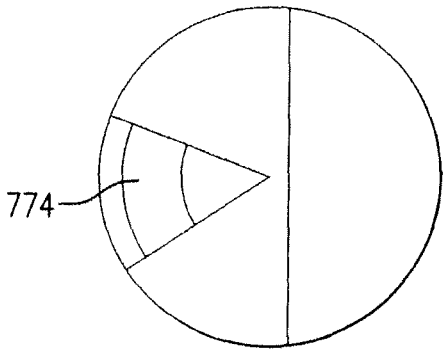


FIG.36A

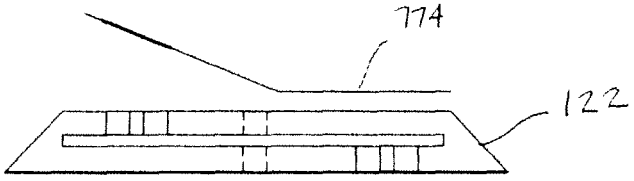


FIG.36B

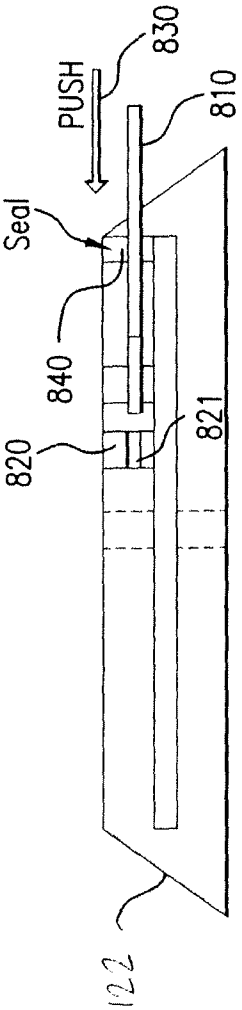


FIG.37

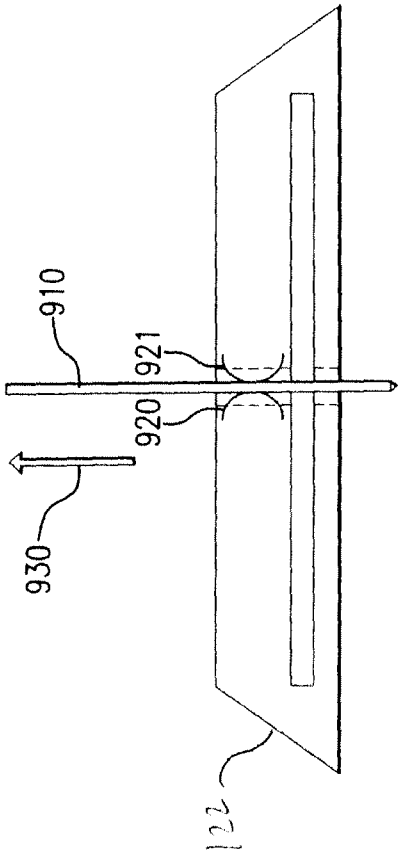


FIG.38

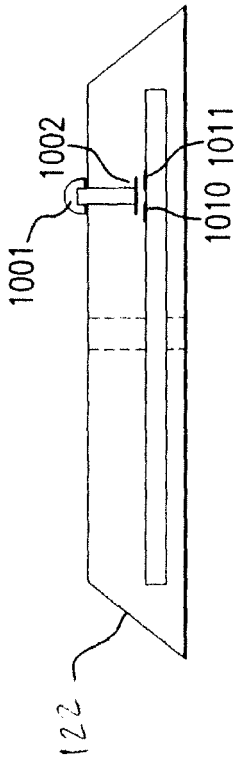


FIG.39

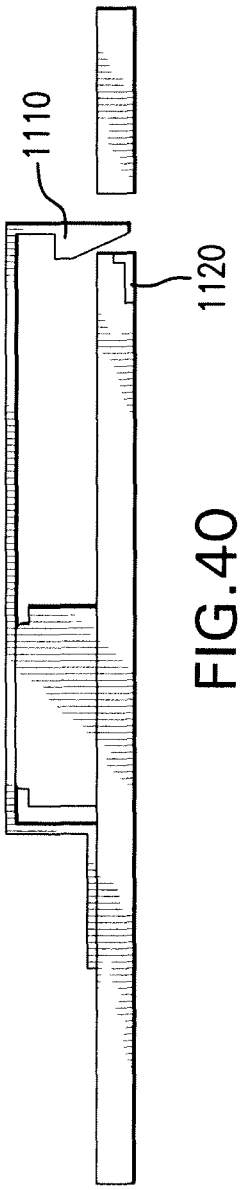


FIG.40

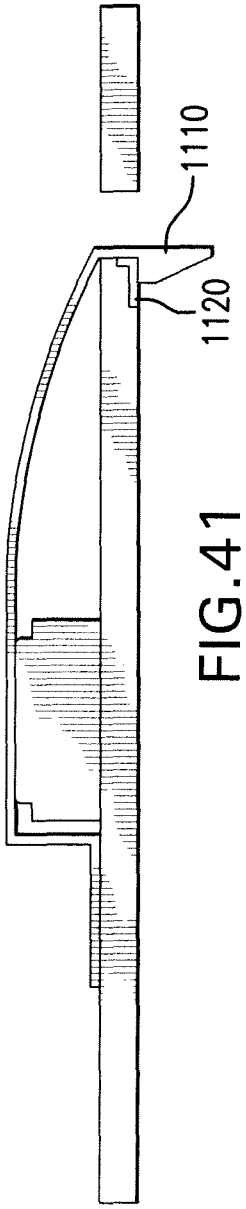


FIG.41

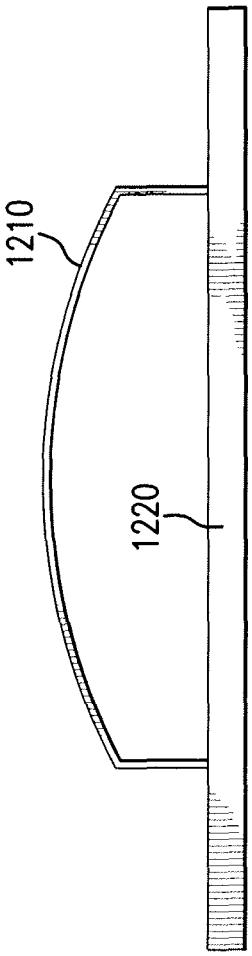


FIG.42

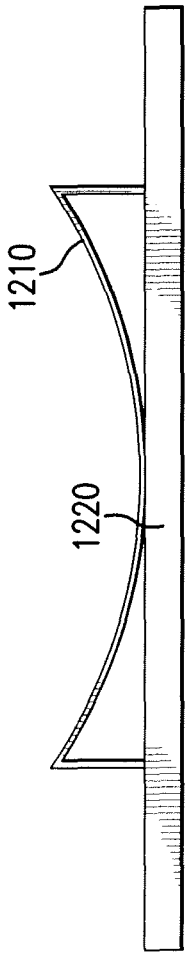


FIG.43

PTO/SB/08a (08-03)
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				First Named Inventor	Phillip Yee
				Art Unit	To be assigned
(use as many sheets as necessary)				Examiner Name	To be assigned
Sheet	1	of	3	Attorney Docket Number	To be assigned

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Examiner Initials	Cite No.[1]	Foreign Patent Document Country[3] Number[4] Kind Code[5] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	T[6]
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	7	WO 2004/098683 A1	11-18-2004	Novo Nordisk A/S	
	8	WO 2005/046780 A1	05-26-2005	Smith Medical MD, Inc.	
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	15	WO 2008/157821 A1	12-24-2008	Abbott Diabetes Care, Inc.	
	16				
	17				

OTHER PRIOR ART - NON PATENT LITERATURE DOCUMENTS			
Examiner Initials'	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	18	AHSON, S., et al., "RFID Handbook: Applications, Technology, Security, and Privacy", 2008, Chapter 4, Far-Field Tag Antenna Design Methodology, and Chapter 13, RFID Tags for Metallic Object Identification, pgs. 71 and 253-254.	
	19	Application Note AN048, Antenna Part Number FR05-S1-N-0-102, Company Reach Xtend™, Bluetooth®, 802.11b/g WLAN Chip Antenna, 2008, pgs. 1-13.	

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	32	Microchip Technology Inc., MRF24J40MA Data Sheet, 2008, pgs. 1-30.	
	33	MOORE, B., "The Potential Use of Radio Frequency Identification Devices for Active Monitoring of Blood Glucose Levels", Journal of Diabetes Science and Technology, 2009, Vol. 3, No. 1, pgs. 180-183.	
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	38	WONG, KL, "Planar Antennas for Wireless Communications," 2003, Chapter 1, Introduction and Overview, pgs. 4-17, 38-45, and 218-221.	
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Examiner Initials'	Cite No.[1]	Country	Description	Date of Issuance MM-DD-YYY	T[2]
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	42	EP	19151577.4 Extended Search Report	08-16-2019	
	43	EP	17201183.5 Extended Search Report	05-07-2018	
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	45	EP	20177712.5 Extended Search Report	09-30-2020	
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U.S. PATENT DOCUMENTS				
Examiner Initials	Cite No.[1]	U.S. Patent Document Number-Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document
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	118	4,935,345	06-19-1990	Guibeau et al.
	119	4,938,860	07-03-1990	Wogoman

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				Art Unit	To be assigned
(use as many sheets as necessary)				Examiner Name	To be assigned
Sheet	5	of	14	Attorney Docket Number	

	120	4,944,299	07-31-1990	Silvian
	121	4,950,378	08-21-1990	Nagara
	122	4,953,552	09-04-1990	DeMarzo
	123	4,954,129	09-04-1990	Giuliani et al.
	124	4,969,468	11-13-1990	Byers et al.
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	128	4,994,167	02-19-1991	Shults et al.
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	131	5,036,860	08-06-1991	Leigh et al.
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	139	5,101,814	04-07-1992	Palti
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	146	5,141,868	08-25-1992	Shanks et al.
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	152	5,198,367	03-30-1993	Aizawa et al.
	153	5,202,261	04-13-1993	Musho et al.
	154	5,205,920	04-27-1993	Oyama et al.
	155	5,208,154	05-04-1993	Weaver et al.
	156	5,209,229	05-11-1993	Gilli
	157	5,217,595	06-08-1993	Smith et al.
	158	5,229,282	07-20-1993	Yoshioka et al.
	159	5,250,439	10-05-1993	Musho et al.
	160	5,262,035	11-16-1993	Gregg et al.
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	166	5,279,294	01-18-1994	Anderson
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	172	5,320,098	06-14-1994	Davidson
	173	5,320,725	06-14-1994	Gregg et al.
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	188	5,431,160	07-11-1995	Wilkins
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT				Application Number	To be assigned
				Filing Date	April 2, 2021
				First Named Inventor	Phillip Yee
				Art Unit	To be assigned
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Sheet	1	of	23	Attorney Docket No:

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				Application Number	To be assigned
				Filing Date	April 2, 2021
				First Named Inventor	Phillip Yee
				Art Unit	To be assigned
				Examiner Name	To be assigned
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Examiner Initials*	Cite No.	Document Number Number-Kind Code	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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First Named Inventor	Phillip Yee
Art Unit	To be assigned
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	Complete if Known
Application Number	To be assigned
Filing Date	April 2, 2021
First Named Inventor	Phillip Yee
Art Unit	To be assigned
Examiner Name	To be assigned

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				First Named Inventor	Phillip Yee
				Art Unit	To be assigned
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Art Unit	To be assigned
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

	Complete if Known
Application Number	To be assigned
Filing Date	April 2, 2021
First Named Inventor	Phillip Yee
Art Unit	To be assigned
Examiner Name	To be assigned

Sheet	19	of	23	Attorney Docket No:

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				Application Number	To be assigned
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				First Named Inventor	Phillip Yee
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Sheet	20	of	23	Attorney Docket No:	

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Application Number:	17221154
International Application Number:	
Confirmation Number:	5985
Title of Invention:	ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR
First Named Inventor/Applicant Name:	Phillip Yee
Customer Number:	95508
Filer:	Glen Liu/Alana Fredericks
Filer Authorized By:	Glen Liu
Attorney Docket Number:	A0130.0113.C11
Receipt Date:	02-APR-2021
Filing Date:	
Time Stamp:	13:08:57
Application Type:	Utility under 35 USC 111(a)

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Document Description	Start	End
Specification	1	31
Claims	32	34
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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR

As the below named inventor, I hereby declare that:

This declaration is directed to:

- ☐ The attached application, or
- ☒ United States application or PCT international application number 15/192,531 filed on June 24, 2016

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

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LEGAL NAME OF INVENTOR

Inventor: PHILIP YEE Date (Optional): 10/13/2016

Signature: Philip Yee

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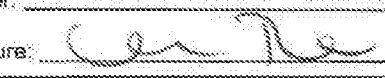
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LEGAL NAME OF INVENTOR

Inventor: CHRISTOPHER A. THOMAS Date (Optional): 14-Dec-2016

Signature: 

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LEGAL NAME OF INVENTOR

Inventor: UDO HOSS Date (Optional): 11 oct 2016

Signature: Udo Hoss

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LEGAL NAME OF INVENTOR

Inventor: LEI HE Date (Optional): 11 OCT 2016

Signature: [signature]

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LEGAL NAME OF INVENTOR

Inventor: MICHAEL R. LOVE Date (Optional): 19 Oct 2016

Signature: Michael R. Love

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REMARKS

Claims 21-50 are newly added and pending. Examination of these claims is respectfully requested. Claims 1-20 have been canceled without prejudice. Support for the new claims can be found, for example, in Figures 2-4, 7-16, and 19-31, paragraphs [0086] to [0145], and elsewhere throughout the application as filed, as well as Provisional Patent Application Serial No. 61/149,639, to which the instant application claims benefit, and which has been incorporated by reference by the instant application in its entirety for all purposes. No new matter has been introduced.

All citations to claim support are purely for the benefit of the Examiner. It is stressed that the citations are only examples and in no way constitute an exhaustive recitation of all written and depicted support for the claims. Additional support can be found elsewhere, including citations from both the specification and figures that are not stated, as well as the knowledge of those of ordinary skill in the art. These citations in no way constitute a disclaimer that the claim covers only that subject matter which is cited herein and in no way define the inventive subject matter as being only that which is cited herein.

The right is reserved to pursue claims to any subject matter supported by the disclosure of this application in one or more continuation and/or divisional applications at a later time, including the subject matter of any previously pending claims regardless of whether those claims were amended or cancelled herein. This may entail the pursuit of broader and/or narrower claims, and/or subject matter that was previously relinquished by virtue of argument or amendment.

It is respectfully submitted that all claims are in allowable form. In the event that the Examiner deems that a discussion would be helpful in advancing prosecution, the Examiner is invited to call the undersigned at (949) 432-9993. The USPTO is hereby authorized to charge any outstanding fees to Deposit Account No. 50-5201.

Dated: April 2, 2021

Respectfully submitted,

/Glen Liu/

Glen Liu
Registration No.: 75,058
ONE LLP
4000 MacArthur Blvd.
East Tower, Suite 500
Newport Beach, CA 92660
Attorney for Applicant

ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation of U.S. Patent Application No. 17/009,647, filed September 1, 2020, which is a continuation of U.S. Patent Application No. 16/736,728, filed January 7, 2020, now U.S. Patent No. 10,786,190, which is a continuation of U.S. Patent Application No. 15/994,129, filed May 31, 2018, now abandoned, which is a continuation of U.S. Patent Application No. 15/475,647, filed March 31, 2017, now U.S. Patent No. 9,993,188, which is a continuation of U.S. Patent Application No. 15/192,531, filed June 24, 2016, now U.S. Patent No. 9,636,068, which is a continuation of U.S. Patent Application No. 12/698,129, filed February 1, 2010, now U.S. Patent No. 9,402,544, which claims priority to U.S. Provisional Application No. 61/149,639, filed February 3, 2009, all of which are incorporated herein by reference in their entireties for all purposes. This application is further related to U.S. Patent Application No. 12/698,124, filed February 1, 2010, the disclosure of which is incorporated by reference in its entirety herein for all purposes.

FIELD OF THE INVENTION

[0002] The present invention relates generally to an inserter device, for example, to insert an analyte sensor and/or an infusion set in an animal such as a human.

BACKGROUND OF THE INVENTION

[0003] Diabetes Mellitus is an incurable chronic disease in which the body does not produce or properly utilize insulin. Insulin is a hormone produced by the pancreas that regulates blood sugar (glucose). In particular, when blood sugar levels rise, e.g., after a meal, insulin lowers the blood sugar levels by facilitating blood glucose to move from the blood into the body cells. Thus, when the pancreas does not produce sufficient insulin (a condition known as Type 1 Diabetes) or does not properly utilize insulin (a condition known as Type II Diabetes), the blood glucose remains in the blood resulting in hyperglycemia or abnormally high blood sugar levels.

[0004] The vast and uncontrolled fluctuations in blood glucose levels in people suffering from diabetes cause long-term, serious complications. Some of these complications include blindness, kidney failure, and nerve damage. Additionally, it is known that diabetes is a factor in accelerating cardiovascular diseases such as atherosclerosis (hardening of the arteries), leading to

stroke, coronary heart disease, and other diseases. Accordingly, one important and universal strategy in managing diabetes is to control blood glucose levels.

[0005] One way to manage blood glucose levels is testing and monitoring blood glucose levels by using conventional in vitro techniques, such as drawing blood samples, applying the blood to a test strip, and determining the blood glucose level using colorimetric, electrochemical, or photometric test meters. Another more recent technique for monitoring blood glucose levels is by using an in vivo glucose monitoring system, that continuously or automatically tests glucose, such as for example, the FreeStyle Navigator® Continuous Glucose Monitoring System, manufactured by Abbott Diabetes Care Inc. Unlike conventional blood glucose meters, continuous analyte monitoring systems employ an insertable or implantable sensor, which detects and monitors blood glucose levels. Prior to each use of a new sensor, the user self-implants at least a portion of the sensor under his skin. Typically, an inserter assembly is employed to insert the sensor in the body of the user. In this manner, an introducer sharp, while engaged to the sensor, pierces an opening into the skin of the user, releases the sensor and is removed from the body of the user. Accordingly, there exists a need for an easy-to-use, simple, insertion assembly which is reliable, minimizes pain, and is easy to use.

SUMMARY

[0006] Sensor assemblies that include a medical device, such as an analyte sensor (e.g., a glucose sensor) and/or an infusion device, and a device to position at least a portion of the medical device beneath a skin surface of a user are provided, as well as methods of positioning at least a portion of a medical device such as an analyte sensor (e.g., a glucose sensor) and/or an infusion device beneath a skin surface of a user, and methods of analyte testing.

[0007] Sensor assembly embodiments include a mount adapted to adhere to a skin of a subject; an analyte sensor coupled to the mount, and an insertion sharp having a longitudinal body including a longitudinal opening to receive at least a portion of the sensor body.

[0008] In certain embodiments, the sensor includes a body having a proximal section and a distal section, and the distal section may be longitudinally (or otherwise) aligned with the proximal section. Some sensor embodiments may include an intermediate section. An intermediate section, if present, may be laterally displaced from at least the distal member (or distal section), and a gap may be defined between the laterally displaced intermediate section and a portion of the distal section. In some embodiments, the sensor is integrated with the mount to define an on-

body device such as a single unit on-body device. A second gap may be defined in the sensor between the proximal section and the laterally displaced intermediate section. The proximal section of the sensor may have a substantially curved profile.

[0009] In some embodiments, the distal section of the sensor body is received in the longitudinally defined opening of the insertion sharp. A gap may be defined between the distal section and the laterally displaced intermediate section, which allows the distal section, in some embodiments a substantial portion--including the entirety of the distal section, to be received in the longitudinal opening of the insertion needle. The intermediate section and the proximal section may be proximate the distal section received in the insertion needle.

[0010] In some embodiments, the proximal section of the sensor body is in communication with conductive material disposed on the mount. The conductive material disposed on the mount may define a printed circuit board. The proximal section of the sensor may be disposed in a horizontal plane, and the distal section of the sensor body may be disposed in a vertical plane. In some embodiments, the sensor is a transcutaneous sensor. In some embodiments, the sensor is configured for implantation in a soft tissue of a user. In some embodiments, the sensor is a glucose sensor.

[0011] Embodiments include sensor assemblies which include a sensor comprising a portion for operative contact with a fluid of the subject; a mount defining a distal surface adapted for attachment to the skin of a subject and housing a circuit coupled to sensor for performing a function with the sensor; and a switch at least partially disposed in the mount comprising a member having a first position which protrudes from the distal surface of the mount and a second position which is recessed in the mount, the member configured to activate the circuit when in the second position.

[0012] In some embodiments, the member is biased in the first position. The member may comprise an elongated member disposed in an opening in the mount. In some embodiments, the member is moved from the first position to the second position when the mount contacts the skin of the subject. In some embodiments, an adhesive layer is disposed on the skin of the subject, and wherein the member is moved from the first position to the second position when the mount contacts the adhesive layer.

[0013] In some embodiments, the switch activates the circuit upon the member reaching the second position. In some embodiments, the switch activates the circuit as long as the member is

maintained in the second position. In some embodiments, the sensor is a glucose sensor.

[0014] In some embodiments, the circuit applies a potential to the sensor. In some embodiments, the circuit applies a current to the sensor.

[0015] In some embodiments, a monitor unit is provided to receive information from the sensor/on-body unit. For example, the system is configured for communication (wired or wirelessly) between the on-body unit and a monitor unit, e.g., using radio frequency communication or other protocol. The communication between the two units may be active or passive. In certain embodiments, the on-body unit circuit includes communication components for wired or wireless transmission of signal relating to analyte level monitored by the sensor to the monitor unit. In certain embodiments, RFID components may be included in the on-body unit and monitor unit to enable RFID communication, in which the on-body unit provides data communication to the monitor unit in response to one or more commands or data communication received from the monitor unit. In some embodiments, the transmitter transmits a signal to the receiver automatically, e.g., continuously or in certain embodiments only periodically, such as according to a predetermined schedule. In some embodiments, in addition to or instead of automatic data communication, the on-body unit may transmit signal to the receiver only in response to a request for the data, e.g., received from the monitor unit or otherwise initiated by the user (e.g., activation of a switch on the receiver or on-body unit to initiate data transfer). In some embodiments, a memory is provided, and the circuit stores a signal relating an analyte level provided by the sensor to the memory. In some embodiments, the sensor is a glucose sensor.

[0016] Embodiments include apparatuses for inserting medical devices through the skin of a subject. An insertion apparatus may include a sheath defining a distal surface for placement on the skin of the subject; a handle movable between a proximal position and distal position relative to the sheath; a device support for supporting the medical device and defining an aperture therethrough; a sharp support for supporting a sharp extending through said aperture and coupled to the handle; and driver for biasing the handle and the sharp support towards the proximal position.

[0017] In some embodiments, the driver comprises a compression member such as a compression spring. In some embodiments, the handle is at least partially disposed within the sheath. In some embodiments, the handle is at least partially disposed surrounding the sheath. In some embodiments, a bellows portion is provided which is disposed between the handle and the

sheath.

[0018] In some embodiments, the sharp support is permanently fixed to the handle. In some embodiments, the device support is permanently affixed to the handle.

[0019] In some embodiments, a stop portion for retaining the device support in the distal position is included. In some embodiments, the device support is coupled to the sharp support until the device support reaches a distal position.

[0020] In some embodiments, the device support is uncoupled from the sharp support when the device support reaches the distal position. In some embodiments, a retention member is provided to couple the sharp support to the sheath when the sharp support is disposed in the proximal position.

[0021] In some embodiments, the medical device is an analyte sensor. In some embodiments, the medical device is a glucose sensor. In some embodiments, the medical device is an infusion set.

[0022] In certain embodiments, apparatuses for inserting a medical device through the skin of a subject, are provided which include a sheath defining a distal surface for placement on the skin of the subject; a handle movable between a proximal position and distal position; a device support for supporting the medical device and defining an aperture therethrough, the device support coupled to the handle; a sharp support for supporting a sharp extending through said aperture and coupled to the device support; and driver for biasing the sharp support towards the proximal position.

[0023] In some embodiments, the driver comprises a compression spring. In some embodiments, the handle is at least partially disposed surrounding the sheath.

[0024] In some embodiments, a stop portion for retaining the device support in the distal position is included. In some embodiments, the device support is coupled to the sharp support until the device support reaches a distal position. In some embodiments, the device support is uncoupled from the sharp support when the device support reaches the distal position.

[0025] Embodiments of analyte sensors are provided which include a body having a proximal section and a distal section. The distal section may be longitudinally aligned with the proximal section. An intermediate section may be included between the proximal and distal sections, and in some embodiments the intermediate section is laterally displaced from at least the distal member. A gap may be defined between the laterally displaced intermediate section and a portion of the distal section.

[0026] In some embodiments, the intermediate section is laterally displaced from at least a portion of the proximal section of the sensor body. A second gap may be defined between the laterally displaced intermediate section and the proximal section of the sensor body. The intermediate section may have a distal end and a proximal end, and further the proximal section may be coupled to the proximal section and the distal section may be coupled to the distal section of the sensor body. In some embodiments, the intermediate section is a longitudinal member. The proximal end may be proximate to the gap defined between the distal member and the intermediate member.

[0027] In some embodiments, the proximal end is received within a needle seat to create an anchor region to allow the sensor body to slide into an opening defined in the insertion sharp but prevent the sensor body from inadvertently slipping out of the insertion needle. In some embodiments, a width of the distal section of the sensor body is sized to fit within the opening of the insertion sharp having a diameter less than about 22 to about 24 gauge.

[0028] In some embodiments, the intermediate member includes a plane-altering portion. The plane-altering portion allows the proximal section of the sensor body to be in a plane different than the distal section of the sensor body. In some embodiments, the proximal section and the distal section are in planes substantially perpendicular to each other, e.g., the area may define an angle of about 120° to about 60°, e.g., about 90 degrees.

[0029] In some embodiments, the proximal section has a curved portion.

[0030] In some embodiments, the sensor body includes conductive material disposed in or on a surface thereto to define one or more electrodes. The sensor body may include conductive material defining traces disposed in or on a surface of the sensor body. The traces are in communication with the one or more electrodes. The traces may be disposed in or on at least surface of the proximal section of the sensor body. The one or more electrodes may be disposed on the distal section of the sensor body. At least one of the traces or electrodes may include a metal or carbon material such as gold, platinum, titanium, carbon. At least one of the traces or electrodes may be formed by ablation of material. The ablation may include laser ablation.

[0031] In some embodiments, the sensor comprises a sensing layer. The sensing layer may comprise an enzyme. The sensing layer may comprise an electron transfer agent. The electron transfer agent may be a redox mediator. In some embodiments, the electron transfer agent includes osmium transition metal complexes and one or more ligands. The electron transfer agent

may be configured to transfer electrons directly between the analyte and the working electrode. The electron transfer agent may be configured to transfer electrons indirectly between the analyte and the working electrode.

[0032] In some embodiments, the sensing layer comprises a redox polymer. The redox polymer may include osmium. The sensing layer may include a catalyst. The catalyst may include an enzyme. The catalyst may act as an electron transfer agent. In some embodiments, the enzyme includes glucose oxidase. In some embodiments, the enzyme includes glucose dehydrogenase.

[0033] In some embodiments, the sensing layer is configured such that the reaction of glucose in the presence of an enzyme forms hydrogen peroxide, and glucose level may be correlated to the level of hydrogen peroxide. In some embodiments, the sensor is a subcutaneous sensor.

[0034] These and other features, objects and advantages of the disclosed subject matter will become apparent to those persons skilled in the art upon reading the detailed description as more fully described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] A detailed description of various aspects, features, and embodiments of the subject matter described herein is provided with reference to the accompanying drawings, which are briefly described below. The drawings are illustrative and are not necessarily drawn to scale, with some components and features being exaggerated for clarity. The drawings illustrate various aspects and features of the present subject matter and may illustrate one or more embodiment(s) or example(s) of the present subject matter in whole or in part.

[0036] FIGURE 1 is a schematic view of the system in accordance with one embodiment of the disclosed subject matter;

[0037] FIGURE 2 is a view, in partial cross section, of an electrochemical sensor in accordance with one embodiment of the disclosed subject matter;

[0038] FIGURE 3 is a view of an electrochemical sensor in accordance with another embodiment of the disclosed subject matter;

[0039] FIGURE 4 is a view of the electrochemical sensor of FIGURE 3 in a folded configuration in accordance with the disclosed subject matter;

[0040] FIGURE 5 is a view of an electrochemical sensor in accordance with a further embodiment of the disclosed subject matter;

[0041] FIGURE 6 is a view of the electrochemical sensor of FIGURE 5 in a folded configuration

in accordance with the disclosed subject matter;

[0042] FIGURE 7 is a perspective view of an on-body unit in accordance with one embodiment of the disclosed subject matter;

[0043] FIGURE 8 is a perspective view in partial cross-section of an on-body unit of FIGURE 7 in accordance with the disclosed subject matter;

[0044] FIGURE 9 is a schematic view of the system in accordance with one embodiment of the disclosed subject matter;

[0045] FIGURE 10 is a sectional, perspective view of another embodiment of an inserter in accordance with the disclosed subject matter;

[0046] FIGURES 11-12 are perspective views of components of the inserter of FIGURE 10 in accordance with the disclosed subject matter;

[0047] FIGURE 13 is a sectional view of a component of the inserter of FIGURE 10 in accordance with the disclosed subject matter;

[0048] FIGURES 14-15 are a perspective views of components of the inserter of FIGURE 10 in accordance with the disclosed subject matter;

[0049] FIGURE 16 is a sectional view of the component of FIGURE 14 in accordance with the disclosed subject matter;

[0050] FIGURES 17-18 are schematic views of a needle hub in accordance with one embodiment of the disclosed subject matter;

[0051] FIGURE 19 is a distal end view of a sharp in accordance with one embodiment of the disclosed subject matter;

[0052] FIGURE 20 is a side view of a sharp in accordance with one embodiment of the disclosed subject matter;

[0053] FIGURE 21 is a side view of a sharp in accordance with one embodiment of the disclosed subject matter;

[0054] FIGURE 22 is a perspective view with parts of an inserter in accordance with one embodiment of the disclosed subject matter;

[0055] FIGURE 23 is a perspective view with parts separated of an inserter in accordance with one embodiment of the disclosed subject matter;

[0056] FIGURE 24 is an enlarged sectional view with parts separated of an inserter in accordance with one embodiment of the disclosed subject matter;

[0057] FIGURES 25-27 are perspective views of components of the inserter of FIGURE 10 in accordance with the disclosed subject matter;

[0058] FIGURES 28-31 are sectional views of the inserter of FIGURE 10 in accordance with the disclosed subject matter;

[0060] FIGURES 32-33 illustrate a power supply switch mechanism including conductive plug of the on-body integrated sensor and sensor electronics assembly in accordance with embodiments of the disclosed subject matter;

[0061] FIGURES 34A-36B illustrate a power supply switch mechanism including conductive pads on the on-body integrated sensor and sensor electronics assembly in accordance with embodiments of the disclosed subject matter;

[0062] FIGURE 37 illustrates a power supply switch mechanism including an internal switch with a push rod activation of the on-body integrated sensor and sensor electronics assembly in accordance with embodiments of the disclosed subject matter;

[0063] FIGURE 38 illustrates power supply switch mechanism including introducer retraction trigger activation of the on-body integrated sensor and sensor electronics assembly in accordance with embodiments of the disclosed subject matter;

[0064] FIGURE 39 illustrates a power supply switch mechanism with a contact switch of the on-body integrated sensor and sensor electronics assembly in accordance with embodiments of the disclosed subject matter;

[0065] FIGURES 40-41 illustrate a power supply switch mechanism with a battery contact locking mechanism of the on-body integrated sensor and sensor electronics assembly in accordance with embodiments of the disclosed subject matter;

[0066] FIGURES 42-43 illustrate a power supply switch mechanism with a bi-modal dome switch of the on-body integrated sensor and sensor electronics assembly in accordance with embodiments of the disclosed subject matter.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0067] A detailed description of the disclosure is provided herein. It should be understood, in connection with the following description, that the subject matter is not limited to particular embodiments described, as the particular embodiments of the subject matter may of course vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting, since the scope of the disclosed

subject matter will be limited only by the appended claims.

[0068] Where a range of values is provided, it is understood that each intervening value between the upper and lower limit of that range and any other stated or intervening value in that stated range, is encompassed within the disclosed subject matter. Every range stated is also intended to specifically disclose each and every "subrange" of the stated range. That is, each and every range smaller than the outside range specified by the outside upper and outside lower limits given for a range, whose upper and lower limits are within the range from said outside lower limit to said outside upper limit (unless the context clearly dictates otherwise), is also to be understood as encompassed within the disclosed subject matter, subject to any specifically excluded range or limit within the stated range. Where a range is stated by specifying one or both of an upper and lower limit, ranges excluding either or both of those stated limits, or including one or both of them, are also encompassed within the disclosed subject matter, regardless of whether or not words such as "from", "to", "through", or "including" are or are not used in describing the range.

[0069] Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosed subject matter belongs. Although any methods and materials similar or equivalent to those described herein can also be used in the practice or testing of the present disclosed subject matter, this disclosure may specifically mention certain exemplary methods and materials.

[0070] All publications mentioned in this disclosure are, unless otherwise specified, incorporated herein by reference for all purposes, including without limitation to disclose and describe the methods and/or materials in connection with which the publications are cited.

[0071] The publications discussed herein are provided solely for their disclosure prior to the filing date of the present application. Nothing herein is to be construed as an admission that the present disclosed subject matter is not entitled to antedate such publication by virtue of prior invention. Further, the dates of publication provided may be different from the actual publication dates, which may need to be independently confirmed.

[0072] As used herein and in the appended claims, the singular forms "a", "an", and "the" include plural referents unless the context clearly dictates otherwise.

[0073] Nothing contained in the Abstract or the Summary should be understood as limiting the scope of the disclosure. The Abstract and the Summary are provided for bibliographic and convenience purposes and due to their formats and purposes should not be considered

comprehensive.

[0074] As will be apparent to those of skill in the art upon reading this disclosure, each of the individual embodiments described and illustrated herein has discrete components and features which may be readily separated from or combined with the features of any of the other several embodiments without departing from the scope or spirit of the present disclosed subject matter. Any recited method can be carried out in the order of events recited, or in any other order which is logically possible. Reference to a singular item, includes the possibility that there are plural of the same item present. When two or more items (for example, elements or processes) are referenced by an alternative "or", this indicates that either could be present separately or any combination of them could be present together except where the presence of one necessarily excludes the other or others.

System Overview

[0075] Certain classes of analyte monitors are provided in small, lightweight, battery-powered and electronically-controlled systems. Such a system may be configured to detect signals indicative of in vivo analyte levels using an electrochemical sensor, and collect such signals, with or without processing the signal. In some embodiments, the portion of the system that performs this initial processing may be configured to provide the raw or initially processed data to another unit for further collection and/or processing. Such provision of data may be effected, for example, via a wired connection, such as an electrical, or via a wireless connection, such as an IR or RF connection.

[0076] Certain analyte monitoring systems for in vivo measurement employ a sensor that measures analyte levels in interstitial fluids under the surface of the subject's skin. These may be inserted partially through the skin ("transcutaneous") or entirely under the skin ("subcutaneous"). A sensor in such a system may operate as an electrochemical cell. Such a sensor may use any of a variety of electrode configurations, such as a three-electrode configuration (e.g., with "working", "reference" and "counter" electrodes), driven by a controlled potential (potentiostat) analog circuit, a two-electrode system configuration (e.g., with only working and counter electrodes), which may be self-biasing and/or self-powered, and/or other configurations. In some embodiments, the sensor may be positioned within a blood vessel.

[0077] In certain systems, the analyte sensor is in communication with a sensor control unit. As used in this disclosure, an on-body unit sometimes refers to such a combination of an analyte

sensor with such a sensor control unit.

[0078] Certain embodiments are modular. The on-body unit may be separately provided as a physically distinct assembly, and configured to provide the analyte levels detected by the sensor over a communication link to a monitor unit, referred to in this disclosure as a "receiver unit" or "receiver device", or in some contexts, depending on the usage, as a "display unit," "handheld unit," or "meter". The monitor unit, in some embodiments, may include, e.g., a mobile telephone device, a personal digital assistant, other consumer electronic device such as MP3 device, camera, radio, etc., or other communication-enabled data processing device.

[0079] The monitor unit may perform data processing and/or analysis, etc. on the received analyte data to generate information pertaining to the monitored analyte levels. The monitor unit may incorporate a display screen, which can be used, for example, to display measured analyte levels, and/or audio component such as a speaker to audibly provide information to a user, and/or a vibration device to provide tactile feedback to a user. It is also useful for a user of an analyte monitor to be able to see trend indications (including the magnitude and direction of any ongoing trend), and such data may be displayed as well, either numerically, or by a visual indicator, such as an arrow that may vary in visual attributes, such as size, shape, color, animation, or direction. The receiver device may further incorporate an in vitro analyte test strip port and related electronics in order to be able to make discrete (e.g., blood glucose) measurements.

[0080] The modularity of these systems may vary. In some embodiments the sensor is attachable and detachable from the sensor control unit (and the on-body unit may be reusable), while in other embodiments, the sensor and sensor control unit may be provided as an integrated, un-detachable package, which may be disposable after use.

[0081] FIGURE 1 shows one embodiment of an analyte measurement system 10. In such a system, a data processing unit or sensor control unit 12 may interact with an analyte sensor 14 to obtain signals representative of analyte levels. Sensor control unit 12 may further include communications circuit with associated electronics (not shown). In some embodiments, the sensor control unit 12 and sensor are constructed to be maintained "on the body" of the subject for a period of time that may include hours, days, weeks, or a month or more. Accordingly, the sensor control unit 12 and sensor 14 may be referred to collectively herein as an on-body unit 16. A receiver unit or monitor unit 18 may also be provided. In the embodiment shown, sensor control unit 12 and monitor unit 18 communicate via connection 20 (in this embodiment, a

wireless RF connection). Communication may occur, e.g., via RF communication, infrared communication, Bluetooth® communication, Zigbee® communication, 802.1x communication, or WiFi communication, etc. In some embodiments, the communication may include an RF frequency of 433 MHz, 13.56 MHz, or the like. In some embodiments, a secondary monitor unit 22 may be provided. A data processing terminal 24 is useful for providing further processing or review of analyte data.

[0082] In certain embodiments, system 10 may be a continuous analyte monitor (e.g., a continuous glucose monitoring system or CGM), and accordingly operate in a mode in which the communications via connection 20 has sufficient range to support a flow of data from on-body unit 16 to monitor unit 18. In some embodiments, the data flow in a CGM system is automatically provided by the on-body unit 16 to the monitor unit 18. For example, no user intervention may be required for the on-body unit 16 to send the data to the monitor unit 18. In some embodiments, the on-body unit 16 provides the signal relating to analyte level to the receiving unit 18 on a periodic basis. For example, the signal may be provided, e.g., automatically sent, on a fixed schedule, e.g., once every 250 ms, once a second, once a minute, etc. In some embodiments, the signal is provided to the monitor unit 18 upon the occurrence of an event, e.g., a hyperglycemic event or a hypoglycemic event, etc. In some embodiments, data processing unit 12 may further include local memory in which it may record, "logged data" or buffered data collected over a period of time and provide the some or all of the accumulated data to monitor unit 18 from time-to-time. Or, a separate data logging unit may be provided to acquire periodically transmitted data from a transmitter device. Data transmission in a CGM system may be one-way communication, e.g., the on-body unit 16 provides data to the monitor unit 18 without receiving signals from the monitor unit 18. In some embodiments, two-way communication is provided between the on-body unit 16 and the monitor unit 18.

[0083] In some embodiments, a signal is provided to the monitor unit 18 "on demand." According to such embodiments, the monitor unit 18 requests a signal from the on-body unit 16, or the on-body unit 16 may be activated to send signal upon activation to do so. Accordingly, one or both of the on-body unit 16 and monitor unit 18 may include a switch activatable by a user or activated upon some other action or event, the activation of which causes analyte-related signal to be transferred from the on-body unit 16 to the monitor unit 18. For example, the monitor unit 18 is placed in close proximity with a transmitter device and initiates a data transfer,

either over a wired connection, or wirelessly by various means, including, for example various RF-carried encodings and protocols and IR links.

[0084] In some embodiments, the signal relating to analyte level is instantaneously generated by the analyte sensor 14 upon receipt of the request, and transmitted to the monitor unit 18 as requested, and/or the signal relating to analyte level is periodically obtained, e.g., once every 250 ms, once a second, once a minute, etc. Upon receipt of the "on demand" request at the on-body unit 16, an analyte signal is provided to the monitor unit. In some cases, the signal provided to the monitor unit 18 is or at least includes the most recent analyte signal(s).

[0085] In further embodiments, additional data is provided to the monitor unit 18 "on demand." For example, analyte trend data may be provided. Such trend data may include two or more analyte data points to indicate that analyte levels are rising, falling, or stable. Analyte trend data may include data from longer periods of time, such as, e.g., several minutes, several hours, several days, or several weeks.

[0086] Further details regarding on demand systems are disclosed in U.S. Patent No. 7,620,438, U.S. Patent Publication Nos. 2009/0054749 A1, published February 26, 2009; 2007/0149873 A1, published June 28, 2007, now U.S. Patent No. 9,014,773; 2008/0064937 A1, published March 13, 2008; 2008/0071157 A1, published March 20, 2008; 2008/0071158 A1, published March 20, 2008; 2009/0281406 A1, published November 12, 2009; 2008/0058625 A1, published March 6, 2008, now U.S. Patent No. 7,920,907; 2009/0294277 A1, published December 3, 2009; 2008/0319295 A1, published December 25, 2008, now U.S. Patent No. 8,597,188; 2008/0319296 A1, published December 25, 2008, now U.S. Patent No. 8,617,069; 2009/0257911 A1, published October 15, 2009, now U.S. Patent No. 8,252,229; 2008/0179187 A1, published July 31, 2008, now U.S. Patent No. 8,808,515; 2007/0149875 A1, published June 28, 2007, now U.S. Patent No. 8,515,518; 2009/0018425 A1, published January 15, 2009, now U.S. Patent No. 8,160,670; and U.S. Patent Application Nos. 12/625,524, filed November 24, 2009, now U.S. Patent No. 8,390,455; 12/625,525, filed November 24, 2009, now U.S. Patent No. 8,358,210; 12/625,528, filed November 24, 2009, now U.S. Patent No. 8,115,635; 12/628,201, filed November 30, 2009, now U.S. Patent Publication No. 2010/0076280; 12/628,177, filed November 30, 2009, now U.S. Patent Publication No. 2010/0076289; 12/628,198, filed November 30, 2009, now U.S. Patent Publication No. 2010/0076291; 12/628,203, filed November 30, 2009, now U.S. Patent Publication No. 2010/0076292;

12/628,210, filed November 30, 2009, now U.S. Patent Publication No. 2010/0076293; 12/393,921, filed February 26, 2009, now U.S. Patent Publication No. 2010/0213057; 61/149,639, filed February 3, 2009; 12/495,709, filed June 30, 2009, now U.S. Patent Publication No. 2010/0326842; 61/155,889, filed February 26, 2009; 61/155,891, filed February 26, 2009; 61/155,893, filed February 26, 2009; 61/165,499, filed March 31, 2009; 61/227,967, filed July 23, 2009; 61/163,006, filed March 23, 2009; 12/495,730, filed June 30, 2009, now U.S. Patent Publication No. 2010/0331643; 12/495,712, filed June 30, 2009, now U.S. Patent No. 8,437,827; 61/238,461, filed August 31, 2009; 61/256,925, filed October 30, 2009; 61/238,494, filed August 31, 2009; 61/238,159, filed August 29, 2009; 61/238,483, filed August 31, 2009; 61/238,581, filed August 31, 2009; 61/247,508, filed September 30, 2009; 61/247,516, filed September 30, 2009; 61/247,514, filed September 30, 2009; 61/247,519, filed September 30, 2009; 61/249,535, filed October 7, 2009; 12/544,061, filed August 19, 2009, now U.S. Patent Publication No. 2011/0046466; 12/625,185, filed November 24, 2009, now U.S. Patent No. 8,354,013; 12/625,208, filed November 24, 2009, now U.S. Patent No. 9,042,954; 12/624,767, filed November 24, 2009, now U.S. Patent Publication No. 2011/0124993; 12/242,780, filed September 30, 2008, now U.S. Patent No. 8,983,568; 12/183,602, filed July 31, 2008, now U.S. Patent Publication No. 2010/0030052; 12/211,014, filed September 15, 2008, now U.S. Patent No. 8,636,884; and 12/114,359, filed May 2, 2008, now U.S. Patent No. 8,080,385, each of which is incorporated by reference in its entirety herein.

The Sensor

[0087] The analyte sensor 14 of the analyte measurement system 10 may be used to monitor levels of a wide variety of analytes. Analytes that may be monitored include, for example, acetyl choline, amylase, bilirubin, cholesterol, chorionic gonadotropin, creatine kinase (e.g., CK-MB), creatine, DNA, fructosamine, glucose, glutamine, growth hormones, hormones, ketones, lactate, peroxide, prostate-specific antigen, prothrombin, RNA, thyroid stimulating hormone, and troponin. The concentration of drugs, such as, for example, antibiotics (e.g., gentamicin, vancomycin, and the like), digitoxin, digoxin, drugs of abuse, theophylline, and warfarin, may also be monitored. One or more analyte may be monitored by a given sensor.

[0088] In one embodiment of the present disclosure, sensor 14 is physically positioned in or on the body of a user whose analyte level is being monitored. Sensor 14 may be configured to continuously sample the analyte level of the user and convert the sampled analyte level, e.g.,

glucose concentration into a corresponding data signal, e.g., a current or voltage, for input into sensor control unit electronics. Alternatively, sensor 14 may be configured to sample analyte levels on demand. The sensor control unit electronics may amplify, filter, or otherwise process the signal provided by the sensor.

[0089] The sensor may take on a number of forms. For example, the sensor may include a flexible or rigid substrate. In some embodiments, the sensor may be a wire. In some embodiments, the sensor may include two or three or more electrodes.

[0090] An embodiment of the sensor 14 is illustrated in FIGURE 2. In some embodiments, sensor 14 includes a substrate which is a dielectric, e.g., a polymer or plastic material, such as polyester or polyamide. In this embodiment, the sensor is constructed so that a portion is positionable beneath skin and a portion is above skin. Accordingly, sensor 14 includes an insertion portion 30 and a contact portion 32. The contact portion 32 typically includes several conductive contacts 36, 38, and 40 (herein shown as 3 contacts) for connection to other electronics, e.g., at the data processing unit 12. The contacts provided in this embodiment are for a working electrode 36, a reference electrode 38, and a counter electrode 40. In some embodiments, two or more working electrodes are provided. The operative portions of these electrodes, that is, working electrode, reference electrode, and counter electrode (not individually shown), are provided at the distal end of insertion portion 30. The contact and operative portions of the electrodes are connected by circuit traces 42, 44, and 46 running on the surface of substrate. In some embodiments, the traces are provided in channels, or may be embedded within the substrate, or may traverse different sides of the substrate. The conductive contacts, conductive traces, and electrodes are fabricated from a conductive material, such as platinum, palladium, gold, or conductive carbon. Further details of sensors are described, e.g., in U.S. Patent Nos. 6,175,572; 6,103,033, which are incorporated by reference herein.

[0091] Sensor 14 may include a proximal retention portion 48. In some embodiments, the insertion portion 30 and the proximal retention portion 48 are substantially longitudinally aligned. The insertion portion 30 and the proximal retention portion 48 are sized and configured to be positioned with a sharp for installation into the skin of a subject, as described herein. In use, the sensor 14 may be configured to bend (e.g., along the line B) and therefore be positioned in two substantially perpendicular, intersecting planes.

[0092] As illustrated in FIGURE 3, sensor 14' is substantially identical to sensor 14, with many

of the differences illustrated in FIGURE 3 and noted herein. Sensor 14' further includes additional features useful for connecting to, e.g., mounting to or in or on, a housing associated with the sensor control unit 12. For example, sensor 14' includes a laterally displaced portion (or sensor tab) 50' and a longitudinal displaced portion 52' which provide a path for electrical connections, e.g., the conductive traces. Sensor 14' is further provided with a notch 54' between the proximal retention portion 48' and the longitudinal displaced portion 52'. Such configuration permits the sensor 14' to bend (e.g., along the line are indicated by line B) and therefore be positioned in two substantially perpendicular, intersecting planes, as illustrated in FIGURE 4. As will be described below, the sensor tab 50' can be encased in a portion of the body of the data processing unit 12 to aid in securing and positioning the sensor 14'. Proximal retention portion 48' maintains its longitudinal alignment with insertion portion 30' for positioning within an insertion sharp.

[0093] FIGURE 5 illustrates a further embodiment of a sensor 14" in accordance with the disclosure. Sensor 14" is substantially identical to sensor 14 and 14', with certain exemplary differences illustrated in FIGURE 5 and noted herein. For example, sensor 14" includes a contact portion 32" which defines a fan-like configuration having a curved edge. Sensor 14" defines a sensor flag indentation 56" which also serves to assist in retaining the sensor 14" in vertical direction, as will be described below, and provides a discrete location for mating with a feature of the data processing unit 12, e.g., the bottom surface of a printed circuit board. Sensor 14" is likewise capable of bending along axis B, as illustrated in FIGURE 6. In any of the embodiments of the sensor described herein, the distance between insertion portion 30 to retention portion 48 may be, e.g., about 5 mm, or about 10 mm, or about 15 mm, or about 20 mm.

[0094] In general, sensors in accordance with the present disclosure operate electrochemically, through an arrangement of electrodes having chemical sensing layers applied thereto, by generating an electrical current proportional to the volume of a redox reaction of the analyte (and indicative of analyte concentration), catalyzed by an analyte-specific oxidizing enzyme. Embodiments exist in which the number of electrodes provided to bring about and detect the level of these reactions is two, three or a greater number.

[0095] A portion of sensor 14 (which collectively refers to sensors 14' and 14" herein) may be situated above the surface of the skin, with a distal portion 30 penetrating through the skin and into the subcutaneous space in contact with the user's biofluid, such as interstitial fluid. The

disposition of the sensor in the illustrated embodiment is referred to as "transcutaneous". In general, the term "transcutaneous" as used herein refers to a sensor that is only partially inserted under one or more layers of the skin of the user, whereas the term "subcutaneous" refers to a sensor that is completely inserted under one or more layers of the skin of the user. It is understood that many features described herein would be applicable to both transcutaneous and subcutaneous sensors. Further details regarding the electrochemistry of sensor 14 is provided in U.S. Patent Nos. 5,264,104; 5,356,786; 5,262,035, 5,320,725, 6,990,366, each of which is incorporated herein by reference

[0096] In some embodiments, the sensor is implantable into a subject's body for a period of time (e.g., three to seven days, or in some embodiments, longer periods of up to several weeks) to contact and monitor an analyte present in a biological fluid. In this regard, the sensor can be disposed in a subject at a variety of sites (e.g., abdomen, upper arm, thigh, etc.), including intramuscularly, transcutaneously, intravascularly, or in a body cavity. In one embodiment, the sensor can be a transcutaneous glucose sensor. Alternatively, the sensor can be a subcutaneous glucose sensor.

[0097] In some embodiments, sensor 14 is employed by insertion and/or implantation into a user's body for some usage period. In such embodiments, substrate may be formed from a relatively flexible material to improve comfort for the user and reduce damage to the surrounding tissue of the insertion site, e.g., by reducing relative movement of the sensor with respect to the surrounding tissue.

[0098] While the embodiments illustrated in FIGURES 2-6 have three electrodes, other embodiments can include a fewer or greater number of electrodes. For example, a two electrode sensor can be utilized. The sensor may be externally-powered and allow a current to pass proportional to the amount of analyte present. Alternatively, the sensor itself may act as a current source in some embodiments. In some two-electrode embodiments, the sensor may be self-biasing and there may be no need for a reference electrode. An exemplary self-powered, two-electrode sensor is described in U.S. Patent Application No. 12/393,921, filed February 26, 2009, and entitled "Self-Powered Analyte Sensor," which is hereby incorporated by reference in its entirety herein for all purposes. The level of current provided by a self-powered sensor may be low, for example, on the order of nanoamperes.

On-Body Unit

[0099] An exemplary configuration for sensor 14 (and sensors 14' and 14") and sensor control unit 12 (e.g., collectively on-body unit 16) is illustrated in FIGURES 7-8. Data processing unit 12, may be provided with a substantially circular configuration having a reduced height (i.e., "Z"-dimension) to provide a low-profile when sitting on the skin of the subject. In some embodiments, the height is about 3 mm to about 25 mm, e.g., may be about 4 mm, about 5 mm, about 10 mm, or about 15 mm. In certain embodiments, the unit 12 may have a variable height. Data processing unit 12, including its associated electronics 80, are housed in a sensor housing 122. For example, electronics may include, e.g., an analog interface for connecting to the sensor 14, a processor, and a power supply. A serial communication section may be provided. A temperature sensor, such as a thermistor, which detects skin and or ambient temperature may be included to provide compensation to the analyte signal. A RF communication circuit is provided to communicate with the monitor unit 18. A data storage unit may be provided to store analyte data points over a short term, e.g., several hours or minutes, or over a long term, e.g., several days or weeks. Additional optional electronics include a serial communication section, a leakage detection circuit, or user input, e.g., a switch to activate/deactivate some or all of the device. Many of the components may be combined together and/or their function provided by common components. Furthermore, certain components may be eliminated entirely. For example, a power supply may be omitted if power is provided by inductive coupling.

[0100] In some embodiments, sensor 14 is disposed within the data transmitting unit 12, e.g., in a bent configuration, as illustrated in certain embodiments herein, e.g., in FIGURES 4 and 6. The contact portion 32 of sensor 14 may be oriented in a substantially horizontal configuration, and secured to a printed circuit board of the transmitter unit 12. The insertion portion 30 of the sensor 14 extends in a substantially downwardly vertical orientation for placement in the skin of the subject. It is understood that sensor 14 may be disposed in other configurations, e.g., in an entirely substantially vertical configuration, etc. As a further example, the insertion portion 30 may be disposed at an oblique angle, e.g., between about 0° and about 90° with respect to the skin surface.

[0101] As illustrated in FIGURE 9, the on-body unit 16 communicates with the monitor unit 18. Such communication may be one-way communication, e.g., from the on-body unit 16 to the monitor unit 18. In some embodiments, the communication may be two-way, e.g., both from the

on-body unit 16 to the receiving unit 18 and from the receiving unit 18 to the on-body unit 16. In such cases, the receiving unit 18 may also be referred to herein as a display unit, transceiver or handheld unit. Communication between the on-body unit 16 and monitor unit 18 may occur via RF communication, inductive coupling, direct wired connection, etc.

Insertion Assembly

[0102] An insertion assembly is provided, which is used to install a medical device to the subject. In some embodiments, the insertion assembly includes an inserter and the medical device itself. The inserter can be configured to insert various medical devices to the subject, such as for example, an analyte sensor, an infusion set, a cannula, or a lancet. In some embodiments, the inserter can be configured to install a combination of such devices, e.g., a combined sensor/infusion set, etc. In certain embodiments, a given inserter can be configured to install a first device and a second device at different times. For example, an inserter may be modifiable to be used with more than one medical device, include more than one type of medical device, e.g., by attaching an adapter and/or removing detaching a portion of an inserter. The inserter can install the medical device transcutaneously in, under, or through the skin of the subject; or subcutaneously; or placed on the surface of the skin. The medical device can include features or structures, e.g., barbs, tabs, adhesive, etc., to maintain the device in position with respect to the skin after insertion.

[0103] In other embodiments, the insertion assembly includes an inserter, a medical device, such as an analyte sensor, and a mount for supporting the medical device at least partially in or on the skin of the subject. The mount may be inserted simultaneously with the medical device by the inserter. In other embodiments, the mount is installed after or before installation of the medical device. In such case the mount may be applied by the inserter or separately. The mount may include features or structures to maintain the sensor in position with respect to the skin after insertion.

[0104] In further embodiments, the insertion assembly includes an inserter, an analyte sensor, a mount, and a power supply. The mount and power supply may be inserted simultaneously with the analyte sensor by the inserter. In other embodiments, the mount and battery are installed after or before installation of the analyte sensor. In such case the mount and/or power supply may be applied by the inserter or separately.

[0105] In still further embodiments, the insertion assembly includes an inserter, a medical device

such as an analyte sensor, a mount, and electronics. The mount and electronics may be inserted simultaneously with the analyte sensor by the inserter. In other embodiments, the mount and electronics are installed after or before installation of the analyte sensor. For example, the mount and the analyte sensor may be installed by the inserter, and the electronics may be subsequently installed. In other embodiments, the mount is installed, followed by insertion of the analyte sensor by the inserter, and further followed by installation of the electronics. In other embodiments, the mount and electronics are installed first, and the analyte sensor is subsequently installed.

[0106] In some embodiments, the electronics provide a voltage or current to the analyte sensor. In some embodiments, the electronics processes signals provided by the analyte sensor. In further embodiments, the electronics may include communication functionality for providing a signal relating to the signal provided by the analyte sensor to a further component, such as, e.g., a monitor unit, a handheld unit, a meter, a display unit, a computer, or other component. In some embodiments, communications circuitry, such as RFID antenna or communications circuitry is provided.

[0107] The inserter can include a plurality of different components. For example, the inserter may include one or more components for advancing a sharp towards the skin of the subject. The sensor and associated electronics and/or mounting structure may be supported by a support structure, such as a carriage. An actuator may be provided for advancing the sharp and/or the analyte sensor/support structure. In some embodiments, the actuator is coupled to the sharp and/or support structure, such that manual force and speed applied by the user to the actuator is transferred to the sharp and/or support structure.

[0108] The inserter can also include one or more components for retracting the sharp, while allowing the analyte sensor and optional mount and/or electronics to remain to the subject. The components for retracting the sharp can include a retractor. It is understood that the retractor and the actuator may be the same structure or include some common components. In some embodiments, the retractor is directly or indirectly coupled to the sharp such that the manual force applied by the user is transferred from the retractor to the sharp to retract the sharp from the skin. In other embodiments, a drive assembly may be provided to retract the sharp. For example, the drive assembly may include a spring, motor, hydraulic piston, etc., to retract the sharp away from the skin of the subject. The drive assembly may also include a linear drive component.

[0109] In some embodiments, the retractor withdraws the sharp upon actuation by the user. In such cases, the user actuates the retractor when it is desired to withdraw the sharp. For example, the retractor may include a release switch. Upon activation of the release switch, the drive assembly, e.g., the spring or other driver, retracts the sharp from the skin. In other embodiments, the retractor and the actuator comprise common components. After activating the actuator to advance the sharp and the analyte sensor, the user releases the actuator, which allows the drive assembly to withdraw the sharp from the skin.

[0110] In some embodiments, the retractor withdraws the sharp without further user interaction after actuation of insertion. For example, the inserter may include features or components which automatically retract the sharp upon advancement of the sharp and support structure by a predetermined amount. Inserter devices, in which no further action by the user is required to initiate withdrawal of the sharp after insertion, are referred to herein as having "automatic" withdrawal of the sharp.

Inserter Devices

[0111] An inserter 100 in accordance with an exemplary embodiment is illustrated in FIGURE 10. Inserter 100 includes a handle 102 and a removable distal cap 104. The cap 104 may maintain a sterile, contaminant-free environment for the medical device and sharp housed therein. As illustrated in FIGURES 10-16, distal cap 104 is secured to handle 102, e.g., by use of one or more mating members, e.g., threads 110 and 111, or hooks, tape, and the like. Inserter 100 includes a base 142 which defines a distal, substantially planar surface 112 for placement on the skin S of a subject, and in other embodiments may be a curved or inclined surface, e.g., a concave or convex surface. Inserter 100 may be utilized to advance a medical device into the skin of the subject, e.g., an analyte sensor, and infusion set, etc. In some embodiments, handle 102 is advanced relative to base 142 in order to advance the medical device into the skin of the patient, as will be described in greater detail herein.

[0112] The components of inserter 100 are illustrated in FIGURES 11-27. As illustrated in FIGURE 11, handle 102 includes a contact surface 114 for contact by a user to insert and install the sensor housing 122 and sensor 14. Threads 110 are provided on handle 102 for attachment to cap 104 via threads 111 (as illustrated in FIGURES 12-13). Cap 104 can include an upwardly extending boss 125 to assist positioning of the sharp 124. The distal portion of cap 104 includes a recess 115 for retaining a desiccant 190 therein. In some embodiments, a silica gel or molecular

sieves may be used. Such material can be in either in granular form (pellets) or pressed into tablets. In some embodiments, silica gel tablets are used.

[0113] Cap 104 is provided with one or more apertures 117, which allows for passage of air to the desiccant 190 to remove moisture from the interior of the inserter 100. Cap 104 includes an annular ridge 113 which engages the distal edge portion 116 of handle 102. In some embodiments, annular ridge 113 prevents distal movement of handle 102 (as well as sharp 124) when cap 104 is attached to handle 102.

[0114] Base 142, as illustrated in FIGURES 10 and 14, includes a distal sheath portion 192, which shields sharp 124 prior to deployment and a distal rim 112 having a substantially planar surface configuration to rest on the subject's skin. Base 142 also includes side walls 191, which along with inner rail 128 defines a recess for retraction spring 146. Base 142 provides a spring floor 148, as illustrated in FIGURE 29.

[0115] Support member or shuttle 134, as illustrated in FIGURES 15-16, supports needle hub 136, from which sharp 124 extends longitudinally within the inserter 100. In some embodiments, the sharp is supported at an oblique angle, e.g., between about 0° and about 90° with respect to the skin surface. Needle hub 136 can be secured to shuttle 134 via an interlocking O-ring configuration, adhesive, or other techniques known in the art. In some embodiments, sharp 124 is a solid needle. In some embodiments, sharp 124 is provided with a substantially cylindrical configuration defining an interior bore, e.g., a rigid cannula or a hypodermic-style needle.

[0116] Needle hub 136 is further illustrated in FIGURES 17-18. Needle hub 136 supports sharp 124, having a sharpened distal portion 160. In some embodiments, as discussed herein, a longitudinal wall opening or gap 162 is provided in at least a portion of the wall of the sharp 124. The length N of the gap 162 is selected to be commensurate with the length of the insertion portion 30 through to the proximal retention portion 48 of the sensor, or about 5 mm, or about 10 mm, or about 15 mm, or about 20 mm. The length L of the sharp 124 may be about 5 mm, or about 10 mm, or about 20 mm, about 30 mm, or about 50 mm, and is selected based upon the desired depth of the insertion portion 30 of the sensor 14.

[0117] The distal portion 160 of sharp 124 is illustrated in greater detail in FIGURES 19-21. As illustrated in FIGURE 19, sharp 124 has a substantially "C"- or "U"-shaped profile in this embodiment, but may have other configurations, e.g., substantially "V"-shaped. A longitudinal gap 162 is provided in the wall of the sharp 124. FIGURE 20 illustrates distal portion 160 is

provided with an angled tip. In some embodiments, the angled tip may be provided with a first angled tip portion 164 and a second steep-angled tip portion 166. The exemplary configuration, which includes multiple edges and faces, provides a sharp point to reduce penetration force, trauma, and bleeding for the subject. The distal section of the sensor body has a width sized to fit within the notch 162 of the insertion sharp 124 having a diameter less than about 22 to about 24 gauge, in certain embodiments the sharp is 25 gauge. In some embodiments, sharp 124 is a fabricated from a sheet of metal, and folded into a substantially "V" or "U" or "C" configuration in cross-section. In some embodiments, a laser is used to form the wall opening or gap 162.

[0118] FIGURES 22-23 illustrate the position of sensor housing 122 with respect to the needle hub 136 and sharp 124. As illustrated in FIGURE 22, the sharp 124 extends through an aperture 168 in the sensor housing 122. The distal portion of sensor 14 is positioned with the sharp 124. As further illustrated in FIGURE 23, electronics 80 (e.g., a printed circuit board containing ASIC electronics) and sensor hub 123 are positioned within sensor housing 122. A power supply 82, such as a battery, e.g., a single use disposable battery, or rechargeable battery, is provided. In some embodiments, the active operational life of the battery may exceed the active operational life of the sensor 14.

[0119] FIGURE 24 illustrates in cross-section the orientation of the sensor housing 122 with respect to the sharp 124 of inserter 100. As discussed herein, sensor 14 is disposed in a substantially bent configuration, such that a portion of the sensor, e.g., the insertion portion 30 and the proximal retention portion 48 are substantially vertical (e.g., substantially aligned with the longitudinal axis of the inserter 100 and substantially perpendicular to the skin surface) and the contact portion 32 (shown in profile) is oriented in a substantially horizontal configuration, and in electrical contact with the data processing unit electronics, such as circuit 80. The sensor tab 50 can be encased in the plastic of the sensor housing 122 (e.g., "overmolded") and secured in place. The notch 56 provides further stability to the sensor 14, e.g., by allowing the sensor tab 50 to be encased by the material of the sensor housing 122, and further provides a means for vertically orienting the sensor 14 during mounting, e.g., by allowing vertical positioning of the notch 56 with respect to a vertical landmark of the housing 122.

[0120] The sensor 14, mounted with the sensor housing 122, is disposed within the concave recess in the carriage 130. In the initial configuration of the inserter 100 (see, e.g., FIGURES 10 and 28-29) the sharp 124 extends through a longitudinal aperture 168 formed in a carriage 130.

In some embodiments, the aperture 168 is appropriately sized, such that neither the sharp 124 nor needle hub 136 is in contact with the carriage 130. Accordingly, the needle hub 136 (and sharp 124) on the one hand, and the carriage 130 and the sensor housing 122, on the other hand, move simultaneously but independently from one another. In other embodiments, a friction fit may be provided between the aperture and the sharp.

[0121] The insertion portion 30 and proximal retention portion 48 of the sensor 14 are disposed within a longitudinal bore 162 within the sharp 124. (See, e.g., FIGURE 19) The proximal retention portion 48 is disposed within the longitudinal bore of the sharp and provides additional stability to the mounting of the sensor 14 within the sharp 124. The longitudinal wall gap or opening 162 of sharp 124 is aligned with the sensor 14, such that the tab 50 and the contact portion 32 extend laterally outward from the sharp 124.

[0122] With continued reference to FIGURES 15 and 16, shuttle 134 includes wings 182 and resilient distally-extending fingers 184. Inner rail 128 is illustrated in FIGURE 25. As illustrated in FIGURE 26, shuttle 134 is sized and configured for slidable movement within inner rail 128. Wings 182 of shuttle 134 are configured for slidable movement within axial notches 188 of inner rail 128. When fingers 184 of shuttle 134 are disposed in their normally biased outward position, fingers 184 engage the lower surface 194 of inner rail 128. In the configuration illustrated in FIGURE 26, shuttle 134 is locked with respect to inner rail 128. As will be discussed herein, fingers 184 may be biased radially inward to allow upward movement of shuttle 134 relative to inner rail 128.

[0123] As illustrated in FIGURE 10, inner rail includes an upper surface 186 for engagement with handle 102. In some embodiments, surface 186 is adhered or otherwise fixed to handle 102.

[0124] The relationship of inner rail 128, shuttle 134 and base 142 is illustrated in FIGURE 27. In an initial configuration, inner rail 128 and shuttle 134 are in a locked relationship by engagement of wings 182 and fingers 184. Inner rail 128 and shuttle 134 are axially movable within base 142. Spring 146, which is secured between spring floor 148 of base 142 and wings 182 of shuttle 134 biases the inner rail 128 and shuttle 134 in a proximal (upward) direction.

[0125] Inserter 100 is illustrated in section in FIGURES 28-29 prior to use in a sensor pre-deployment position. Cap 104 is attached to the distal portion of inserter 100, via inter-engagement of threads 110 and 111.

[0126] As illustrated in FIGURE 28, the inserter 100 includes an initial configuration in which

the handle 102 is disposed in a proximal position with respect to the base 142. In such configuration, the sharp 124 is disposed in a configuration spaced apart from an aperture of the adhesive layer 118.

[0127] As illustrated in FIGURE 30, inner rail 128 includes a carriage 130. In a sensor insertion position, the handle 102 is depressed downward (arrow D) against the bias of spring 146, the inner rail 128 moves downwardly with the carriage 130 and the sensor housing 122. Shuttle 134 supports needle hub 136, from which sharp 124 extends longitudinally within the inserter 100. Initially shuttle 134 is coupled to inner rail 128 via inter-engagement of fingers 184 of shuttle 134 with distal surface 194 of inner rail 128, and both shuttle 134 and inner rail 128 move distally together as a unit.

[0128] As the sharp 124 is urged distally (FIGURE 30), it carries the sensor insertion portion 30 of sensor 14 into the subcutaneous portion of the subject's skin S and into contact with the interstitial fluid. As carriage 130 reaches a distal position, the distal surface of the sensor housing 122 engages the upper surface of adhesive pad 118, thereby becoming adhered to the skin surface S of the subject.

[0129] Flanges 170 on base 142 engage fingers 184 of shuttle 134. Fingers 184 are pivoted or bend inwards by contact with flanges 170 (as indicated by arrows F).

[0130] As illustrated in FIGURE 31, such pivoting of fingers 184 causes fingers 184 to become disengaged from distal edge 194 of inner rail 128. Shuttle 134 is thereby disengaged from inner rail 128. Disengagement of the shuttle 134 from the inner rail 128 permits the spring 146 to expand, thereby advancing the shuttle 134 to a proximal position, and withdrawing the sharp 124 from the sensor 14 and the skin S of the subject, while leaving the sensor 14 in the skin. Once the sharp has been withdrawn from the subject, it is no longer accessible from the distal portion of the inserter 100, which prevents accidental needle sticks. When the carriage 130 reaches the distal position in which flanges 170 engage fingers 184 of needle shuttle 134, needle shuttle 134 withdraws needle 124 automatically without further input from the user.

[0131] Prior to activation of the integrated sensor 14 and sensor electronics assembly 16 for use, there may be a period of time from the manufacturing that the assembly 16 may be in a "sleep" or "idle" mode. With a power supply such as a battery integrated within the assembly, for reasons including cost optimization and prolonging shelf life, embodiments of the present disclosure include systems that are activated merely by positioning the sensor 14 and electronics

unit 16 on a skin surface as described above, i.e., no additional action may be required of the user other than applying a force to housing 122. As such, insertion of the sensor 14 and/or mounting of the housing 122 causes activation of the electronics 80. In certain embodiments, activation switch configurations are included which may be configured to be triggered, for example, by the insertion device activation, thereby turning on the integrated sensor and sensor electronics assembly into an active mode.

[0132] As illustrated in FIGURE 29, inserter 100 is also provided with a plunger switch 185, which provides automatic activation of the electronics 80 of the data processing unit 12. In some embodiments, the plunger switch 185 is a longitudinally slidable member disposed on the distal surface of the sensor housing 122. When the sensor housing is advanced proximally, it engages the adhesive pad 118, or alternatively the skin surface of the subject. Upon such engagement, the plunger switch 185 is moved axially (proximally) with respect to the housing 122. The plunger switch in the proximal position is shown in FIGURE 30, for example. Such axial movement is used to activate the sensor electronics 80. In some embodiments, the plunger switch is spring biased. Accordingly, as long as the sensor housing is maintained in a fixed relationship with the adhesive pad 118 against the bias, electronic activation is maintained. If the sensor housing is removed from the adhesive or the skin, the plunger switch moves with the bias, and the electronics are deactivated. In other embodiments, the plunger switch provides a one-time activation of the electronics. In such cases, once the electronics are activated, the sensor housing is not required to remain in contact with the adhesive or the skin in order to maintain activation.

[0133] As illustrated in FIGURES 32-33, embodiments of a power supply switch mechanism include conductive plugs of the on-body integrated sensor and sensor electronics assembly 16 in accordance with the present disclosure. FIGURES 32-33 illustrate enlarged sectional views of sensor housing 122. As shown, the sensor electronics assembly circuit board 710 may be provided with a physical gap 750 that breaks the electrical circuit between the power supply (e.g., battery) and the other circuitry of the sensor electronics assembly.

[0134] In one embodiment, when the predetermined force is applied on the insertion device 100 as discussed above, a conductive portion 720 provided within the housing 122 of the sensor electronics may be moved in a direction as shown by arrow 730 such that electrical contact is established in the physical gap 750 on the circuit board, by for example, the conductive portion 720 coming into physical contact with the conductive portions 760 of the circuit board 710. In

this manner, in one embodiment, the electrical path from the power supply and the remaining circuitry on the circuit board of the sensor electronics is completed, thereby powering the sensor electronics.

[0135] By way of another example, referring to FIGURE 33, the conductive portions 760 of the circuit board are provided on the board itself, and the conductive plug 740, for example, when pushed into the cavity 750, establishes electrical contact between the conductive portions 760 of the circuit board.

[0136] In one embodiment, as discussed above, the actuation of the insertion device 100 to position the sensor and sensor electronics assembly triggers the switch mechanism shown in FIGURES 32-33 by also moving the conductive portion 720 or the conductive plug 760 in the direction complimentary to the direction of the introducer movement, and thereby switching on the sensor electronics. Within the scope of the present disclosure, the activation of the sensor electronics by moving the conductive portion 720 or the conductive plug may include a separate procedure, where after positioning the sensor and the sensor electronics assembly on the skin surface, a predetermined force is applied on the housing of the integrated sensor 14 and sensor electronics assembly such that the desired movement of the conductive portion 720 or the conductive plug 760 may be achieved.

[0137] FIGURES 34A-36B illustrate another configuration of the power supply switch mechanism including conductive pads of the on-body integrated sensor and sensor electronics assembly in accordance with embodiments of the present disclosure. Referring to FIGURE 34A, an exposed conductive ring 771 may be provided and configured to contact the surface of the circuit board in the sensor housing 122 (shown in cross section in FIGURE 34B) such that, the insertion device activation positions the conductive ring 771 on the surface of the circuit board so as to complete the electrical contact of the sensor housing 122 (by for example, manual force applied on the insertion device placing the conductive ring in contact with the circuit board of the sensor electronics).

[0138] Referring to FIGURES 35A-B, in another aspect, electrical contact pads 772, 773 may be provided to the circuit board in the sensor housing 122 (shown in cross section in FIGURE 35B, such that the mating of the contact pads with the conductive ring 771 switches on the sensor electronics device to provide power to the device from its power source. FIGURES 36A-B show yet another configuration of the switch activation mechanism in accordance with the present

disclosure, where a portion of the conductive ring 774 is selectively positioned and provided to establish electrical contact in the sensor housing 122 (shown in cross section in FIGURE 36B).

[0139] As discussed, each of the activation configurations described above includes a break in the circuitry from the power source such that the power supply is not drained when the device is not in use, and upon activation, the break in the electrical contact is completed, thereby powering the device and activating it for operation.

[0140] FIGURE 37 illustrates a power supply switch mechanism including an internal switch with a push rod activation of the on-body integrated sensor and sensor housing 122 in accordance with embodiments of the present disclosure. As shown, in one embodiment, push rod 810 may be provided and positioned in the sensor electronics such that when a force is applied in the direction as shown by arrow 830, the push rod 810 is displaced in the same direction and completes the electrical contact between the two contacts 820, 821. In one aspect, the push rod 810 may be provided within a seal 840 such as an O-ring or similar components.

[0141] FIGURE 38 illustrates power supply switch mechanism including introducer retraction trigger activation of the on-body integrated sensor and sensor housing 122 in accordance with embodiments of the present disclosure. As shown, a nonconducting needle or device 910 is provided to physically separate two electrical contacts 920, 921. Each of the electrical contacts 920, 921 is biased or spring loaded to be urged towards each other, physically separated by the nonconducting needle 910. Accordingly, when the nonconducting needle 910 is retracted or pulled away from the sensor electronics assembly in the direction as shown by arrow 930, the electrical contacts 920, 921 are configured to contact each other, thereby completing the break in the circuit and establishing electrical connection to activate the sensor electronics assembly. In one aspect, the nonconducting device or needle 910 may include, for example, but not limited to, glass, plastic or any other material suitable to separate two electrical contacts and provide insulation therebetween.

[0142] FIGURE 39 illustrates power supply switch mechanism with a contact switch of the on-body integrated sensor and sensor electronics assembly in accordance with embodiments of the present disclosure. As shown, in a further aspect, there is provided an electronic switch 1001 (that is configured to draw an insubstantial amount of power from the sensor electronics power supply), and when triggered, completes the break between the contacts 1010, 1011 by physically contacting the two contacts 1010, 1011 with the activation component 1002 that completes the

circuit in the sensor electronics from its power supply such as battery to activate the device for operation.

[0143] FIGURES 40-41 illustrate a power supply switch mechanism with a battery contact locking mechanism of the on-body integrated sensor and sensor electronics assembly 122 in accordance with the present disclosure. Referring to FIGURES 40-41, in still another aspect, the battery contact of the sensor electronics may be provided with a barbed tab 1110. In post manufacturing shelf mode when the device is nonoperational, the tab 1110 is positioned within the sensor electronics housing in the position as shown in FIGURE 40 so that it is not in contact with the conductive contact 1120 of the sensor electronics circuit board. When in use as shown in FIGURE 41, the tab 1110 may be biased such that it physically contacts the conductive contact 1120 on the circuit board, thereby closing the circuit to/from the battery/power source and thus activating or switching on the sensor electronics. As shown in the Figures, the tab 1110 may be configured that upon biasing to establish contact with the conductive contact 1120, it locks or latches with the conductive contact 1120 and the circuit board so as to maintain the electrical connection.

[0144] FIGURES 42-43 illustrate power supply switch mechanism with a bi-modal dome switch of the on-body integrated sensor and sensor electronics assembly in accordance with embodiments of the present disclosure. Yet in another embodiment, a bi-modal dome shaped switch 1210 is provided on the circuit board of the sensor electronics assembly such that, when pressed down (as shown in FIGURE 42), the dome shaped layer 1210 (which may include, for example, a thin sheet metal dome) may be configured to retain the concave shape as shown in FIGURE 43 and effectively closing the circuit on the circuit board at the contact point 1220. In one aspect, the dome shaped layer 1210 may be configured to shunt to short two or more electrical contacts at the contact point 1220 of the circuit board. Alternatively, the dome shaped layer 1210 may be connected to the circuit board such that one end of the dome shaped layer 1210 is in contact with one of the two or more open electrical contacts, and the depression of the dome shaped layer 1210 closes the circuit on the circuit board by physically contacting the other one or more of the open electrical contacts.

[0145] In the manner described above, in accordance with various embodiments of the present disclosure, sensor electronics activation switch configurations are provided that may be triggered or activated automatically or semi-automatically in response to the activation of the insertion

device described above, or alternatively, may be separately activated by the user by, for example, depressing upon a portion of the housing or switch provided on the housing of the sensor electronics. Accordingly, power consumption may be optimized for the sensor electronics assembly while improving post manufacturing shelf life of the device prior to use or activation.

[0146] It is understood that the subject matter described herein is not limited to particular embodiments described, as such may, of course, vary. It is also understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting, since the scope of the present subject matter is limited only by the appended claims.

[0147] Additional detailed description of embodiments of the disclosed subject matter are provided in but not limited to: U.S. Patent No. 7,299,082; U.S. Patent No. 7,167,818; U.S. Patent No. 7,041,468; U.S. Patent No. 6,942,518; U.S. Patent No. 6,893,545; U.S. Patent No. 6,881,551; U.S. Patent No. 6,773,671; U.S. Patent No. 6,764,581; U.S. Patent No. 6,749,740; U.S. Patent No. 6,746,582; U.S. Patent No. 6,736,957; U.S. Patent No. 6,730,200; U.S. Patent No. 6,676,816; U.S. Patent No. 6,618,934; U.S. Patent No. 6,616,819; U.S. Patent No. 6,600,997; U.S. Patent No. 6,592,745; U.S. Patent No. 6,591,125; U.S. Patent No. 6,560,471; U.S. Patent No. 6,540,891; U.S. Patent No. 6,514,718; U.S. Patent No. 6,514,460; U.S. Patent No. 6,503,381; U.S. Patent No. 6,461,496; U.S. Patent No. 6,377,894; U.S. Patent No. 6,338,790; U.S. Patent No. 6,299,757; U.S. Patent No. 6,299,757; U.S. Patent No. 6,284,478; U.S. Patent No. 6,270,455; U.S. Patent No. 6,175,752; U.S. Patent No. 6,161,095; U.S. Patent No. 6,144,837; U.S. Patent No. 6,143,164; U.S. Patent No. 6,121,009; U.S. Patent No. 6,120,676; U.S. Patent No. 6,071,391; U.S. Patent No. 5,918,603; U.S. Patent No. 5,899,855; U.S. Patent No. 5,822,715; U.S. Patent No. 5,820,551; U.S. Patent No. 5,628,890; U.S. Patent No. 5,601,435; U.S. Patent No. 5,593,852; U.S. Patent No. 5,509,410; U.S. Patent No. 5,320,715; U.S. Patent No. 5,264,014; U.S. Patent No. 5,262,305; U.S. Patent No. 5,262,035; U.S. Patent No. 4,711,245; U.S. Patent No. 4,545,382; U.S. Patent Publication No. 2004/0186365, published September 23, 2004, now U.S. Patent No. 7,811,231; U.S. Patent Application No. 61/238,646, filed August 31, 2009, the disclosures of each of which is incorporated herein by reference.

PTO/AIA/424 (03-14)

CERTIFICATION AND REQUEST FOR PRIORITIZED EXAMINATION UNDER 37 CFR 1.102(e) (Page 1 of 1)

First Named Inventor:	Phillip Yee	Nonprovisional Application Number (if known):	
Title of Invention:	ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR		

APPLICANT HEREBY CERTIFIES THE FOLLOWING AND REQUESTS PRIORITIZED EXAMINATION FOR THE ABOVE-IDENTIFIED APPLICATION.

1. The processing fee set forth in 37 CFR 1.17(i)(1), the prioritized examination fee set forth in 37 CFR 1.17(c), and if not already paid, the publication fee set forth in 37 CFR 1.18(d) have been filed with the request. The basic filing fee, search fee, and examination fee are filed with the request or have been already been paid. I understand that any required excess claims fees or application size fee must be paid for the application.

2. I understand that the application may not contain, or be amended to contain, more than four independent claims, more than thirty total claims, or any multiple dependent claims.

3. The applicable box is checked below:

I. ☑ Original Application (Track One) - Prioritized Examination under § 1.102(e)(1)

i. (a) The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a). This certification and request is being filed with the utility application via EFS-Web.

---OR---

(b) The application is an original nonprovisional plant application filed under 35 U.S.C. 111(a). This certification and request is being filed with the plant application in paper.

ii. An executed inventor's oath or declaration under 37 CFR 1.63 or 37 CFR 1.64 for each inventor, **or** the application data sheet meeting the conditions specified in 37 CFR 1.53(f)(3)(i) is filed with the application.

II. ☐ Request for Continued Examination - Prioritized Examination under § 1.102(e)(2)

i. A request for continued examination has been filed with, or prior to, this form.
ii. If the application is a utility application, this certification and request is being filed via EFS-Web.
iii. The application is an original nonprovisional utility application filed under 35 U.S.C. 111(a), or is a national stage entry under 35 U.S.C. 371.
iv. This certification and request is being filed prior to the mailing of a first Office action responsive to the request for continued examination.
v. No prior request for continued examination has been granted prioritized examination status under 37 CFR 1.102(e)(2).

Signature /Glen Liu/	Date 4/2/2021
Name (Print/Typed) Glen Liu	Practitioner Registration Number 75,058

Note: *This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. Submit multiple forms if more than one signature is required.**

☑ *Total of 1 forms are submitted.

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Docket Nos.: A0130.0113.C11
(PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Phillip Yee et al.

Application No.: To be assigned | Confirmation No.: To be assigned

Filed: April 2, 2021 | Art Unit: To be assigned

For: ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR | Examiner: To be assigned

INFORMATION DISCLOSURE STATEMENT (IDS)

EFS Web
Commissioner for Patents

Dear Sir:

Pursuant to 37 CFR 1.56, 1.97 and 1.98, the attention of the Patent and Trademark Office is hereby directed to the references listed on the attached PTO/SB/08. It is respectfully requested that the information be expressly considered during the prosecution of this application, and that the references be made of record therein and appear among the "References Cited" on any patent to issue therefrom.

Timing of Filing of the Information Disclosure Statement:

☒ This IDS is being filed before the First Office Action.

☐ This IDS is being filed after the issuance of the First Office Action but before the issuance of a Final Office Action.

☐ This IDS is being filed after the issuance of a Final Office Action, Ex Parte Quayle Action or Notice of Allowance but before the payment of the Issue Fee.

Certifications:

If checked, the undersigned makes the following statement(s):

☐ Statement under 37 CFR § 1.97(e):

☐ Each item of information contained in this information disclosure statement was first cited in any communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this information disclosure statement; or

☐ No item of information contained in this information disclosure statement was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the undersigned after making reasonable inquiry, no item of information contained in this information disclosure statement was known to any individual designated in § 1.56(c) more than three months prior to the filing of the information disclosure statement.

☐ Statement Under 37 C.F.R. § 1.704(d):

Each item of information contained in this information disclosure statement was cited a counterpart application less than thirty days prior to the filing of this information disclosure statement.

Fee Required by 37 C.F.R. § 1.97(c)(2) or 1.97(d)(2):

☐ If checked, the fee of $240.00 set forth in 37 C.F.R. §1.17(p).

Copies of Information:

In accordance with 37 C.F.R. §1.98(a), the following are enclosed:

☒ A legible copy of each document (or relevant portion thereof) cited in the attached PTO/SB/08, except for U.S. patent and U.S. published applications.

☒ With respect to any information which is not in English, a concise explanation of the relevance, as it is presently understood by the individual designated in § 1.56(c) most knowledgeable about the content of the information, is attached.

This concise explanation is provided by way of:

☒ A translation of the relevant portions of the non-English language information;

☐ A statement explaining the relevant portions of the non-English language information;

☐ A copy [and where not in the English language, a translation] of at least the relevant portion(s) of the communication from _____in which the information was cited; or

☐ This information is contained in the specification of the present application.

☒ In accordance with 37 C.F.R. 1.98(d), copies of the cited documents are not enclosed as they were provided in application Serial No. 12/698,129, filed February 1, 2010, and Serial No. 17/009,647, filed September 1, 2020, which the present application relies upon for an earlier effective filing date under 35 U.S.C. 120.

Materiality:

Whether or not the information and references disclosed in this Information Disclosure Statement is "material" pursuant to 37 CFR 1.56, this submission is not intended to constitute an admission that any patent, publication or other information referred to therein is "prior art" for this invention unless specifically designated as such.

In accordance with 37 CFR 1.97(g), the filing of this Information Disclosure Statement shall not be construed to mean that a search has been made or that no other material information as defined in 37 CFR 1.56(a) exists.

It is submitted that the Information Disclosure Statement is in compliance with 37 CFR 1.98 and the Examiner is respectfully requested to consider the listed references.

Dated: April 2, 2021

Respectfully submitted,

Electronic signature: /Glen Liu/
Glen Liu
Registration No.: 75,058
ONE LLP
4000 MacArthur Boulevard
East Tower, Suite 500
(949) 502-2870
Attorney for Applicants

Electronic Patent Application Fee Transmittal

Application Number:	
Filing Date:	
Title of Invention:	ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR
First Named Inventor/Applicant Name:	Phillip Yee
Filer:	Glen Liu/Alana Fredericks
Attorney Docket Number:	A0130.0113.C11

Filed as Large Entity

Filing Fees for Track I Prioritized Examination - Nonprovisional Application under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
UTILITY APPLICATION FILING	1011	1	320	320
UTILITY SEARCH FEE	1111	1	700	700
UTILITY EXAMINATION FEE	1311	1	800	800
REQUEST FOR PRIORITIZED EXAMINATION	1817	1	4200	4200
Pages:				
Claims:				
CLAIMS IN EXCESS OF 20	1202	10	100	1000
Miscellaneous-Filing:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
PUBL. FEE- EARLY, VOLUNTARY, OR NORMAL	1504	1	0	0
PROCESSING FEE, EXCEPT PROV. APPLS.	1830	1	140	140

Petition:	
Patent-Appeals-and-Interference:	
Post-Allowance-and-Post-Issuance:	
Extension-of-Time:	
Miscellaneous:	
Total in USD ($)	**7160**

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
17/221,154	04/02/2021	3791	2820	A0130.0113.C11	30	2

CONFIRMATION NO. 5985

FILING RECEIPT

95508
One LLP
4000 MacArthur Blvd.
East Tower, Suite 500
Newport Beach, CA 92660

OC000000124771327

Date Mailed: 04/12/2021

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Phillip Yee, San Francisco, CA;
Christopher A. Thomas, San Leandro, CA;
Udo Hoss, Castro Valley, CA;
Lei He, Moraga, CA;
Michael R. Love, Pleasanton, CA;

Applicant(s)

ABBOTT DIABETES CARE INC., Alameda, CA;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 17/009,647 09/01/2020
which is a CON of 16/736,728 01/07/2020 PAT 10786190
which is a CON of 15/994,129 05/31/2018 ABN
which is a CON of 15/475,647 03/31/2017 PAT 9993188
which is a CON of 15/192,531 06/24/2016 PAT 9636068
which is a CON of 12/698,129 02/01/2010 PAT 9402544
which claims benefit of 61/149,639 02/03/2009

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 04/09/2021

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 17/221,154**

Projected Publication Date: 07/22/2021

Non-Publication Request: No

Early Publication Request: No

Title

ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR

Preliminary Class

600

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor

community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 17/221,154

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	320
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	700
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	800
TOTAL CLAIMS (37 CFR 1.16(i))	30 minus 20 =	* 10			OR	x 100 =	1000
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2 minus 3 =	*				x 480 =	0.00
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0.00
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0.00
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	2820

APPLICATION AS AMENDED - PART II

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))									
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
17/221,154	04/02/2021	Phillip Yee	A0130.0113.C11	5985

95508 7590 05/20/2021

One LLP
4000 MacArthur Blvd.
East Tower, Suite 500
Newport Beach, CA 92660

EXAMINER	
ART UNIT	PAPER NUMBER
3791	

NOTIFICATION DATE	DELIVERY MODE
05/20/2021	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

IPdocketing@onellp.com
PAIRgroup@onellp.com
onellpdocketing@onellp.com

Decision Granting Request for Prioritized Examination (Track I)	**Application No.** 17/221,154	**Applicant(s)** Yee et al.	
	Examiner TERRI S JOHNSON	**Art Unit** OPET	**AIA (FITF) Status** No

1. THE REQUEST FILED 02 April 2021 IS **GRANTED** .

The above-identified application has met the requirements for prioritized examination

A. ☑ for an original nonprovisional application (Track I).
B. ☐ for an application undergoing continued examination (RCE).

2. **The above-identified application will undergo prioritized examination**. The application will be accorded special status throughout its entire course of prosecution until one of the following occurs:

A. filing a **petition for extension of time** to extend the time period for filing a reply;

B. filing an **amendment to amend the application to contain more than four independent claims, more than thirty total claims** , or a multiple dependent claim;

C. filing a **request for continued examination** ;

D. filing a notice of appeal;

E. filing a request for suspension of action;

F. mailing of a notice of allowance;

G. mailing of a final Office action;

H. completion of examination as defined in 37 CFR 41.102; or

I. abandonment of the application.

Telephone inquiries with regard to this decision should be directed to TERRI JOHNSON at (571)272 -2991. In his/her absence, calls may be directed to Petition Help Desk at (571) 272-3282.

/TERRI S JOHNSON/ Paralegal Specialist, OPET	

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
17/221,154	04/02/2021	Phillip Yee	A0130.0113.C11

CONFIRMATION NO. 5985

PUBLICATION NOTICE

95508
One LLP
4000 MacArthur Blvd.
East Tower, Suite 500
Newport Beach, CA 92660

OC000000127155584

Title:ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR

Publication No.US-2021-0219886-A1
Publication Date:07/22/2021

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently https://portal.uspto.gov/pair/PublicPair. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:
Phillip Yee et al.

Application No.: 17/221,154 | Confirmation No.: 5985

Filed: April 2, 2021 | Art Unit: 3791

For: ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR | Examiner: Christian Yongkyun Jang

SECOND PRELIMINARY AMENDMENT

EFS Web
Commissioner for Patents

INTRODUCTORY COMMENTS

Prior to examination, please amend the application as follows:

Amendments to the Claims beginning on page 2 of this paper; and

Remarks beginning on page 9 of this paper.

AMENDMENTS TO THE CLAIMS

This listing of claims replaces all previous versions of the claims in the application.

1-20. (Canceled)

21. (Previously presented) An insertion assembly, comprising:

(a) an on-body unit, comprising:

a housing comprising a top surface and a bottom surface, wherein the top surface comprises an opening of the top surface, wherein the bottom surface comprises an opening of the bottom surface, and wherein a longitudinal axis extends through the opening of the top surface and the opening of the bottom surface;

a glucose sensor; and

sensor electronics disposed within the housing and coupled with the glucose sensor; and

(b) an inserter, comprising:

a proximal end, a distal end, and an interior; and

a sharp,

wherein the on-body unit and the sharp are entirely disposed in the interior of the inserter,

wherein at least a portion of the glucose sensor is disposed in the sharp,

wherein the inserter is configured to advance the on-body unit and the sharp in a linear direction from a first position to a second position such that the sharp pierces skin of a user and the housing of the on-body unit is secured to the skin of the user in the second position,

wherein the sharp extends through the opening of the top surface and the opening of the bottom surface along the longitudinal axis when the on-body unit is in the first position,

wherein the distal end of the inserter is configured to be positioned on the skin of the user before advancement of the on-body unit and the sharp,

wherein the inserter is further configured to automatically retract the sharp from within the user and entirely into the interior of the inserter and leave a part of the glucose sensor in the skin of the user, and

wherein the distal end of the inserter is further configured to be removed from the skin of the user after automatic retraction of the sharp from within the user.

22. (Previously presented) The insertion assembly of claim 21, further comprising an adhesive portion configured to secure the housing to the skin of the user, wherein the adhesive portion is further configured to extend outwardly beyond the bottom surface of the housing along the skin in all directions when the housing is secured to the skin of the user.

23. (Previously presented) The insertion assembly of claim 22, wherein a distance between the housing when the on-body unit is in the first position and the housing when the on-body unit is in the second position is greater than a maximum height of the housing.

24. (Previously presented) The insertion assembly of claim 23, wherein the sensor electronics comprise a processor, a power source, an analog interface, a data storage unit, and wireless communication circuitry configured to communicate data indicative of a glucose level.

25. (Previously presented) The insertion assembly of claim 23, wherein the sharp is configured to pierce the skin of the user at an angle substantially perpendicular to the skin of the user.

26. (Previously presented) The insertion assembly of claim 23, wherein the on-body unit further comprises a side wall of the housing, wherein the side wall is located between the top surface and the bottom surface, wherein the side wall comprises a first portion and a second portion, and wherein the second portion of the side wall defines a non-orthogonal angle relative to both the first portion of the side wall and the top surface of the housing.

27. (Previously presented) The insertion assembly of claim 23, wherein the sensor electronics are in a sleep mode or an idle mode when the on-body unit is in the first position.

28. (Previously presented) The insertion assembly of claim 23, wherein the sensor electronics are configured to be activated when the on-body unit is at or near the second position.

29. (Previously presented) The insertion assembly of claim 23, wherein the sensor electronics further comprise an opening of the sensor electronics along the longitudinal axis, and wherein the sharp extends through the opening of the sensor electronics when the on-body unit is in the first position.

30. (Currently amended) The insertion assembly of claim 23, ~~wherein the proximal end of the inserter comprises an inserter handle,~~ wherein ~~the distal end of~~ the inserter further comprises an inserter base, and wherein the ~~inserter handle~~ proximal end of the inserter is configured to move in a downward direction toward the skin of the user relative to the inserter base in response to an application of force on the ~~inserter handle~~ proximal end of the inserter.

31. (Currently amended) The insertion assembly of claim 30, wherein the inserter is configured to advance the on-body unit and the sharp from the first position to the second position after the application of force on the ~~inserter handle~~ proximal end of the inserter.

32. (Previously presented) The insertion assembly of claim 23, further comprising a cap removably attached to a distal portion of the inserter by a plurality of threads, and wherein the cap comprises an interior space comprising a sterile environment.

33. (Previously presented) The insertion assembly of claim 32, wherein the cap further comprises a plurality of vertically extending grooves spaced apart around an outer perimeter surface of the cap.

34. (Previously presented) The insertion assembly of claim 23, wherein a height profile of the housing is less than or equal to approximately 10 millimeters.

35. (Previously presented) The insertion assembly of claim 23, further comprising a sensor hub,

wherein the glucose sensor comprises a distal sensor portion and a proximal sensor portion,

wherein the distal sensor portion is configured to sense a glucose level of the user,

wherein the proximal sensor portion is engaged with the sensor hub, and

wherein the distal sensor portion is substantially orthogonal to the proximal sensor portion.

36. (Previously presented) The insertion assembly of claim 23, wherein the distal end of the inserter defines a plane, and wherein the bottom surface of the housing is parallel to the plane when the on-body unit is in the first position.

37. (Previously presented) The insertion assembly of claim 22, wherein the opening of the top surface is a first opening of the top surface, wherein the top surface further comprises a second opening of the top surface, wherein the first opening of the top surface has a first maximum width, and wherein the second opening of the top surface has a second maximum width less than the first maximum width.

38. (Previously presented) The insertion assembly of claim 23, wherein the on-body unit is configured to be disposed after a single use.

39. (Previously presented) An insertion assembly, comprising:

(a) an on-body unit, comprising:

a housing comprising a top surface and a bottom surface, wherein the top surface comprises an opening of the top surface, wherein the bottom surface comprises an opening of the bottom surface, and wherein a longitudinal axis extends through the opening of the top surface and the opening of the bottom surface;

a glucose sensor; and

sensor electronics disposed within the housing and coupled with the glucose sensor, wherein the sensor electronics comprise a processor, a power source, an analog interface, a data storage unit, and wireless communication circuitry configured to communicate data indicative of a glucose level; and

(b) an inserter, comprising:

a proximal end, a distal end, and an interior; and

a sharp;

wherein the on-body unit and the sharp are entirely disposed in the interior of the inserter,

wherein at least a portion of the glucose sensor is disposed in the sharp,

wherein the inserter is configured to advance the on-body unit and the sharp in a linear direction from a first position to a second position such that the sharp pierces skin of a user and the housing of the on-body unit is secured to the skin of the user in the second position,

wherein a distance between the housing when the on-body unit is in the first position and the housing when the on-body unit is in the second position is greater than a maximum height of the housing,

wherein a height profile of the housing is less than or equal to approximately 10 millimeters,

wherein the sharp is configured to pierce the skin of the user at an angle substantially perpendicular to the skin of the user,

wherein the sharp extends through the opening of the top surface and the opening of the bottom surface along the longitudinal axis when the on-body unit is in the first position,

wherein the distal end of the inserter is configured to be positioned on the skin of the user before advancement of the on-body unit and the sharp,

wherein the inserter is further configured to automatically retract the sharp from within the user and entirely into the interior of the inserter and leave a part of the glucose sensor in the skin of the user, and

wherein the distal end of the inserter is further configured to be removed from the skin of the user after automatic retraction of the sharp from within the user.

40. (Previously presented) The insertion assembly of claim 39, further comprising an adhesive portion configured to secure the housing to the skin of the user, wherein the adhesive portion is configured to extend outwardly beyond the bottom surface of the housing along the skin in all directions when the housing is secured to the skin of the user.

41. (Previously presented) The insertion assembly of claim 40, wherein the opening of the top surface is a first opening of the top surface, wherein the top surface further comprises a second opening of the top surface, wherein the first opening of the top surface has a first maximum width, and wherein the second opening of the top surface has a second maximum width less than the first maximum width.

42. (Previously presented) The insertion assembly of claim 41, wherein the sensor electronics further comprise an opening of the sensor electronics along the longitudinal axis, and wherein the sharp extends through the opening of the sensor electronics when the on-body unit is in the first position.

43. (Previously presented) The insertion assembly of claim 42, wherein the distal end of the inserter defines a plane, and wherein the bottom surface of the housing is parallel to the plane when the on-body unit is in the first position.

44. (Currently amended) The insertion assembly of claim 43, ~~wherein the proximal end of the inserter comprises an inserter handle,~~ wherein ~~the distal end of~~ the inserter further comprises an inserter base, wherein the ~~inserter handle~~ proximal end of the inserter is configured to move in a downward direction toward the skin of the user relative to the inserter base in response to an application of force on the ~~inserter handle~~ proximal end of the inserter, and wherein the inserter is configured to advance the on-body unit and the sharp from the first position to the second position after the application of force on the ~~inserter handle~~ proximal end of the inserter.

45. (Previously presented) The insertion assembly of claim 43, wherein the sensor electronics are in a sleep mode or an idle mode when the on-body unit is in the first position.

46. (Previously presented) The insertion assembly of claim 43, wherein the sensor electronics are configured to be activated when the on-body unit is at or near the second position.

47. (Previously presented) The insertion assembly of claim 43, wherein the on-body unit further comprises a side wall of the housing, wherein the side wall is located between the top surface and the bottom surface, wherein the side wall comprises a first portion and a second portion, and wherein the second portion of the side wall defines a non-orthogonal angle relative to both the first portion of the side wall and the top surface of the housing.

48. (Previously presented) The insertion assembly of claim 43, further comprising a sensor hub,

wherein the glucose sensor comprises a distal sensor portion and a proximal sensor portion,

wherein the distal sensor portion is configured to sense a glucose level of the user,

wherein the proximal sensor portion is engaged with the sensor hub, and

wherein the distal sensor portion is substantially orthogonal to the proximal sensor portion.

49. (Previously presented) The insertion assembly of claim 43, further comprising a cap removably attached to a distal portion of the inserter by a plurality of threads, and wherein the cap comprises an interior space comprising a sterile environment.

50. (Previously presented) The insertion assembly of claim 49, wherein the cap further comprises a plurality of vertically extending grooves spaced apart around an outer perimeter surface of the cap.

Electronic Acknowledgement Receipt

EFS ID:	43640306
Application Number:	17221154
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Confirmation Number:	5985
Title of Invention:	ANALYTE SENSOR AND APPARATUS FOR INSERTION OF THE SENSOR
First Named Inventor/Applicant Name:	Phillip Yee
Customer Number:	95508
Filer:	Glen Liu/Alana Fredericks
Filer Authorized By:	Glen Liu
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Receipt Date:	30-AUG-2021
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Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		9591USC17_A0130_0113_C11_2nd_Preliminary_Amendment.pdf	109717 19145f61520ddb6d319602d6d27e2d7c09d42cc0	yes	10

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Preliminary Amendment	1	1
	Claims	2	8
	Applicant Arguments/Remarks Made in an Amendment	9	10
Warnings:			
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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

REMARKS

Claims 21-50 are pending, of which claims 30, 31, and 44 have been amended without prejudice. Claims 1-20 remain canceled without prejudice. Examination of the pending claims is respectfully requested. Support for the amendments can be found, for example, in Figures 10, 28, 29, 30, and 31 and paragraphs [0110]-[0113], [0123]-[0127], and elsewhere throughout the application as filed, as well as Provisional Patent Application Serial No. 61/149,639, to which the instant application claims benefit, and which has been incorporated by reference by the instant application in its entirety for all purposes. No new matter has been introduced.

All citations to claim support are purely for the benefit of the Examiner. It is stressed that the citations are only examples and in no way constitute an exhaustive recitation of all written and depicted support for the claims. Additional support can be found elsewhere, including citations from both the specification and figures that are not stated, as well as the knowledge of those of ordinary skill in the art. These citations in no way constitute a disclaimer that the claim covers only that subject matter which is cited herein and in no way define the inventive subject matter as being only that which is cited herein.

The right is reserved to pursue claims to any subject matter supported by the disclosure of this application in one or more continuation and/or divisional applications at a later time, including the subject matter of any previously pending claims regardless of whether those claims were amended or cancelled herein. This may entail the pursuit of broader and/or narrower claims, and/or subject matter that was previously relinquished by virtue of argument or amendment.

It is respectfully submitted that all claims are in allowable form. In the event that the Examiner deems that a discussion would be helpful in advancing prosecution, the Examiner is invited to call the undersigned at (949) 432-9993. The USPTO is hereby authorized to charge any outstanding fees to Deposit Account No. 50-5201.

Dated: August 30, 2021

Respectfully submitted,

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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 17/221,154	Filing Date 04/02/2021	☐ To be Mailed

ENTITY: ☑ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA		RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A		N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A		N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*		x $100 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*		x $480 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).				
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))					
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL	

APPLICATION AS AMENDED - PART II

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT	08/30/2021	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 30	Minus	** 30	= 0		x $100 =	0
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0		x $480 =	0
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	0

		(Column 1)		(Column 2)	(Column 3)			
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=		x $0 =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=		x $0 =	
	☐ Application Size Fee (37 CFR 1.16(s))							
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							
							TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.	LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".	/ROSS W BROWN/
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The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.	

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Transcutaneous gas sensor

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(73) Proprietors
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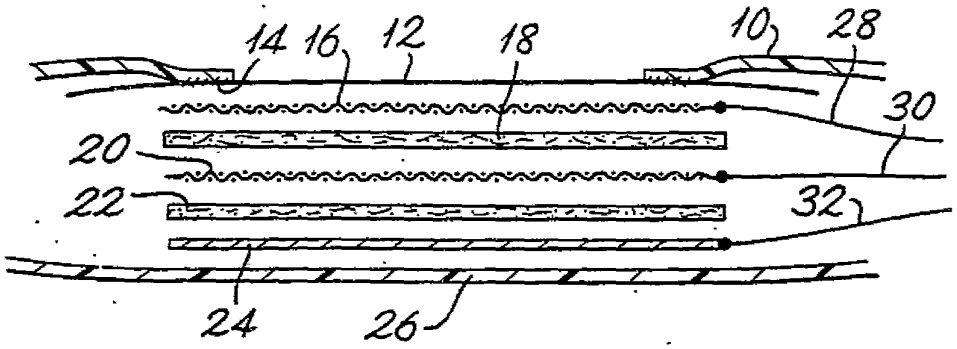
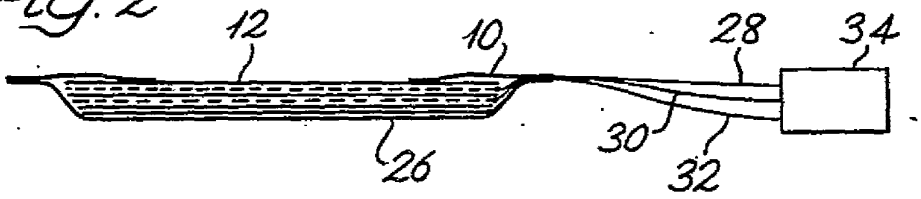


Fig. 1

Fig. 2



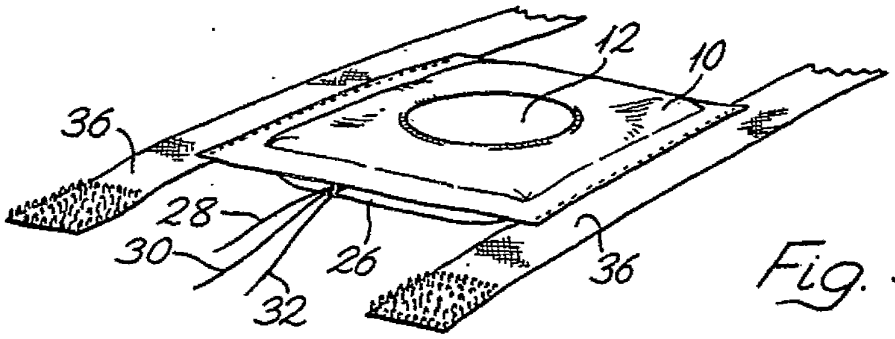


Fig. 3

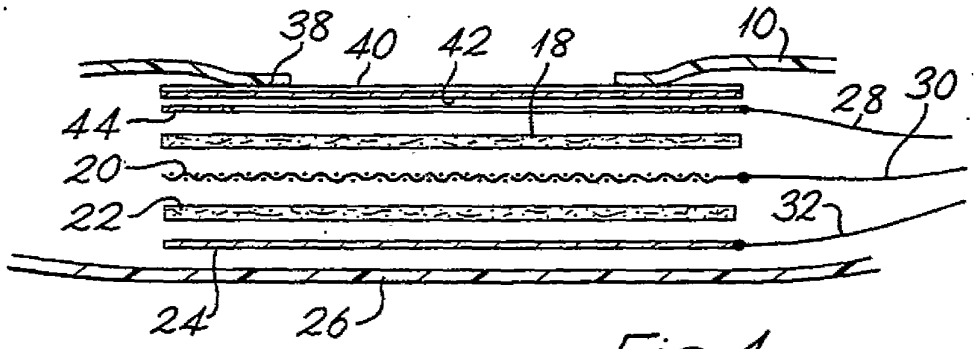


Fig. 4

TRANSCUTANEOUS GAS SENSOR

When a measurement is required of the concentration of a gas in a body tissue, it is preferable if the method of measurement is non-invasive. When the concentration of a gas is low, it may be difficult to make a reliable measurement by such a method.

One example of a non-invasive measurement is that in which oxygen in arterial blood is measured transcutaneously by placing a gas sensor housed in a rigid container on a patient's body over an artery. A disadvantage of the method is that the skin must be heated to about 40°C to increase its permeability to oxygen, with the attendant risk of burning unless the sensor is frequently moved to different locations. Consequently the sensor cannot be left in position for long periods for use in a gas monitoring mode. Moreover, adequate sealing between the sensor and the skin is not ensured.

According to the invention, a transcutaneous gas sensor comprises a series of essentially flat, flexible components, the components being in order:-

a first fluid-impermeable film of high polymeric material, at least an area of which is permeable to the gas to be sensed;

a working electrode;

a first porous insulating layer;

a reference electrode;

a second porous insulating layer;

a counter electrode; and

a second fluid-impermeable film of high polymeric material;

the three electrodes and the two insulating layers being of approximately the same area, the first and second films being of larger area than the other components and being sealed together at their edges in a liquid-tight manner so as to retain an electrolyte, and there being also provided a connection to each electrode which extends outside the first and second films through a liquid-tight seal.

The working electrode may be a platinum electrode, either in the form of a gauze, or in the form of a metallised membrane of hi ʰ polymeric material, the membrane then constituting the gas-permeable area of the first film.

The reference electrode may be a gauze of silver, having an anodization coating of silver chloride.

The counter electrode may be a lead/lead dioxide electrode, formed electrochemically in situ by providing a sheet or gauze of lead, and causing the conditions in the sensor to be such that lead is oxidised in the electrolyte.

The gas permeable area of the first film may comprise a piece of relatively thin film sealed at its edges to cover an aperture in a relatively thick, gas-impermeable film, which in turn is sealed to the second film. The relatively thin film may be the membrane layer of a metallised membrane electrode.

The invention will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 illustrates in exploded form the layers in a first embodiment of a transcutaneous gas sensor;

Figure 2 is a section through the sensor in its operating form;

Figure 3 is a view of the sensor; and

Figure 4 illustrates in exploded form the layers in a second embodiment of a transcutaneous gas sensor.

In Figure 1, a first sheet 10 of polyethylene 0.5 to 1.0 millimetres thick has a circular aperture which is closed by a sheet 12 of 6 to 12 microns thick polyethylene film; the sheets are heat sealed together around the aperture, as indicated at reference 14. Below the polyethylene film 12 is a platinum gauze 16, a filter paper 18, a silver/silver chloride gauze 20, a filter paper 22, a lead/lead oxide sheet or gauze 24

and a second sheet 26 of polyethylene 0.5 to 1.0 millimetres thick. The polyethylene sheets are of larger areas than the metal and filter paper layers, and are heat sealed together at their outer edges to give a sandwich construction of sensor as illustrated in Figure 2. Just before the final length of heat seal is made, the sensor is filled with an electrolyte, then fully sealed. Wire contacts 28, 30, 32 to respectively the working, reference and counter electrodes extend through the heat seal and are connected to a potentiostatic electrical circuit 34.

A suitable electrolyte is a conductive gel, such as "Neptic" (Registered Trade Mark) electrode gel, which contains sodium chloride and glycerol, and is used for electrocardiograph or electroencephalograph electrodes. Alternatively, a gel made up with sodium sulphate may be used.

In use, the potentiostatic circuit 34 applies a voltage (which may be variable) to the lead/lead oxide counter electrode 24 such that the platinum working electrode 16 is held at a fixed potential with respect to the silver/silver chloride reference electrode 20 which is constant and at which any hydrogen gas permeating through the permeable membrane 12 is oxidised. There is a corresponding reduction reaction at the counter electrode and the current generated by the electrochemical reaction is measured as the potential drop across a current measuring resistor in series with the counter electrode. The electrochemical cell is operated in the diffusion limited mode i.e. the rate of reaction is limited by the diffusion or mass transport of the reacting gas passing through the polyethylene film 12; the current generated is proportional to the concentration (partial pressure) of reactive gas in the gas sample. The current is measured by the circuit 34.

When the cell is constructed, a sheet or gauze of freshly

scraped lead is placed at the counter electrode position, and is oxidised in situ when the sensor is complete and filled with electrolyte. The membrane 12 is exposed to an oxygen-containing gas, such as air, and the connections 28, 32 of the working electrode and counter electrode to the circuit 34 are reversed. The circuit is arranged to apply to the working electrode a potential (about - 400 to-600 millivolts) with respect to the reference electrode 20 such that the lead sheet or gauze is oxidised. A layer of lead dioxide forms on the surface of the lead to give a lead/lead dioxide electrode. For use as a hydrogen sensor, the two connections are then reversed to their original positions and a potential of +200 to +300 millivolts with respect to the reference electrode is applied.

The layer of lead dioxide formed in this way is ordered, with regular close packing, and adheres to the lead very strongly; the electrode is therefore insensitive to vibration. Further, only one allotrope of three possible oxides is formed giving further stability in contrast with a mixed allotrope lead dioxide which has varying electrical properties.

The thickness of the lead dioxide layer increases with time in accordance with Faraday's and Coulomb's laws and since lead dioxide is reduced in the sensing mode of the cell, the life of the counter electrode can be predicted. It is a great advantage that the counter electrode can be regenerated after use by reversal of the two electrode connections as before. As an example, if the hydrogen sensor is to measure very low concentrations of hydrogen, such as a few parts per million, then a lead/lead dioxide counter electrode having a life of 12 months can be prepared by running the cell in the reverse mode for 8 hours.

The fully-prepared sensor is moderately flexible, and even when flexed the components retain essentially the same geometric

relationship. As a consequence the electrochemical kinetic equilibria are undisturbed by minor flexing. The flexibility allows the sensor to be applied to a curved surface, such as a human limb, and an air-tight seal between the skin and the gas permeable film can be made. The sensor is very sensitive and the skin does not need to be heated to allow measurement of hydrogen concentration to be made, even if it is as low as 1 or 2 parts per million. The sensor can be left in place to allow continuous gas monitoring over extended periods.

An external construction suitable for application to a human limb is illustrated in Figure 3. Two edges of the square sensor are attached to strips 36 of "Velcro" (Registered Trade Mark). The sensor is placed in position with membrane 12 on the skin over a vein or artery in a limb, and the strips 36 are wrapped round to overlap and hold the sensor securely in position without discomfort.

In a modification (not illustrated) a rubber washer is placed between the human limb and the outer part of the area of the device which contacts it. Use of such a washer minimises noise generation due to movement of the patient.

A modified construction is shown in Figure 4. Items identical to those in Figure 1 are given the same reference numerals. The aperture in the first sheet 10 is attached by a heat seal 38 to the membrane layer 40 of a metallised membrane electrode, which comprises a 6 to 25 micron sheet of polycarbonate or polyethylene on to which a layer 42 of platinum has been deposited. The metal layer 42 is in contact with a platinum ring 44 to which the working electrode connection 28 is attached. The other parts of the cell are identical to those in Figure 1. It is an advantage of the use of a metallized membrane electrode that the response time of the cell is reduced in comparison with a cell having a gas-permeable layer and a separate platinum gauze working electrode.

By choice of suitable materials for the permeable film, the electrodes and the electrolyte, gases other than hydrogen can be sensed. However, it is an advantage of the use of a dilute sodium chloride as in the example above that if the membrane punctures when in contact with a patient, the released liquid is not harmful.

CLAIMS

1. A transcutaneous gas sensor comprises a series of essentially flat, flexible components, the components being in order:-

a first fluid-impermeable film of high polymeric material, at least an area of which is permeable to the gas to be sensed;

a working electrode;

a first porous insulating layer;

a reference electrode;

a seond porous insulating layer;

a counter electrode; and

a second fluid-impermeable film of high polymeric material;

the three electrodes and the two insulating layers being of approximately the same area, the first and second films being of larger area than the other components and being sealed together at their edges in a liquid-tight manner so as to retain an electrolyte, and there being also provided a connection to each electrode which extends outside the first and second films through a liquid-tight seal.

2. A sensor according to Claim 1 in which the working electrode is a platinum gauze.

3. A sensor according to Claim 1 in which the working electrode is a metallised membrane of high polymeric material, the membrane also constituting the gas-permeable area of the first film.

4. A sensor according to any preceding claim in which the reference electrode is a silver gauze having an anodisation coating of silver chloride.

5. A sensor according to any preceding claim in which the counter electrode is a lead/lead dioxide electrode formed electrochemically in situ by providing a sheet or gauze of lead, and causing the lead to be oxidised in the electrolyte.

6. A sensor according to any preceding claim in which the gas permeable area of the first film comprises an area of

relatively thin film sealed at its edges to cover an aperture in a relatively thick, gas-impermeable film.

7. A sensor according to any preceding claim containing an electrolyte which is an electrically conductive gel.

8. A transcutaneous gas sensor substantially as hereinbefore described with reference either to Figure 1, 2 and 3 or to Figure 4 of the accompanying drawings.

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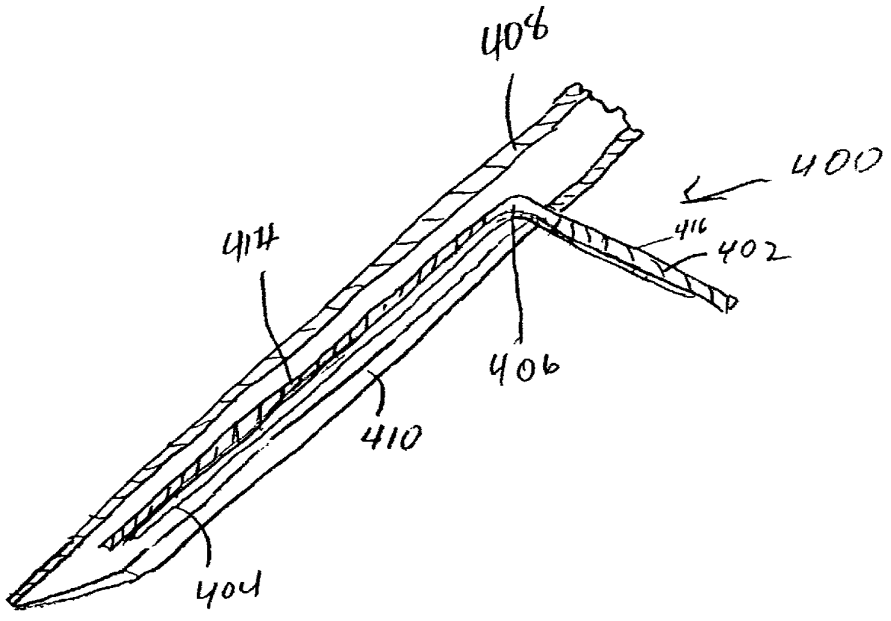
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(54) Title: IMPROVED ANALYTE SENSOR AND METHOD OF MAKING THE SAME



(57) Abstract: A sensor and method of making the same for implantation in a body that includes a substrate with notches cut in the substrate to form a necked down region in the substrate; and at least one sensor electrode formed from one or more conductive layers. Preferably, the thickness of the substrate ranges from approximately 25 μ to 350 μ, but the thickness of the substrate can range from 5 μ to 750 μ. The sensor may be incorporated in to a sensor assembly includes a slotted needle having a slot. The notches creating the necked down region allow the substrate to slide into the slotted needle, which has the slot narrow enough to permit passage of the necked down region. However, a non-necked down region of the substrate is prevented from pulling out of the slotted needle through the slot. The slot of the slotted needle may also permit the necked down region of the substrate to slide down the slot.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Title:

IMPROVED ANALYTE SENSOR AND METHOD OF MAKING THE SAME

Related Applications:

This application is a continuation of U.S. Patent Application Serial No. 09/502,444, filed February 11, 2000, which is a continuation of U.S. Patent Application Serial No. 09/502.204 filed February 10, 2000, both of which are specifically incorporated by reference.

Field of the Invention

The present invention relates to methods for producing sensors that include flexible substrates and one or more sensor electrodes, and in particular embodiments to sensor sets including such sensors.

Background of the Invention

Methods for producing sensors, particularly sensors useful in sensor sets for the determination of a body characteristic such as blood glucose levels, are known. Examples of such sensors, sensor sets and methods for production thereof are described, e.g., in commonly assigned U.S. Patent No. 5,390,691; No. 5,391,250; No. 5,482,473; No. 5,299,571; No. 5,586,553; and No. 5,568,806, each of which is incorporated in its entirety herein by reference.

Certain known methods, such as that described in U.S. Patent No. 5,391, 250, form the sensor electrodes by an etching process. Etching processes are often multi-step procedures that can be time-consuming and expensive. Accordingly, a need exists for a simplified process for producing sensors.

Alternative methods described in PCT/US99/03781, published September 10, 1999 and based on U.S Patent Application Serial No. 09/034,422, form sensor electrodes by, for example, first forming a channel in a substrate, which can be a continuous web, and then depositing conductive material in the channel to form the electrode.

A need also exists for an improved process that enables continuous formation of sensors.

Summary of the Preferred Embodiments

It is an object of an embodiment of the present invention to provide an improved sensor and method of making the same, which obviates for practical purposes, the above mentioned limitations.

According to an embodiment of the invention, a sensor and a method of making the same for implantation in a body includes a substrate with notches cut in the substrate to form a necked down region in the substrate; and at least one sensor electrode formed from one or more conductive layers. In preferred embodiments, the thickness of the substrate ranges from approximately 25μ to 350μ, but the thickness of the substrate can range from 5μ to 750μ. In particular embodiments, a sensor assembly includes the sensor and a slotted needle having a slot. The notches creating the necked down region allow the substrate to slide into the slotted needle, which that has the slot narrow enough to permit passage of the necked down region. However, a non-necked down region of the substrate is prevented from pulling out of the slotted needle through the slot. In other embodiments, the slot of the slotted needle permits the necked down region of the substrate to slide down the slot.

In further embodiments, a width of the substrate in the non-necked down portion is sized to fit within a slotted needle having a diameter smaller than 21 gauge, 22 gauge, 23 gauge, 24 gauge or the like. In additional embodiments, at least one of the at least one sensor electrode is formed on a first surface of the substrate. In alternative embodiments, all of the at least one sensor electrode are only formed on the first surface. In other alternative embodiments, at least another one of the at least one sensor electrodes is formed on a second surface of the substrate. In still other alternative embodiments, a third one of the at least one sensor electrode is a reference electrode configured to contact a skin surface.

In yet another embodiment, sensors are formed as a part of sensor set that includes a sensor, mounting base and insertion needle. The mounting base adapted for mounting onto a patient's skin. The insertion needle is carried by the

mounting base to protrude from the mounting base and has at least a portion of the sensor nested within the insertion needle. The insertion needle defines a longitudinally extending slot along one side to permit sliding withdrawal of the insertion needle from the mounting base and the nested portion of the sensor. The slot is also configured to accept the necked down region of the substrate.

In accordance with one aspect of the present invention, there is provided a method of making a sensor that includes the steps of providing a pre-formed self-supporting flexible substrate; sputter-depositing a metal layer on the substrate; etching the sputter-deposited metal layers to form a sensor electrode having a proximal segment and a distal segment; plating a metal layer on the sensor electrode; and separating the sensor electrode and at least a portion of the substrate underlying the sensor electrode from the remainder of the substrate. Preferably, the substrate is comprised of a polymeric material, such as a polyimide, and in more particular embodiments, the substrate is supplied in the form of a continuous web.

In particular embodiments, a plurality of metal layers are sequentially sputter-deposited, and the plated layer is formed on the uppermost sputter-deposited layer of the sensor electrode. Preferably, the sputter-deposited metal layers are comprised of different metals, such as layers of chromium and copper.

According to another preferred embodiment, prior to the sputter-deposition step a layer of a material that promotes adhesion between the sputter-deposited metal layer and the substrate is deposited on the substrate. In other embodiments, during the plating step, a layer of copper or a layer of gold is plated on the sensor electrode. Alternatively, a plurality of layers are sequentially plated on the sensor electrode.

In other embodiments, prior to the separation step, the sensor electrode is provided with a coating, such as a coating of a polymeric material, and/or a biocompatible polymeric material. Preferably, the coating is subsequently removed from the proximal segment and the distal segment of the sensor electrode. In further embodiments, the coating is removed from the distal segment of the sensor electrode and the distal segment is subsequently provided with an electrode chemistry. In other embodiments, the sensor electrode is

provided with a membrane after the distal segment is provided with the electrode chemistry.

According to a particular embodiments, a plurality of sprocket holes are formed in the substrate adjacent to the sensor electrode. Also, in preferred embodiments, the step of removing the sensor is carried out using a laser.

In preferred embodiments, the substrate has an upper surface and a lower surface. The sensor electrode is formed on the upper surface, and after the etching step a bead is formed on at least one of the lower surface and the sensor electrode. The bead is formed, according to one particular embodiment, below and in alignment with the sensor electrode. According to another particular embodiment, a first bead is formed on the lower surface of the substrate and a second bead is formed on the sensor electrode. Preferably, the bead is formed using a liquid polymer, and is formed using a molding process.

In accordance with another embodiment of the present invention, a method of making a sensor includes the steps of providing a pre-formed self-supporting flexible substrate; sequentially sputter-depositing a plurality of metal layers on the substrate, the plurality of layers including an uppermost layer; plating a metal layer on the uppermost sputter-deposited metal layer; etching the plated and sputter-deposited metal layers to form a sensor electrode having a proximal segment and a distal segment; sequentially plating first and second metal layers on the sensor electrode; coating the sensor electrode with a polymeric material; forming at least one opening in the coating; and separating the sensor electrode and at least a portion of the substrate underlying the sensor electrode from the remainder of the substrate.

In preferred embodiments, layers of chromium and copper are sequentially sputter-deposited. Preferably, at least one layer of copper is plated on the sputtered layer(s) prior to etching, and layers of copper and gold are sequentially plated after the etching step.

In accordance with an additional embodiment of the present invention, a method of making a sensor includes the steps of providing a pre-formed self-supporting flexible substrate; sputter-depositing at least one metal layer on the substrate; etching the at least one metal layer to form a sensor electrode having a

proximal segment and a distal segment; and separating the sensor electrode and at least a portion of the substrate underlying the sensor electrode from the remainder of the substrate.

In accordance with still another embodiment of the present invention, a method of making a sensor includes the steps of providing a substrate having an upper surface and a lower surface; sputter-depositing at least one metal layer on at least one surface of the substrate; etching the at least one metal layer to form a sensor electrode having first and second edges, a proximal segment and a distal segment; forming a bead on at least one of the upper surface and the lower surface of the substrate; and separating the sensor electrode and the portion of the substrate underlying the sensor electrode from the remainder of the substrate.

In preferred embodiments, the sensor electrode is formed on one of the upper and lower surfaces of the substrate and the bead is formed on the other surface of the substrate. In a further embodiments, the bead is formed on the substrate beneath the sensor electrode.

According to particular embodiments, the bead is formed by forming a perforation in the substrate adjacent to the first and second edges of the sensor electrode; securing the lower surface of the substrate to a mold, the mold having a channel that extends beneath the sensor electrode; flowing a liquid polymer over the upper surface of the substrate and through the perforations into the channel until the polymer beads on the upper surface of the substrate and covers at least a portion of the sensor electrode; curing the liquid polymer; and removing the substrate from the mold. In further embodiments, the perforations on each side of the sensor electrode include at least one perforation gap. The liquid polymer that flows over the sensor electrode does not cover the portion of the sensor electrode between the perforation gaps. The perforations on each side of the sensor electrode may include a plurality of perforation gaps. In still other embodiments, each perforation has a perforation gap adjacent to at least one of the proximal and distal segments of the sensor electrode. In a preferred embodiment, the distal segment is provided with an electrode chemistry.

According to yet another embodiment of the present invention, a method of making a sensor includes the steps of: providing a substrate having an upper

surface and a lower surface; forming at least one channel in at least one of the upper and lower surfaces of the substrate; disposing a conductive material in the at least one channel to form at least one electrode; and forming a bead on at least one of the upper and lower surfaces of the substrate to produce a sensor.

According to a further embodiment of the present invention, a method of making a sensor includes the steps of: providing a substrate having an upper surface and a lower surface; disposing a conductive material on at least one of the upper and lower surfaces of the substrate by non-impact printing to form at least one electrode; and forming a bead on at least one of the upper and lower surfaces of the substrate to produce a sensor.

According to yet a further embodiment of the present invention, a method of making a sensor includes the steps of: providing a substrate having an upper surface and a lower surface; providing a film or sheet comprising a conductive material; transferring the conductive material from the film or sheet to the substrate to form at least one electrode; and forming a bead on at least one of the upper and lower surfaces of the substrate to produce a sensor.

According to still a further embodiment of the present invention, a method of making a sensor includes the steps of: providing a substrate having an upper surface and a lower surface; depositing at least one layer of a metal on the upper surface of the flexible substrate; etching the at least one metal layer to form a sensor electrode having first and second edges, a proximal segment and a distal segment; forming a perforation in the substrate adjacent to the first and second edges of the sensor electrode; securing the lower surface of the substrate to a mold, the mold having a channel that extends below the metal layer; flowing a liquid polymer over the upper surface of the substrate and through the perforations into the channel until the polymer covers the upper surface of the substrate and at least a portion of the sensor electrode; curing the liquid polymer; removing the substrate from the mold; and removing the sensor electrode, the cured polymer and the portion of the substrate between the first and second perforations by separating the substrate adjacent to the perforations.

According to another embodiment of the present invention, a method of making a sensor includes the steps of: providing a substrate; forming a bead on a

surface of the substrate; forming a sensor electrode on the substrate; and separating the bead, the sensor electrode and at least a portion of the substrate between the bead and the sensor electrode from the remainder of the substrate.

According to yet another embodiment of the present invention, a method of making a sensor includes the steps of: providing a substrate; forming a sensor electrode on a surface of the substrate; forming a bead on the substrate; and separating the bead, the sensor electrode and at least a portion of the substrate between the bead and the sensor electrode from the remainder of the substrate.

In accordance with further embodiments of the present invention, sensors produced according to the foregoing methods are also provided. In accordance with other embodiments of the present invention, sensor sets that include sensors, as described herein, together with appropriate mounting bases and insertion needles are provided. In additional embodiments, the sensor sets include cannula in which portions of the sensor are disposed and which in turn are at least partially disposed within the insertion needles. In other embodiments, the sensor includes a bead, which is at least partially nested within the insertion needle, obviating the need for a cannula.

Other objects, features and advantages of the present invention will become apparent to those skilled in the art from the following detailed description. It is to be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the present invention, are given by way of illustration and not limitation. Many changes and modifications within the scope of the present invention may be made without departing from the spirit thereof, and the invention includes all such modifications.

Brief Description of the Drawings

A detailed description of embodiments of the invention will be made with reference to the accompanying drawings, wherein like numerals designate corresponding parts in the several figures.

FIGS. 1-4 illustrate an embodiment of a first method according to the invention in which a substrate, illustrated as a flexible tape supplied from a reel,

is provided with at least one metal layer deposited on its upper surface, an optional plating of one or more metal layers, followed by an etching step to form one or more sensor electrodes, and an optional plating of one or more additional layers, after which the metal layer(s) and the underlying portion of the substrate are subsequently separated from the remainder of the substrate;

FIG. 1 is an illustration of a reel and tape used to provide a substrate for use in the methods in accordance with embodiments of the present invention;

FIG. 2a is a cross-sectional view of the substrate as viewed along the line 2-2 in FIG. 1 with the inclusion of a sputter deposited layer.

FIG. 2b is a cross-sectional view of the substrate with multiple sputter deposited layers;

FIG. 2c is a cross-sectional view of the substrate with multiple sputter deposited and plated layers;

FIG. 2d is a cross-sectional view of the sensor electrode after it has been etched back and the substrate after it has been formed with sprocket holes;

FIG. 2e is a cross-sectional view of a sensor electrode after additional layers have been plated onto the sensor electrode;

FIG. 3a is a cross-sectional view of the substrate and sensor electrode after being covered by a polymer coating;

FIG. 3b is a cross-sectional view of the substrate and sensor electrode after the polymer coating has been etched back;

FIG. 4 is a cross-sectional view of the sensor after being separated from the remainder of the substrate;

FIG. 5 is a perspective view illustrating a sensor set that includes a sensor formed according to the invention;

FIG. 6 is an enlarged longitudinal vertical section taken generally on the line 6-6 of FIG. 5;

FIG. 7 is an enlarged longitudinal sectional of a slotted insertion needle used in the insertion set of FIGS. 5 and 6;

FIG. 8 is an enlarged transverse section taken generally on the line 8-8 of FIG. 7;

FIG. 9 is an enlarged transverse section taken generally on the line 9-9 of FIGS. 7;

FIG. 10 is an enlarged fragmented sectional view corresponding generally with the encircled region 10 of FIG. 6;

FIG. 11 is an enlarged transverse section taken generally on the line 11-11 of FIG. 6;

FIGS. 12a-b are transverse sections of alternative embodiments of a sensor produced according to the invention that include tubular (FIG. 12a) or solid (FIG. 12b) beads;

FIG. 13 is a transverse section illustrating the engagement of the sensor of FIG. 12a and a slotted insertion needle;

FIG. 14 is a transverse section illustrating another alternative embodiment of a sensor of the invention including beads on each side of the sensor, and the engagement of the sensor with a slotted insertion needle;

FIGS. 15-21 illustrate another alternative embodiment of a method according to the invention, wherein

FIGS. 15a-b are side sectional views illustrating deposition of a metal layer (FIG. 15a) or metal layers (FIG. 15b) on a flexible substrate,

FIG. 16 is a transverse section illustrating formation of perforations on either side of the metal layer of FIG. 15a,

FIG. 17 is a transverse section showing the position of the substrate of FIG. 16 in relation to a mold having defined therein a channel;

FIGS. 18a-b illustrate provision of a liquid polymer through the perforations formed in the substrate into the mold channel (FIG. 18a) and its beading over the upper surface of the substrate and the metal layer (FIG. 18b);

FIG. 19 is a transverse section illustrating the curing of the liquid polymer;

FIG. 20 is a side section illustrating disengagement of the mold from the substrate and the cured polymer;

FIG. 21 is a transverse section along the lines 21-21 of FIG. 20 showing separation of the completed sensor from the remainder of the substrate;

FIG. 22 is a sectional view of an alternative embodiment of the inventive method in which a sensor membrane is provided after the liquid polymer is supplied;

FIGS. 23-25 illustrate alternative methods for producing sensors, after which beads are provided in accordance with the methods described herein, in which

FIGS. 23a-b illustrate a first alternative method in which channels are formed in a substrate and subsequently filled with a conductive material to form the sensor electrodes,

FIG. 24 illustrate a second alternative method in which sensor electrodes are formed electrographically using a conductive toner, and

FIGS. 25a-b illustrate a third alternative method in which sensors are formed by a printing process;

FIG. 26 is a top plan view of a sensor in accordance with another embodiment of the present invention;

FIG. 27 is a side plan view of the sensor shown in FIG. 26; and

FIG. 28 is a partial cross-sectional view of the sensor of FIG. 26 inside of an insertion needle.

Fig. 29 is a top plan view of another sensor similar to the embodiment of the sensor shown in Fig. 26.

Figs. 30(a) and (b) are plan views of an alternative embodiment of the sensor shown in Figs. 26-29.

Figs. 31(a) and (b) are plan views of another alternative embodiment of the sensor shown in Figs. 26-29.

Detailed Description of the Preferred Embodiments

As shown in the drawings for purposes of illustration, the invention is embodied in an improved sensor and method of manufacturing the sensor. In preferred embodiments of the present invention, the sensor is a glucose sensor that utilizes glucose oxidase. However, alternative embodiments may use other materials, such as optical, fluorescence or electrical materials to sense the glucose levels, or may uses other materials to sense the presence of different analytes,

such as, including but not limited to, HIV, viruses, medication levels, cholesterol, hormones, fluids or the like. Preferred embodiments are for use with humans. However, it will be recognized that further embodiments of the invention may be used in animals, laboratory tests, agriculture related testing, or the like.

According to embodiments of the inventive method, sensors are produced by deposition of a metal layer or layers followed by etching production methods. Subsequent layers are then added by electroplating. The metal layer(s) can be deposited on either a non-self supporting substrate, or in a preferred embodiment on a self-supporting substrate such as a polyimide tape. Thus, sensors can be produced cleanly and at high density on the substrate according to the inventive method; and in further embodiments, the sensors can be produced on one or both sides of the substrate.

Referring now to FIGS. 1-4, a substrate 10 is provided in accordance with a first embodiment of the inventive method. In preferred embodiments, substrate 10 is a flexible, self-supporting substrate in the form of a continuous tape 12 supplied from a reel 14. The continuous tape 12 is preferably formed from a polymeric material such as a polyimide. However, other flexible, self-supporting materials can be used. The thickness of tape 12 is preferably about 10μ to 125μ. However, in alternative embodiments, thinner or thicker films from 5μ to 500μ may be used. In particular embodiments, sprocket holes 15 (see Fig. 2c) are formed in the substrate adjacent the outer edge of the tape 12 to facilitate manufacturing of the sensors through automated processes. For instance, the tape 12 is fed through stages that perform various steps of the methods described in this application. Sensor electrodes 20 can be formed on the tape 12 using techniques described in "3M Specifications and Design Guidelines, Microflex circuits for IC Interconnect Solutions," pages 1-32 (the entire document), 1997 (3M Electronic Products Division, Austin TX), "3M Offers More Solutions for the Semiconductor Industry" the entire document, 1997 (3M Electronic Products Division, Austin TX), and "Microflex Solutions from 3M", the entire document, 1996 (3M Electronic Products Division, Austin TX), all of which are publicly available from 3M and are specifically incorporated herein by reference.

Alternatively, substrate 10 can be formed by a casting process, for example by spin-coating a layer of a liquid polyimide or other polymeric material onto a temporary glass carrier and then cured. Such substrates can be self-supporting or non-self supporting. The sensor electrodes 20 can be formed on the substrate 10 using techniques described in "Micron Wide Conductors and Spaces on ... PZT, Alumina, Glass and Flexible Materials" 1 page, no date (Metrigraphics, Wilmington, MA), "Flexibel circuits at Extreme Density, 8 unnumbered pages of various dates (Metrigraphics, Wilmington, MA), and "Metrigraphics Ion Beam Etching Capability", 1 page, no date (Metrigraphics, Wilmington, MA), and all of which are publicly available and are specifically incorporated herein by reference.

Substrate 10 has an upper surface 16 and a lower surface 18. The substrate 10 is preferably cleaned, and subsequently at least one metal layer 20a is formed on the upper surface 16 of the substrate 10 by a deposition process (see FIG. 2a). A particularly preferred process is sputter deposition, or sputtering. Sputtering can be carried out using commercially available sputtering reactors using an RF (radio frequency). Magnetron sputtering can also be carried out; magnetron sputtering uses a magnetic field to concentrate electrons near the target surface to increase the deposition rate. Other known deposition processes, such as chemical vapor deposition (CVD) methods, can also be employed. The thickness of the deposited layer preferably ranges from about 0.05μ to about 300.0μ, more preferably about 0.5μ to about 25.0μ. When multiple layers are deposited, the total thickness of the layers preferably has a thickness within the foregoing ranges.

One or more metal layers can be deposited on the substrate 10 according to the inventive method. For example, two layers 20a and 20b of different metals can be deposited (see FIG. 2b). Exemplary metals include, but without limitation, elemental metals such as chromium, gold, copper, aluminum, nickel, tantalum and titanium, alloys such as Inconel and Nichrome, and mixtures thereof. The term "metal layer" is also intended to encompass layers that include one or more non-metallic elements in a mixture or chemical combination with one or more metallic elements, and thus also encompasses materials such as oxides, for

example alumina. Reactive as well as non-reactive layers can be formed; reactive materials, such as tantalum oxide, chromium oxide, etc., are also intended to be encompassed by the term "metal layer." Specific combinations of metal layers that are useful according to the invention include chromium and copper; copper and gold; and chromium, gold and chromium; copper, nickel and gold; and chromium, copper, nickel and gold.

In particular embodiments, chromium forms the first sputtered metal layer. Chromium provides an additional benefit in promoting adhesion between certain polymeric materials, such as polyimides, and other metals. Other metal layers, such as nickel or the like, that promote adhesion can also be employed if desired.

As shown in FIG 2d, in particular embodiments, subsequent to the sputter deposition step but prior to an etching step, one or more metal layers 20c can be plated on the upper surface of the sputter deposited metal layer (or the uppermost sputter deposited layer if more than one such layer is prepared). Such layers, in preferred embodiments, are comprised of copper. However, in alternative embodiments, other metals, such as nickel, chromium, gold, or the like, may be plated onto the layers used to form the sensor electrodes.

After the sputter deposition of the metal layer(s), and/or one or more layers are applied by plating, an etching process is carried out in order to form the sensor electrode 20 (see FIG. 2d). Any conventional etching process can be employed. For example, the etching processes described above and in U.S. Patent No. 5,391,250 issued February 21, 1995 to Cheney, II et al. and entitled "Method of Fabricating Thin Film Sensors", which is incorporated herein in its entirety by reference, may be used to form one or more sensor electrodes. In alternative embodiments, the one or more metal layers applied by plating prior to etching may be omitted and just the sputtered layers are etched. Preferred embodiments form the sprocket holes 15 by etching at the same time that metal etching process is carried out. Alternative embodiments may form the sprocket holes 15 before or after the etching of the metal layer(s). Sprocket holes 15 may be formed by other methods, such as water knife, laser ablation, punching, cutting, or the like.

In further embodiments, subsequent to the etching step one or more additional metal layers 23a, 23b can be plated on the sensor electrode(s) 20' (see Fig. 2e). The optional additional plating step is advantageous in providing a protective coating over the sputter-deposited metal layers, including the sides thereof. In particular embodiments, layers of copper; copper and gold; or copper, nickel and gold are plated after the etching step. In preferred embodiments, gold is plated over the sensor electrodes 20' as the final layer 23b to seal in all of the other layers.

As shown in FIG. 3a, in a preferred embodiment, prior to separation from the remainder of the substrate, the sensor can be provided with a polymeric coating 26, preferably formed from a non-toxic, biocompatible polymer. For instance, the polymer coating 26 provides an insulative and/or protective coating that covers the substrate 10 and the sensor electrodes 20. Exemplary useful polymers include, without limitation, polyimide, biocompatible soldermasks, epoxy acrylate copolymers, or the like. In preferred embodiments, the polymers are photo-imaginable to permit portions of the polymers to be removed for exposure of contacts, electrodes for application of sensor chemistry, or the like. Portions of the coating polymer are masked to form a pattern, which is them exposed and developed to remove the portions of the polymer coating 26 for further processing of the sensor 8. In alternative embodiments, the coating polymer may be removed by other methods, such as by laser ablation, chemical milling, or the like. Use of a secondary photo resist can be employed to target specific sites for removal. As shown in FIG. 3b, the coating polymer 26 is etched (ablated, milled, or the like) back to expose windows (or openings) 28 to expose the contact pads to permit connection with a monitoring device (discussed below) and to form windows (or openings) 28 over the sensor electrodes 20 to allow sensor chemistry materials to be applied to the exposed sensor electrodes 20 to complete the manufacture of the sensors 8.

In further embodiments, the exposed areas that form windows (or openings 28) are plated with additional layers of metal. This saves money and can reduce the thickness of the sensor electrodes, except where the thickness or layer is required. Plating after forming the windows (or openings) 28 also allows

the plating to fill in any potential leaks around the windows (or openings) 28 caused by gaps between the polymer layer and the sensor electrodes. Additionally, if the final metal layer is plated after the last etching and coating step, the surface of the final metal layer is in its best condition for application of enzymes and membranes. Thus, doing a final plating step increase reliability and predictability of sensor performance. In preferred embodiments, the final metal layer is gold. However, in alternative embodiments, other final metal layers, such as platinum, iridium, chromium, copper or the like may be used.

After completion of the etching and optional plating steps and any polymer coating steps, the sensor 8, including a portion of the substrate underlying the metal layer(s) 23n forming the sensor electrode 20 and any polymer coating 26, is removed from the remainder of the substrate (see FIG. 4). In a preferred embodiment, the sensor is removed from the remainder portions 22 of the substrate 10 by cutting along lines 24, for example using a laser. Other known cutting devices, such as blades, ultrasonic, water knifes, or the like, can also be used.

Sensors formed according to the inventive method are usefully employed in a variety of known sensor sets. Exemplary sensor sets are illustrated in FIGS. 5-11, generally similar to those described herein, not including a bead, into a sensor set generally similar to that described in U.S. Patent No. 5,586,533, to Halili et al., and entitled "Transcutaneous Sensor Insertion Set", and U.S. Patent No. 5,954,643 issued September 21, 1999 to Van Antwerp et al. and entitled "Insertion Set for a Transcutaneous Sensor", which are incorporated herein in its entirety by reference. In an embodiment illustrated in FIGS. 5-10, a sensor set referred to generally by the reference numeral 110 is provided for transcutaneous placement of a flexible sensor 112 (see FIG. 6) at a selected site within the body of a patient. The insertion set 110 includes a rigid hollow slotted insertion needle 114 for quick and easy placement at a desired placement site (e.g., transcutaneous, intraperitoneal, peritoneal, etc.) of a cannula 115 with a distal segment 116 of the sensor 112 therein. The distal segment 116 has at least one sensor electrode 118 (three are illustrated, which generally correspond to the sensor electrode 20 described above), formed by deposition as described above,

exposed to patient fluid through a window 119 in the cannula 115. The insertion needle 114 is then withdrawable to leave the cannula 115 with the sensor distal segment 116 and the sensor electrodes 118 in place at the selected site.

The sensor set 110 is particularly designed for facilitating accurate placement of a flexible thin film electrochemical sensor of the type used for monitoring specific blood parameters representative of patient condition. The sensor set 110 is designed to place the sensor at a selected site within the body of a patient, in a manner minimizing patient discomfort and trauma. In one preferred application, the sensor 112 may be designed to monitor blood glucose levels, and may be used in conjunction with automated or semiautomated medication infusion pumps of the external or implantable type as described in U.S. Pat. Nos. 4,562,751; 4,678,408; 4,685,903 or 4,573,994, to deliver insulin to a diabetic patient.

The flexible electrochemical sensor 112 is constructed according to the methods described herein. The sensor electrodes 118 (shown in exaggerated form in the drawings) are exposed for direct contact with patient interstitial fluid, or the like, when the sensor is transcutaneously placed. The distal segment 116 is joined to a proximal segment 120, (see FIG. 6) the end of which terminates in suitable conductive contact pads or the like. As is known in the art, and illustrated schematically in FIG. 6, the proximal segment 120 and the contact pads are adapted for electrical connection to a suitable monitor 122 for monitoring patient condition in response to signals derived from the sensor electrodes 118 in manners known to those skilled in the art.

According to the embodiment of FIGS. 5 and 6, the sensor 112 is carried by a mounting base 126 adapted for placement onto the skin of a patient. An exemplary mounting base 126 comprises an enlarged and generally rectangular pad having an underside surface coated with a suitable pressure sensitive adhesive layer, with a peel-off paper strip 128 normally provided to cover and protect the adhesive layer, until the insertion set 110 is ready for use. As shown in FIGS. 5 and 6, the mounting base comprises upper and lower layers 130 and 132, with the proximal segment 120 of the sensor 112 sandwiched between the layers 130 and 132. The proximal sensor segment 120 has a forwardmost end

joined to the distal segment 116 which is folded angularly to extend downwardly through a slot 134 formed in the lower base layer 132.

The insertion needle 114 is adapted for slide-fit reception through a needle port 136 formed in the upper base layer 130 and further through the lower slot 134 in the lower base layer 132. As shown, the insertion needle 114 has a sharpened tip 138 and an open slot 140 which extends longitudinally from the tip 138 at the underside of the needle to a position at least within the slot 134 in the lower base layer 132. Above the mounting base 126, the insertion needle 114 can have a full round cross sectional shape and is desirably closed at a rear end. In a more specific preferred embodiment, the slotted needle 114 has a part-circular cross sectional shape, with an arcuate dimension or span greater than 180°, such as an arcuate dimension of about 210°. This leaves a longitudinal slot in the needle with an arcuate dimension of about 150°.

The cannula 115 illustrated in FIGS. 10 and 11 comprises a first portion 144 of part circular cross section fitted within the insertion needle 114 to extend downwardly from the mounting base 126. This cannula 115 is preferably constructed from a suitable medical grade plastic or elastomer, such as polytetrafluoroethylene, silicone, etc., to define an open lumen 142 in a second portion for receiving, protecting and guidably supporting the distal segment 116 of the sensor 112. The cannula 115 has one end fitted into the slot 134 formed in the lower layer 132 of the mounting base 126, wherein the cannula 115 is desirably secured to the mounting base by a suitable adhesive or other selected attachment methods. From the mounting base 126, the cannula extends angularly downwardly with the first portion 144 nested within the insertion needle 114, terminating slightly before the needle tip 138. Importantly, at least one window 119 is formed in the lumen 142 near the distal end, in general alignment with the sensor electrodes 118, to permit direct electrode exposure to patient body fluid when the sensor is transcutaneously placed.

According to the preferred embodiment illustrated FIG. 11, the second portion 142 of the cannula 115 has a part-circular cross sectional shape which cooperates with the part-circular shape of the insertion needle 114 to define a substantially full-circle geometry for facilitated insertion through the patient's

skin. The first portion 144 of the cannula 115 has a smaller cross sectional profile than the second portion 142, for sliding nested reception into the needle 114. The needle 114 and first cannula portion 144 are thus mechanically interlocked to prevent lateral dislocation of the cannula 115 from the insertion needle, while permitting longitudinal sliding motion of the needle over the cannula first portion 144. The distal or free end of the cannula second portion 142 is appropriately cut or otherwise set at an oblique angle, as viewed in FIG. 6, to form a continuation of the angle-cut tip 138 of the insertion needle.

In use, the sensor set 110 permits quick and easy placement of the sensor distal segment 116 at a selected site within the body of the patient. More specifically, the peel-off strip 128 (FIG. 5) is removed from the mounting base 126, at which time the mounting base 126 can be pressed onto and seated upon the patient's skin. The set may be inserted by hand or inserted with an insertion tool, such as disclosed in U.S. Patent Application Serial No. 09/215,356 (PCT No. US98/26978) filed December 18, 1998, and entitled "Insertion Device for an Insertion Set and Method of Using the Same", which is incorporated herein by reference. During this step, the insertion needle 114 pierces the patient's skin and carries the protective cannula 115 with the sensor distal segment 116 therein to the appropriate transcutaneous placement site. During insertion, the cannula 115 provides a stable support and guide structure to carry the sensor to the desired insertion site.

When the sensor 112 is placed at the insertion site, with the mounting base 126 seated upon the patient's skin, the insertion needle 114 can be slidably withdrawn from the patient. During this withdrawal step, the insertion needle 114 slides over the first portion 144 of the protective cannula 115, leaving the sensor distal segment 116 with electrodes 118 at the selected insertion site. These electrodes 118 are directly exposed to patient body fluid via the window 119. The sensor proximal segment 120 is appropriately coupled to the monitor 132, so that the sensor 112 can then be used over a prolonged period of time for taking chemistry readings, such as blood glucose readings in a diabetic patient. If desired, the first portion 144 of the cannula 115 can be hollow as shown to form a second lumen available to deliver medication and/or sensor calibration fluid to

the vicinity of the electrodes 118, or alternately to withdraw patient fluid such as blood for analysis.

Sensors produced as described above can also beneficially be included in sensor sets such as those described in PCT Application Serial No. WO 98/56293, to applicant MiniMed Inc., published December 17, 1998, which corresponds to copending, commonly assigned U.S. Patent Application Serial No. 08/871,831, filed June 9, 1997, entitled "Insertion Set for a Transcutaneous Sensor", now U.S. Patent No. 5,954,643, and in copending, commonly assigned U.S. Patent Application Serial No. 09/161,128, to Mastrototaro et al., filed September 25, 1998, now U.S. Patent No. 5,951,521, the disclosures of each of which are incorporated in their entireties herein by reference.

In an alternative method according to the invention, illustrated in FIGS. 12-14, one or more beads are provided to the sensor. The beads facilitate engagement of the sensors directly with a slotted insertion needle without the need for a cannula. Use of beads on each side of the substrate that is used to form the sensor, can also enable production of sensors having sensor electrodes on each side of the substrate.

As shown in FIGS. 12a-b, a bead, which can be hollow (see FIG. 12a, bead (or tube) 150) or solid (FIG. 12b, bead 152), is formed on the lower surface 18 of the substrate 10. The bead can be formed on the surface of the substrate by a variety of means, such as by securing a cylindrical element to the surface, by molding, laminating, or the like. The bead can be provided either before or after the sensor is removed from the remainder of the substrate 10. Once formed, the bead directly engages a slotted insertion needle 114 (FIG. 13) of a sensor set as described herein.

In FIG. 14, an alternative embodiment of a sensor includes beads, preferably solid beads 152, formed on both the upper surface 16 and the lower surface 18 of the substrate 10. This embodiment is useful in preparing sensors having sensor electrodes 20 on each side of the substrate. Such two-sided sensors can be used, for example, to detect two different body conditions, such as blood glucose level and the presence of an antibody, simultaneously, when appropriate

electrode chemistries are provided; or the same body condition, such as glucose levels, by providing a cross-check using two different sensor readings.

Another alternative method according to the invention is illustrated in Figures 15-21. In FIG. 15a, at least one metal layer 220a is deposited on the upper surface 212 of the substrate 210 and formed into a sensor electrode as described above. Two or more metal layers can be deposited to form the sensor electrode, as illustrated in Figure 15b, in which first and second metal layers 220a, 220b are sequentially deposited on upper surface 212 of substrate 210. Also, although formation of one sensor electrode is illustrated for the sake of clarity, two or more sensor electrodes 220 can be formed on the same substrate by deposition of appropriate metal layers at different sites on the substrate. And multiple sensors may be formed on the substrate at the same time. The method of forming the sensor electrode 220 may be carried out as described for the sensor electrode 20 above and as shown in FIGS. 1-4.

After formation of the sensor electrodes 220 on the upper surface 212 of substrate 210, substrate 210 is perforated on either side of the metal layer(s) (see FIG. 16). Perforations 230 can be formed by any desired means, for example by laser cutting, etching, the use of a blade or other appropriate tool, or the like. The perforations preferably are sized to permit flow of a fluid, in particular a liquid polymer, through the perforations. In alternative embodiments, the perforations may be formed at the same time the sprocket holes on the tape 12 (as described above) are formed. Preferred embodiments use chemical etching to form the perforations.

Once the perforations 230 are formed, the lower surface 214 of substrate 210 is secured to a mold 232. The mold 232 may be attached while the substrate 210 is still a part of the tape 12, or after the substrate 210 has been cut from the tape 12. In addition, cut sections of the tape 12 may include one or more sensors. The mold may also be applied to substrates formed as sheets rather than tapes 12, as described above.

Mold 232, as shown in FIG. 17, has defined in its upper surface adjacent to the lower surface 214 of substrate 210 a channel 234, which preferably extends below the metal layer(s). Next, a liquid polymer 240 is flowed through the

perforations 230 and into the channel 234 in mold 232. The liquid polymer is preferably a biocompatible polymer, such as polyurethane, polycarbonate, silicone, acrylic or other thermoplastics. In preferred embodiments, the polymer flow is continued until the liquid polymer fills the mold and overflow to form a bead on the upper surface 212 of substrate 210 and the upper surface of the metal layer(s). This upper bead can also provide an upper protective coating to the sensor. See FIGS. 18a-b.

The liquid polymer 240 is then cured, for example by exposure to a source 245 of actinic radiation, heat or the like (see FIG. 19) to form bead 242 on the lower surface 214 of substrate 210 and coating 244 on the upper surface 212 and over the metal layer(s). After completion of the curing step, mold 232 is removed from contact with the substrate 210, for example by sliding the mold laterally away from the substrate in the direction defined by channel 234 (see FIG. 20). Finally, the finished sensor, including the metal layer(s), the cured polymer and the portion of the substrate therebetween and between the first and second perforations, is removed from the remainder of the substrate by separating the substrate adjacent the perforations. As shown in FIG. 21, the sensor 260 is separated from the remainder 262 of the substrate along separation lines 254, 256, which are formed, for example, by cutting using a laser, etching, a blade or another appropriate tool, or the like.

The liquid polymer 240 can be flowed over the entire surface of the metal layer(s) if desired. Preferably, however, one or more portions of the metal layers remain exposed. In this preferred alternative, the perforations 230 are formed such that they include one or more perforation gaps, that is, segments that include no perforations. The surface of the metal layer(s) extending between these perforation gaps remains uncovered by the liquid polymer, which does not bead over such areas.

As shown in FIG. 20, perforation gaps 246, 248 adjoining the perforations 230 allow proximal segment 250 and distal segment 252 of the sensor electrodes 220 to remain exposed without the liquid polymer 240 beading up over these segments. Proximal segment 250 can, as discussed above, terminate in a

conductive contact pad, while the distal segment 252 can include a portion that is provided with an appropriate electrode chemistry.

In an alternative embodiment, additional protective layers or membranes can be provided to the upper surface of the substrate and the metal layer(s). In Figure 22, a sensor membrane 264 is placed above the metal layer and adhered to the liquid polymer prior to, or after, curing to improve biocompatibility of the sensor.

Sensors including beads can also be prepared by methods other than those set forth above. For example, sensors can be prepared by any of the methods set forth in U.S. Patent App. No. 09/034,433, to Say et al., corresponding to PCT Application No. PCT/US99/03781, published September 10, 1999 under International Publication No. WO 99/45375 and incorporated herein in its entirety by reference, and provided with beads according to the methods set forth herein.

In one such method, one or more channels 312 are formed in the substrate 310, for example by an embossing process using an embossing die or roller (see FIG. 23a). Other methods for forming the channels, such as the use of a laser, or photolithography and etching of the substrate can also be employed if desired.

Once the channels 312 have been formed, a conductive material 314 is placed, flowed, applied, filled, flooded or otherwise disposed within the channels 312 to form the sensor electrodes 316 (FIG. 23b). The conductive material can be applied as a precursor conductive material having a liquid form. An exemplary precursor conductive material is a carbon-based ink that can be flooded in liquid form into the channels 312. Other conductive inks or pastes that include carbon or metal, such as gold, copper or silver, can also be used. Other techniques for applying the conductive material or precursor conductive material, including spraying, coating, flooding, applying with a saturated roller, pumping, as well as impact and non-impact printing methods such as electrostatic or magnetographic methods.

According to a second embodiment, a non-impact process is used to form the sensor electrodes 324. Exemplary non-impact processes include electrophotography and magnetography, in which an image of the conductive traces is electrically or magnetically formed on a drum 320. The image attracts a

toner material 322 to the drum. The toner 322 material is subsequently transferred to the substrate 310, for example by rolling, followed preferably by a curing step to adhere the toner material to the substrate. See FIG. 24. Other useful non-impact processes include ink jet printing and piezo jet printing, in which an image is formed by ejection of a conductive material, such as a conductive ink, onto the substrate. Still other useful non-impact processes include the use of photosensitive resins to form a layer on the substrate in which channels are defined, followed by filling the channels with conductive material to form the sensor electrodes.

According to a third embodiment, a film of conductive material 332 is formed, for example, as a continuous sheet or as a coating layer deposited on a carrier film 330. The film is brought, for example, between a print head 334 and the substrate 310. A pattern of sensor electrodes 336 is formed on the substrate 310 using the print head. The conductive material is transferred by pressure and/or heat to the substrate 310. See FIGS. 25a-b. Channels can be formed in the substrate as a result of the printing process, or alternatively the conductive material can be deposited on the substrate substantially without the formation of depressions or channels.

Once the sensor electrodes have been formed, a bead 342 can be provided in accordance with the methods described above.

FIGS. 26-29 illustrate a sensor 400 formed in accordance with another embodiment of the present invention. The sensor 400 includes a substrate 402 and at least one sensor electrode 404 formed from one or more conductive layers. In particular embodiments, the layers are formed from metal. However, alternative embodiments may utilize semiconductors, conductive polymers, DNA, RNA, molecular wires, or the like. The substrate 402 and the sensor 404 are formed and process by methods similar to those described above in the other embodiments. However, in this embodiment, the substrate 402 is formed from a thicker film (from a reel or as a sheet) so that no bead is required. The thickness of the substrate ranges from approximately 25μ to 350μ. In further embodiments, thicker films may be used up to 750μ or thinner films down to 5μ may be used, with the thickness being determined by the strength of the substrate 402 material,

the substrate material's resistance to tearing, the flexibility of the substrate material, or the like. For instance, if the substrate is contained within a slotted needle (or supporting structure) during insertion, a comparable normal or thinner thickness to the other embodiments described above may be used.

The sensor 400 is formed to obviate the need for a sensor set housing that remains attached to the body or the use of an additional bead, as described above in FIGS. 5-25b. To achieve this capability, the substrate 402 is formed (or cut) to include one or more notches 406. The notches 406 create a necked down region in the sensor 400 that allows the sensor 400 to slide into a slotted needle 408 that has a slot 410 that is narrow enough to permit passage of the necked down region 412 of the sensor 400, but prevent the non-necked down region 414 of the sensor 400 from pulling out of the slotted needle 408 through the slot 410. The slot 410 does permit the necked down region 412 of the sensor 400 to slide down the slot 410.

To insert the sensor, a sensor 400 is placed inside a slotted needle 408 by sliding the necked down region 412 into the slot 410 of the slotted needle 408 so that the non-necked down region 414 is slid up and into the interior of the slotted needle 408, while a connection region 416 remains outside of the slotted needle. The slotted needle 408, including the sensor 400, is inserted into a body (not shown). The sensor 400 is held against the body by the connection region 416 and the slotted needle 408 is then pulled out of the body (alternatively, the sensor may be included in a sensor set that holds the needle and the sensor). As the slotted needle 408 is pulled from the body, the necked down region 412 slides down the slot 410 of the slotted needle 410 and remains implanted in the body. Thus, in this embodiment, a sensor set and bead are not required, and the substrate 402 is of sufficient strength to remain in the body without any other support structures. In particular embodiments, the sensor may fit within a 21 gauge to a 27 gauge slotted needle for easy insertion into the skin.

In an alternative of these embodiments, to provide for the manufacture of a narrower sensor in width, with the aim to further minimize the size of the needle used to surround the sensor during insertion, several different approaches to sensor electrode layouts may be used. In one embodiment, two electrodes 502

and 504 are formed on one side 506 of the sensor 500 and a single electrode 508 is formed on the other side 510 (see Figs. 30(a) and 30(b)). This allows the size of the electrodes to be maintained with a consummate reduction in width. In further alternative embodiments, one electrode 552 is formed on one side 554 of the sensor 550 and another single electrode 556 is formed on the back 558 of the sensor 550 (see Figs. 31(a) and 31(b)). A third electrode 560, if needed, such as a ground (or reference) electrode is formed before the necked down region of the sensor to form an electrode that rests on (or is in contact with) the top of the skin (see Fig. 31(a). This substantially reduces the width of the sensor permitting small gauge needles to be used. For instance slotted needles of 22 gauge to 28 gauge may be used.

While the description above refers to particular embodiments of the present invention, it will be understood that many modifications may be made without departing from the spirit thereof. In particular, it is to be understood that the exemplary embodiments set forth herein, whether referred to as preferred embodiments or otherwise, are in no way to be taken as limiting the scope of the present invention. The accompanying claims are intended to cover such modifications as would fall within the true scope and spirit of the present invention.

The presently disclosed embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated solely and exclusively by the appended claims, rather than the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

WHAT IS CLAIMED IS:

1. A sensor for implantation in a body, the sensor comprising:

a substrate with notches cut in the substrate to form a necked down region in the substrate; and

at least one sensor electrode formed from one or more conductive layers.

2. A sensor in accordance with claim 1, wherein the thickness of the substrate ranges from approximately 25μ to 350μ.

3. A sensor in accordance with claim 1, wherein the thickness of the substrate ranges from 5μ to 750μ.

4. A sensor assembly in accordance with claim 1; further including:

a slotted needle having a slot; and

wherein the notches creating the necked down region that allows the substrate to slide into the slotted needle that has the slot narrow enough to permit passage of the necked down region, but prevents a non-necked down region of the substrate from pulling out of the slotted needle through the slot.

5. A sensor assembly in accordance with claim 4, wherein slot of the slotted needle permits the necked down region of the substrate to slide down the slot.

6. A sensor in accordance with claim 1, wherein a width of the substrate in the non-necked down portion is sized to fit within a slotted needle having a diameter smaller than 21 gauge.

7. A sensor in accordance with claim 6, wherein a width of the substrate in the non-necked down portion is sized to fit within a slotted needle having a diameter smaller than 22 gauge.

8. A sensor in accordance with claim 7, wherein a width of the substrate in the non-necked down portion is sized to fit within a slotted needle having a diameter smaller than 23 gauge.

9. A sensor in accordance with claim 8, wherein a width of the substrate in the non-necked down portion is sized to fit within a slotted needle having a diameter smaller than 24 gauge.

10. A sensor in accordance with claim 1, wherein at least one of the at least one sensor electrode is formed on a first surface of the substrate.

11. A sensor in accordance with claim 10, wherein all of the at least one sensor electrode are only formed on the first surface.

12. A sensor in accordance with claim 10, wherein at least another one of the at least one sensor electrodes is formed on a second surface of the substrate.

13. A sensor in accordance with claim 12, wherein a third one of the at least one sensor electrode is a reference electrode configured to contact a skin surface.

14. A method of making a sensor comprising the steps of:

i) providing a preformed self-supporting flexible substrate;

ii) sputter-depositing at least one metal layer on the substrate;

iii) etching the at least one metal layer to form a sensor electrode having a proximal segment and a distal segment;

iv) plating a metal layer on the sensor electrode; and

v) separating the sensor electrode and at least a portion of the substrate underlying the sensor electrode from the remainder of the substrate.

15. The method of claim 14, wherein the substrate is comprised of a polymeric material.

16. The method of claim 15, wherein the polymeric material is a polyimide.

17. The method of claim 14, wherein in step i) the substrate is a continuous web.

18. The method of claim 14, wherein in step ii) a plurality of metal layers are sequentially sputter-deposited, and in step iv) the plated layer is formed on the uppermost sputter-deposited layer.

19. The method of claim 18, wherein the plurality of metal layers are comprised of at least two different metal layers.

20. The method of claim 19, wherein the plurality of metal layers are layers of chromium and copper that are sequentially sputter-deposited.

21. The method of claim 14, wherein prior to step ii) a layer of a material that promotes adhesion between the sputter-deposited metal layer and the substrate is deposited on the substrate.

22. The method of claim 14, wherein in step iv) a layer of copper is plated on the sensor electrode.

23. The method of claim 14, wherein in step iv) a plurality of layers are sequentially plated on the sensor electrode.

24. The method of claim 14, wherein in step iv) a layer of gold is plated on the sensor electrode.

25. The method of claim 14, wherein in step iv) layers of copper and gold are sequentially plated on the sensor electrode.

26. The method of claim 14, wherein before step v) the sensor electrode is provided with a coating.

27. The method of claim 26, wherein the coating comprises a polymeric material.

28. The method of claim 27, wherein the polymeric material is biocompatible.

29. The method of claim 27, wherein the polymeric material is selected from the group consisting of acrylates, polyimide, soldermasks, and epoxy acrylate copolymers.

30. The method of claim 26, wherein the coating is subsequently removed from at least one of the proximal segment and the distal segment of the sensor electrode.

31. The method of claim 30, wherein the coating is removed from both the proximal segment and the distal segment of the sensor electrode.

32. The method of claim 30, wherein the coating is removed from the distal segment of the sensor electrode and the distal segment is subsequently provided with an electrode chemistry.

33. The method of claim 32, wherein the sensor electrode is provided with a membrane after the distal segment thereof is provided with the electrode chemistry.

34. The method of claim 26, wherein a plurality of sprocket holes are formed in the substrate adjacent to the sensor electrode.

35. The method of claim 14, wherein the substrate has an upper surface on which the sensor electrode is formed and a lower surface, and wherein after step iv) a bead is formed on at least one of the lower surface and the sensor electrode.

36. The method of claim 35, wherein the bead is formed below and in alignment with the sensor electrode.

37. The method of claim 35, wherein a first bead is formed on the lower surface of the substrate and a second bead is formed on the sensor electrode.

38. The method of claim 35, wherein the bead is formed using a liquid polymer.

39. The method of claim 35, wherein the bead is formed by a molding process.

40. The method of claim 14, wherein step v) is carried out using a laser.

41. The method according to claim 14, wherein in step ii) a plurality of metal layers is sequentially sputter-deposited on the substrate, the plurality of layers including an uppermost layer, and a metal layer is plated on the uppermost sputter-deposited metal layer; wherein in step iii) the plated and sputter-deposited metal layers are etched to form the sensor electrode having the proximal segment and the distal segment; and wherein in step iv) sequentially plating first and second metal layers on the sensor electrode; and

further comprising between the steps iv) and v) the steps of:

a) coating the sensor electrode with a polymeric material; and

b) forming at least one opening in the coating.

42. The method of claim 41, wherein in step ii) layers of chromium and copper are sequentially sputter-deposited.

43. The method of claim 41, wherein in step ii) a layer of copper is plated.

44. The method of claim 41, wherein in step iv) layers of copper and gold are sequentially plated.

45. The method of claim 41, wherein in step vi) the polymeric material is a polyimide.

46. The method according to claim 14, wherein in step i) the substrate is provided having an upper surface and a lower surface, wherein in step ii) at least one metal layer is sputter-deposited on at least one surface of the substrate, wherein in step iii) the at least one metal layer is etched to form the sensor electrode to have first and second edges, and

further comprising a step z) forming a bead on at least one of the upper surface and the lower surface of the substrate.

47. The method of claim 46, wherein the substrate is comprised of a polymeric material.

48. The method of claim 47, wherein the polymeric material is a polyimide.

49. The method of claim 46, wherein in step i) the substrate is provided in the form of a tape supplied from a reel.

50. The method of claim 46, wherein in step i) the substrate is formed by a casting process.

51. The method of claim 46, wherein in step ii) a plurality of metal layers are sequentially deposited on the substrate.

52. The method of claim 51, wherein layers of chromium and copper are sequentially deposited on the substrate.

53. The method of claim 46, wherein in step z) the sensor electrode is formed on one of the upper and lower surfaces of the substrate and the bead is formed on the other surface of the substrate.

54. The method of claim 53, wherein in step z) the bead is formed on the substrate beneath the sensor electrode.

55. The method of claim 54, wherein in step z) the bead is formed by

a) forming a perforation in the substrate adjacent to the first and second edges of the sensor electrode;

b) securing the lower surface of the substrate to a mold, the mold having defined therein a channel that extends beneath the sensor electrode;

c) flowing a liquid polymer over the upper surface of the substrate and through the perforations therein into the channel until the polymer beads on the upper surface of the substrate and covers at least a portion of the sensor electrode;

d) curing the liquid polymer; and

e) removing the substrate from the mold.

56. The method of claim 55, wherein in step z-a) the perforations on each side of the sensor electrode include at least one perforation gap, so that the liquid polymer that flows over the sensor electrode does not cover the portion of the sensor electrode between the perforation gaps.

57. The method of claim 56, wherein the perforations on each side of the sensor electrode include a plurality of perforation gaps.

58. The method of claim 57, wherein each perforation has a perforation gap adjacent to at least one of the proximal and distal segments of the sensor electrode.

59. The method of claim 58, wherein each perforation has a perforation gap adjacent to both the proximal segment and the distal segment of the sensor electrode.

60. The method of claim 59, wherein the distal segment is provided with an electrode chemistry.

61. The method of claim 46, wherein a first bead is formed on one surface of the substrate, a second bead is formed on the other surface of the substrate, and the sensor electrode is formed adjacent to at least one of the beads.

62. The method of claim 46, wherein at least one sensor electrode is formed on each surface of the substrate and a bead is formed on each surface of the substrate adjacent to the sensor electrode.

63. The method of claim 46, wherein after step iii) at least one additional metal layer is formed on the sensor electrode.

64. The method of claim 46, wherein after step iii) a layer of gold is electroplated on the sensor electrode.

65. The method of claim 46, wherein the step z) includes:

a) forming a perforation in the substrate adjacent the first and second edges of the sensor electrode;

b) securing the lower surface of the substrate to a mold, the mold having a channel that extends below the metal layer;

c) flowing a liquid polymer over the upper surface of the substrate and through the perforations therein into the channel until the polymer covers the upper surface of the substrate and at least a portion of the sensor electrode;

d) curing the liquid polymer; and

e) removing the substrate from the mold; and

wherein step ix) includes removing the sensor electrode, the cured polymer and the portion of the substrate between the first and second perforations by separating the substrate adjacent to the perforations.

66. The method of claim 65, wherein after step iii) at least one additional metal layer is formed on the sensor electrode.

67. The method of claim 66, wherein after step iii) a layer of gold is electroplated on the sensor electrode.

68. The method of claim 66, wherein after step viii) the distal segment of the sensor electrode is provided with the electrode chemistry.

69. A method of making a sensor comprising the steps of:

i) providing a substrate;

ii) forming at least one sensor electrode on the substrate;

iii) forming a bead on the substrate; and

iv) separating the bead, the sensor electrode and at least a portion of the substrate between the bead and the sensor electrode from the remainder of the substrate.

70. The method of claim 69, wherein in step i) the substrate is provided having an upper surface and a lower surface, wherein in step ii) at least one channel is formed in at least one of the upper and lower surfaces of the substrate, and a conductive material is disposed in the at least one channel to form the at least one sensor electrode, and wherein in step iii) a bead is formed on at least one of the upper and lower surfaces of the substrate.

71. The method of claim 69, wherein in step i) the substrate is provided having an upper surface and a lower surface, wherein in step ii) a conductive material is disposed on at least one of the upper and lower surfaces of the substrate by non-impact printing to form at least one electrode, and wherein in step iii) a bead is formed on at least one of the upper and lower surfaces of the substrate to produce a sensor.

72. The method of claim 69, wherein in step i) the substrate is provided having an upper surface and a lower surface, wherein in step ii) a film or sheet comprising a conductive material is provided, and the conductive material from the film or sheet is transferred to the substrate to form at least one sensor electrode, and wherein in step iii) a bead is formed on at least one of the upper and lower surfaces of the substrate.

73. A sensor produced by the method of claim 14.

74. A sensor set comprising:

a) a mounting base adapted for mounting onto a patient's skin;

b) a sensor as claimed in claim 73;

c) a cannula protruding from the mounting base and having a portion of the sensor; and

d) an insertion needle carried by the mounting base to protrude from the mounting base and having at least a portion of the cannula nested within the insertion needle, the insertion needle defining a longitudinally extending slot along one side to permit sliding withdrawal of the insertion needle from the mounting base and the nested portion of the cannula.

75. A sensor produced by the method of claim 41.

76. A sensor set comprising:

a) a mounting base adapted for mounting onto a patient's skin;

b) a sensor as claimed in claim 75;

c) a cannula protruding from the mounting base and having a portion of the sensor; and

d) an insertion needle carried by the mounting base to protrude from the mounting base and having at least a portion of the cannula nested within the insertion needle, the insertion needle defining a longitudinally extending slot along one side to permit sliding withdrawal of the insertion needle from the mounting base and the nested portion of the cannula.

77. A sensor produced by the method of claim 46.

78. A sensor set comprising:

a) a mounting base adapted for mounting onto a patient's skin;

b) a sensor as claimed in claim 77; and

c) an insertion needle carried by the mounting base to protrude from the mounting base and having at least a portion of the bead of the sensor nested within the insertion needle, the insertion needle defining a longitudinally extending slot along one side to permit sliding withdrawal of the insertion needle from the mounting base and the nested portion of the sensor.

79. A sensor produced by the method of claim 65.

80. A sensor set comprising:

a) a mounting base adapted for mounting onto a patient's skin;

b) a sensor as claimed in claim 79; and

c) an insertion needle carried by the mounting base to protrude from the mounting base and having at least a portion of the bead of the sensor nested within the insertion needle, the insertion needle defining a longitudinally extending slot along one side thereof to permit sliding withdrawal of the insertion needle from the mounting base and the nested portion of the sensor.

81. A sensor produced by the method of claim 70.

82. A sensor set comprising:

a) a mounting base adapted for mounting onto a patient's skin;

b) a sensor as claimed in claim 81; and

c) an insertion needle carried by the mounting base to protrude from the mounting base and having at least a portion of the bead of the sensor nested within the insertion needle, the insertion needle defining a longitudinally extending slot along one side to permit sliding withdrawal of the insertion needle from the mounting base and the nested portion of the sensor.

83. A sensor produced by the method of claim 71.

84. A sensor set comprising:

a) a mounting base adapted for mounting onto a patient's skin;

b) a sensor as claimed in claim 83; and

c) an insertion needle carried by the mounting base to protrude from the mounting base and having at least a portion of the bead of the sensor nested within the insertion needle, the insertion needle defining a longitudinally extending slot along one side to permit sliding withdrawal of the insertion needle from the mounting base and the nested portion of the sensor.

85. A sensor produced by the method of claim 71.

86. A sensor set comprising:

a) a mounting base adapted for mounting onto a patient's skin;

b) a sensor as claimed in claim 85; and

c) an insertion needle carried by the mounting base to protrude from the mounting base and having at least a portion of the bead of the sensor nested within the insertion needle, the insertion needle defining a longitudinally extending slot along one side thereof to permit sliding withdrawal of the insertion needle from the mounting base and the nested portion of the sensor.

87. The method of claim 30, wherein an additional metal layer is applied to the sensor electrode where the coating was removed.

88. The method of claim 41, wherein an additional metal layer is applied to the sensor electrode where the coating was removed.

89. A sensor set comprising:

a) a mounting base adapted for mounting onto a patient's skin;

b) a sensor as claimed in claim 1; and

c) an insertion needle carried by the mounting base to protrude from the mounting base and having at least a portion of the sensor nested within the insertion needle, the insertion needle defining a longitudinally extending slot along one side to permit sliding withdrawal of the insertion needle from the mounting base and the nested portion of the sensor and to accept the necked down region of the substrate.

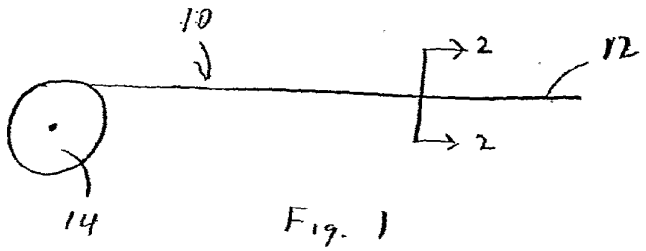


Fig. 1

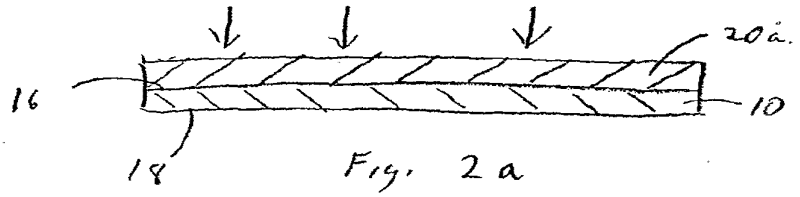


Fig. 2a

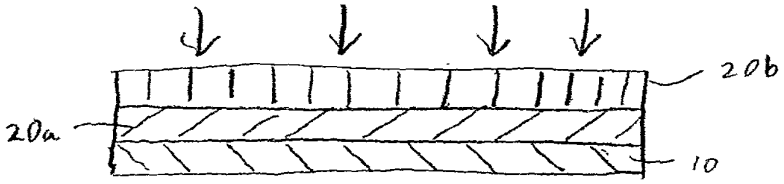


Fig. 2b

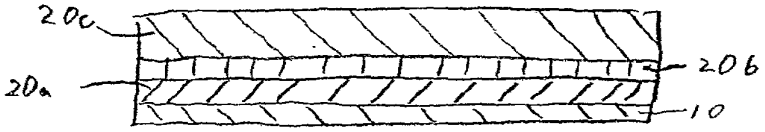


Fig. 2c

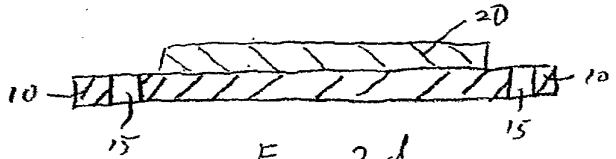


Fig. 2d

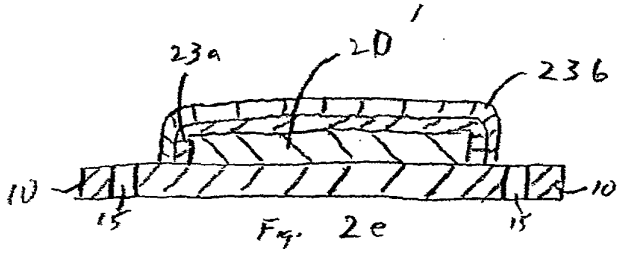


Fig. 2e

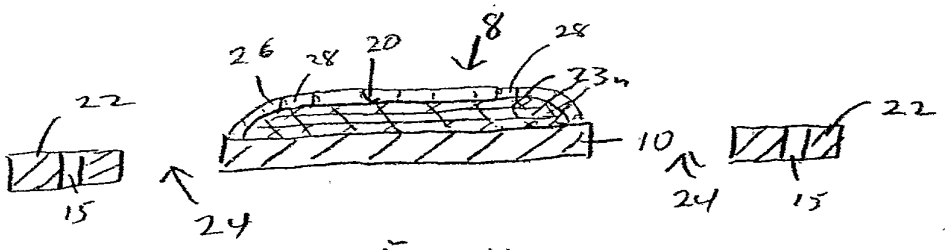


Fig. 4

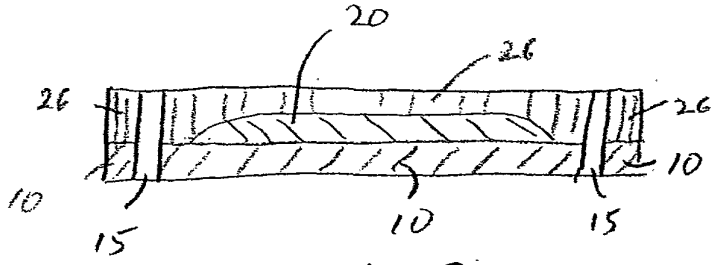


Fig. 3a

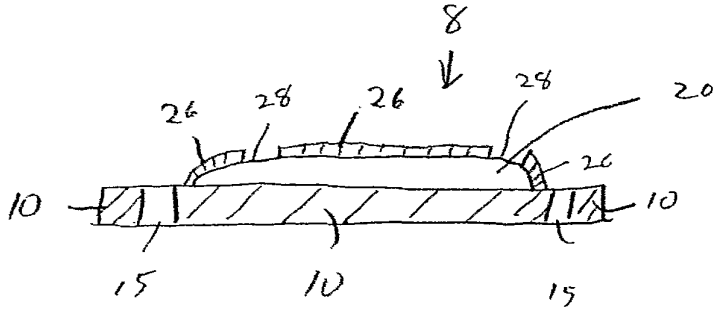


Fig. 3 b

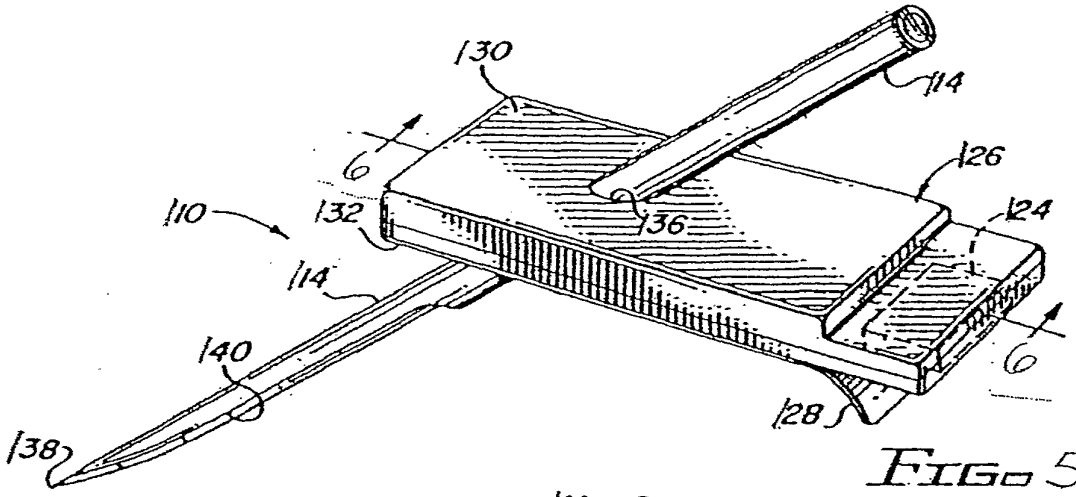


FIG. 5

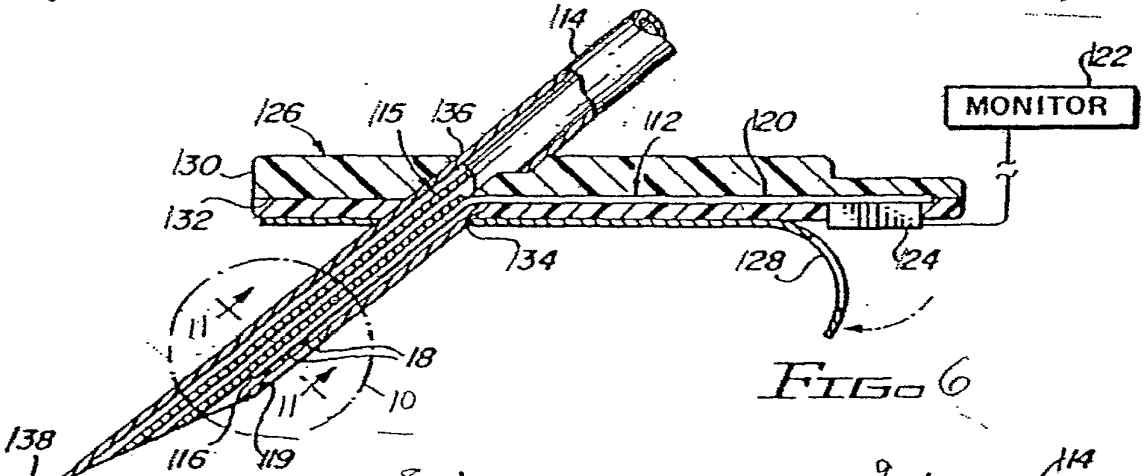


FIG. 6

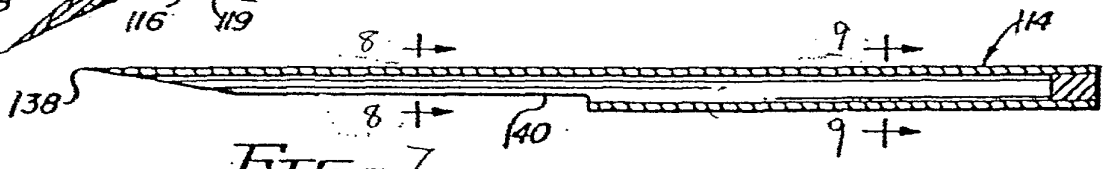


FIG. 7

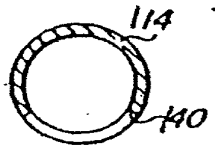


FIG. 8



FIG. 9

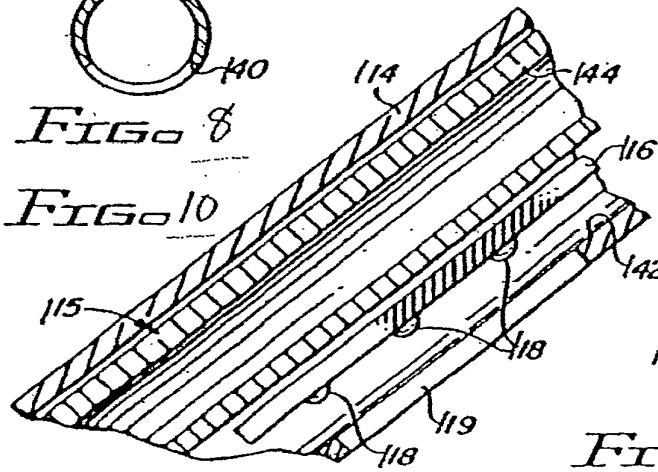


FIG. 10

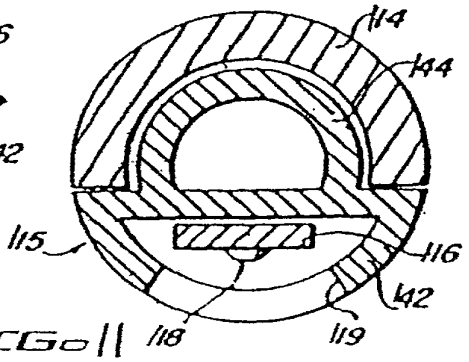


FIG. 11

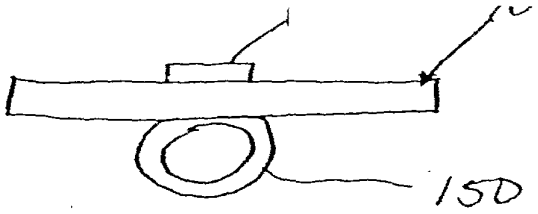


Fig. 12a

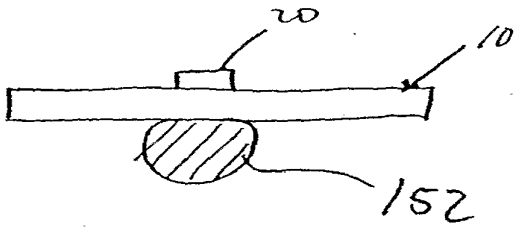


Fig. 12b

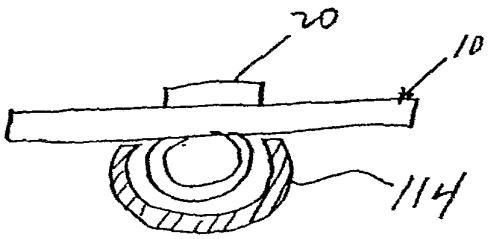


Fig. 13

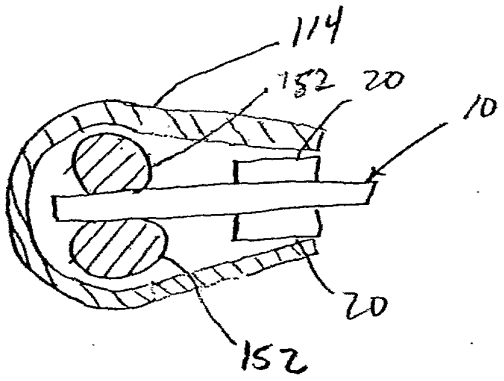


Fig. 14

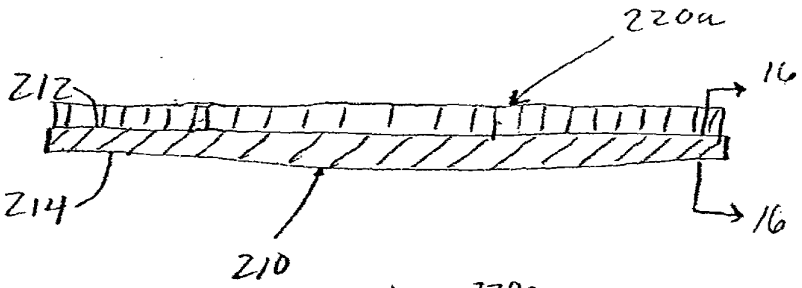


Fig. 15a

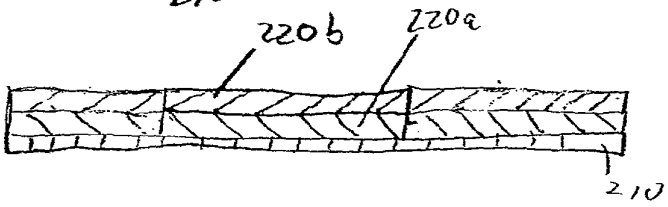


Fig. 15b

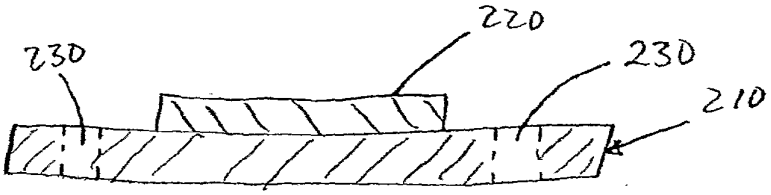


Fig. 16

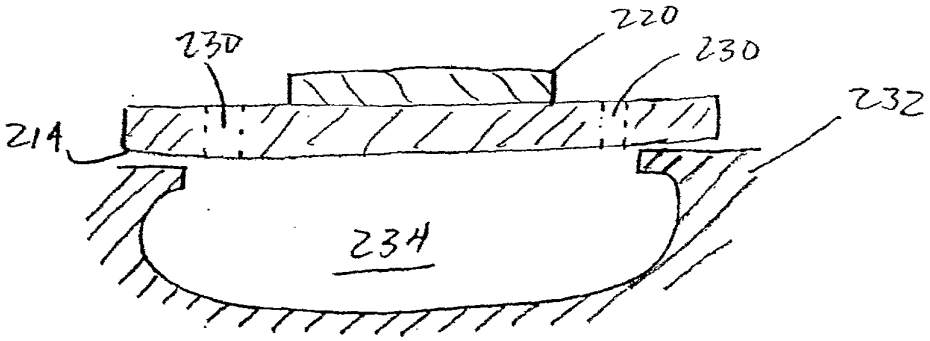


Fig. 17

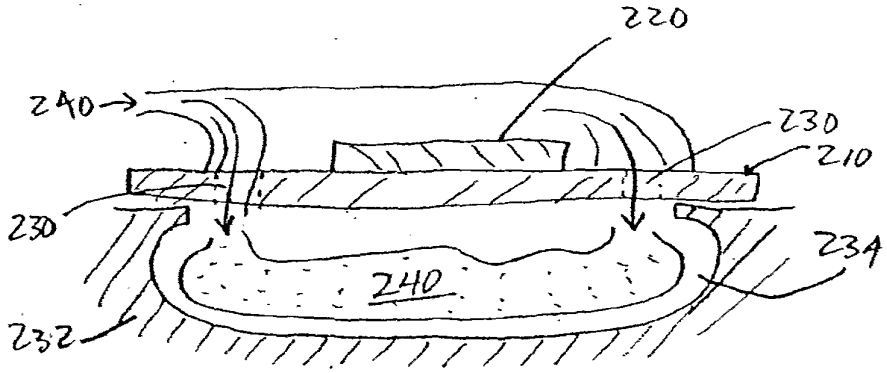


Fig. 18c

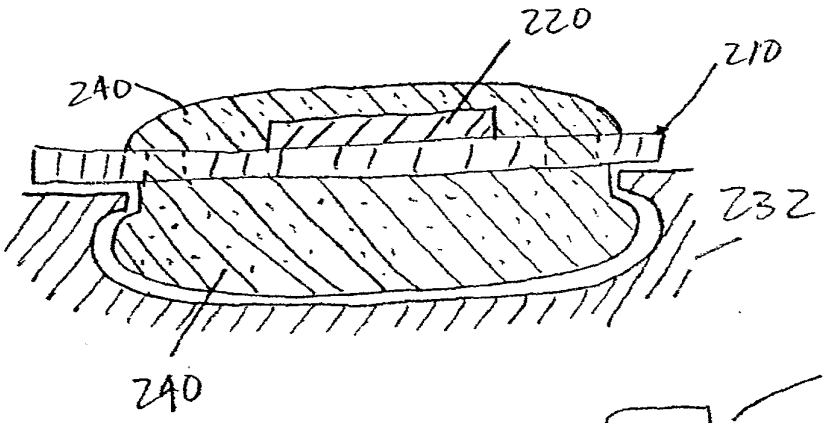


Fig. 18b

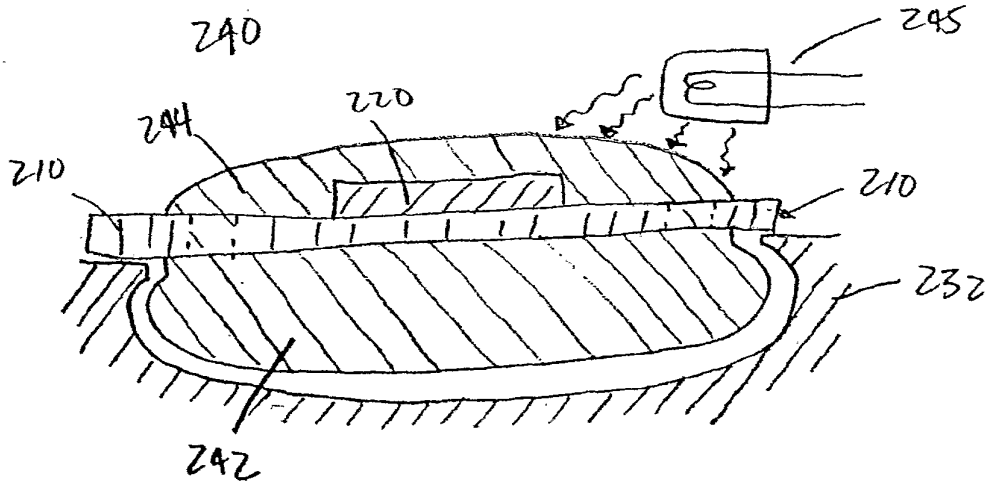


Fig. 19

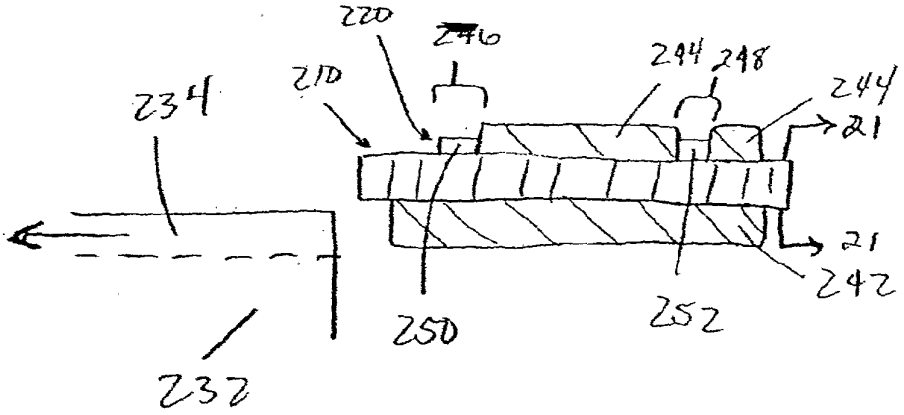


Fig. 20

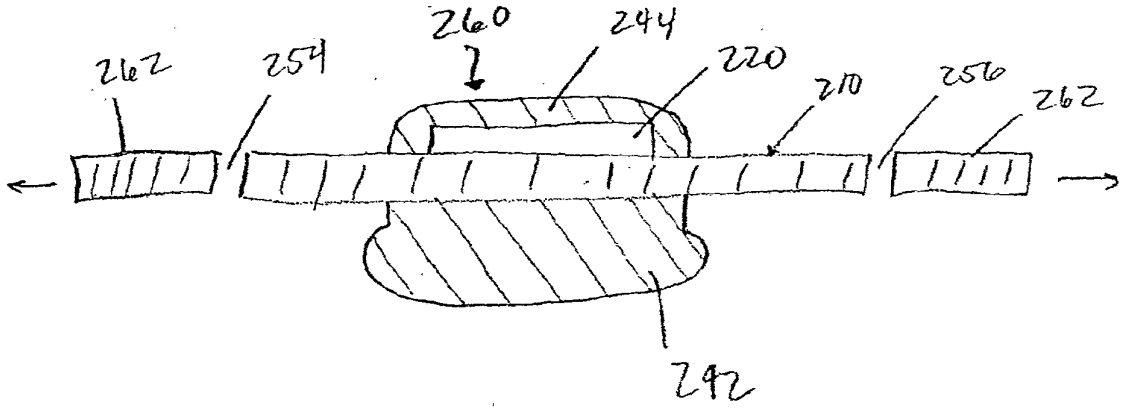


Fig. 21

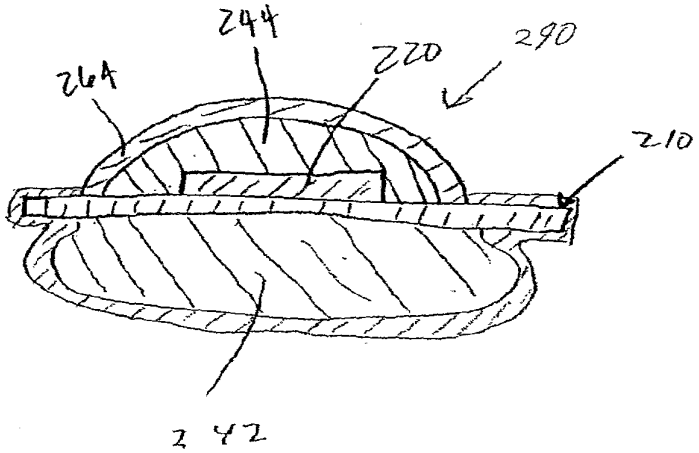


Fig. 22

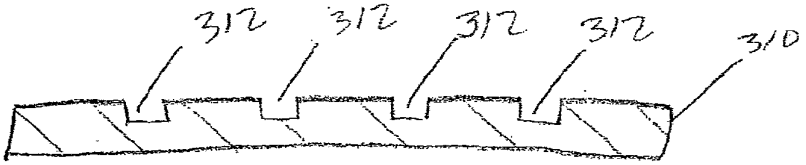


FIG. 23a

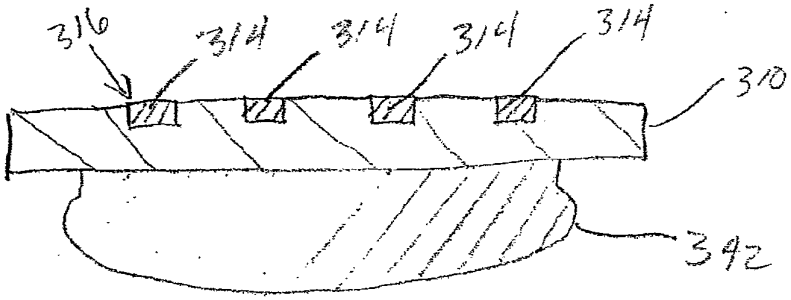


FIG. 23b

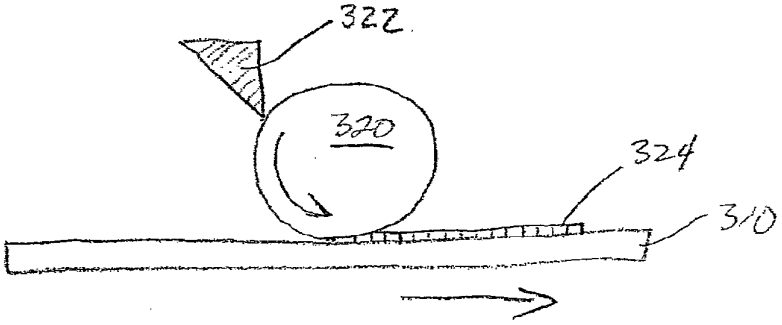


FIG. 24

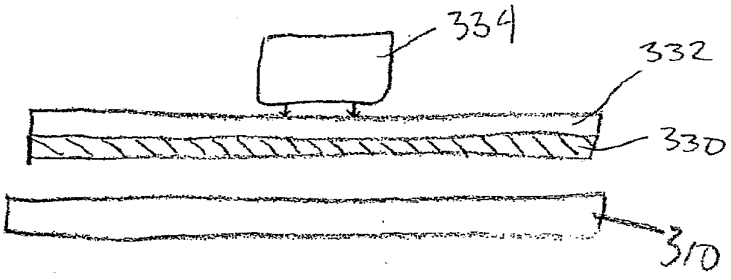


FIG. 25a

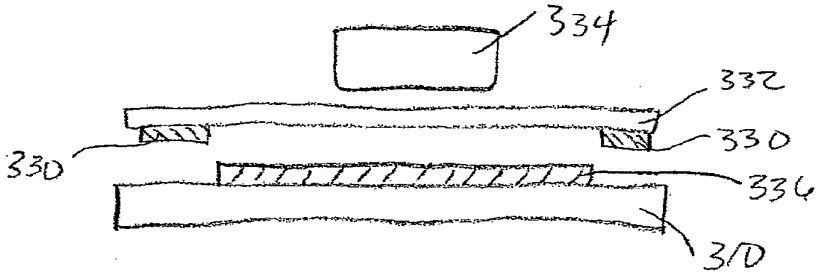


FIG. 25b

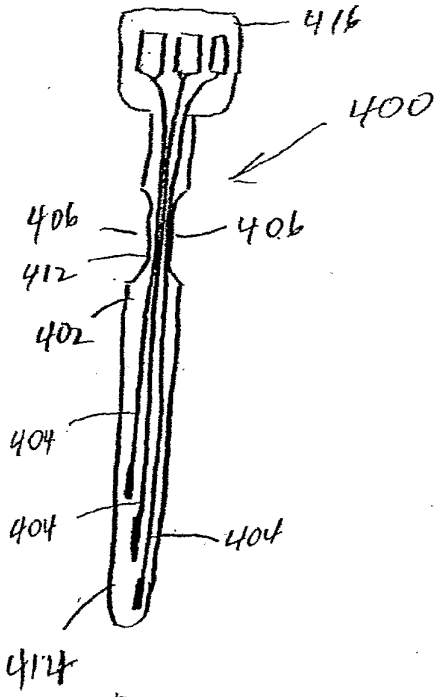


Fig. 26

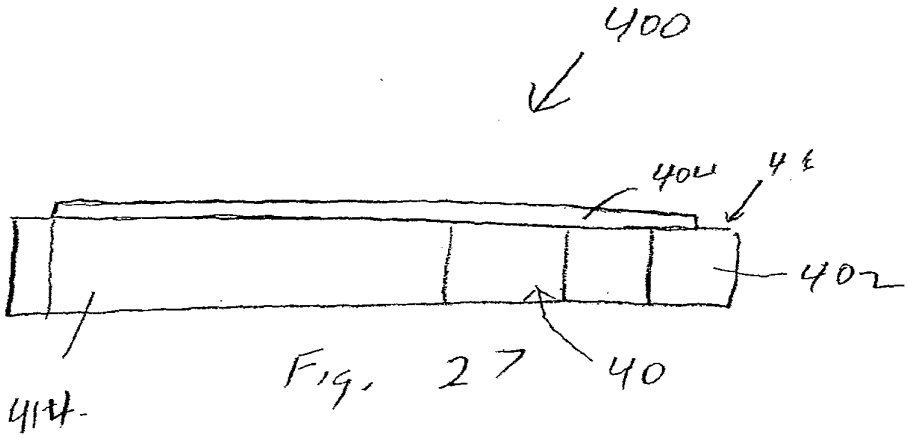


Fig. 27

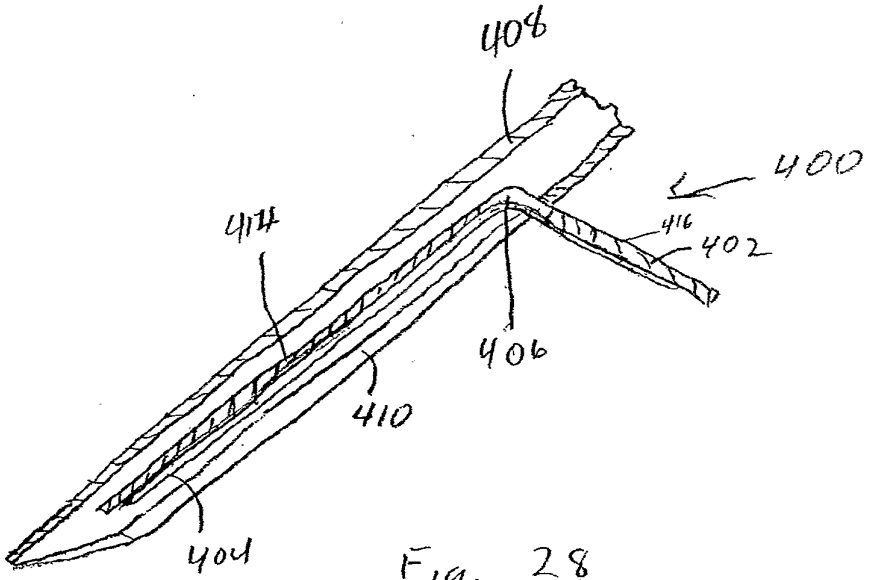


Fig. 28

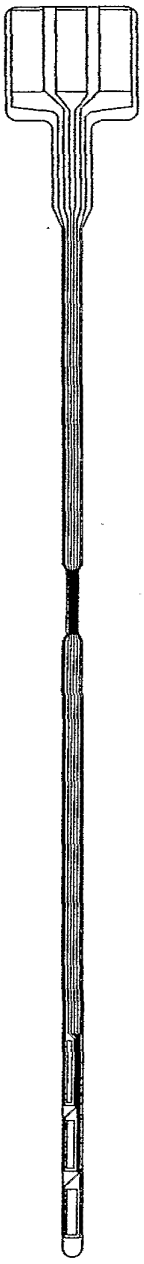


Fig. 29

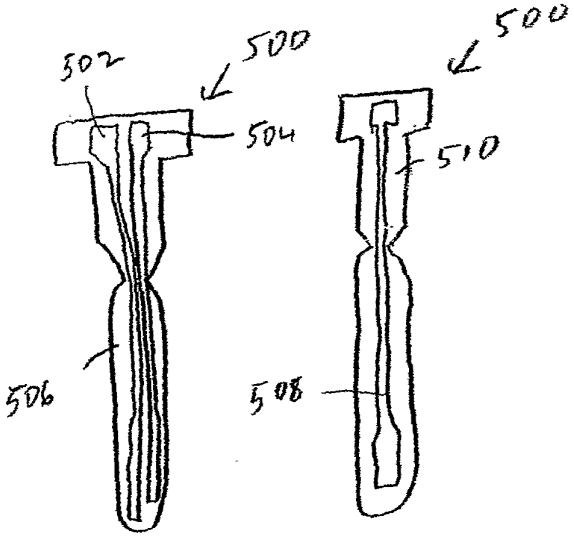


Fig. 30(a) Fig. 30(b)

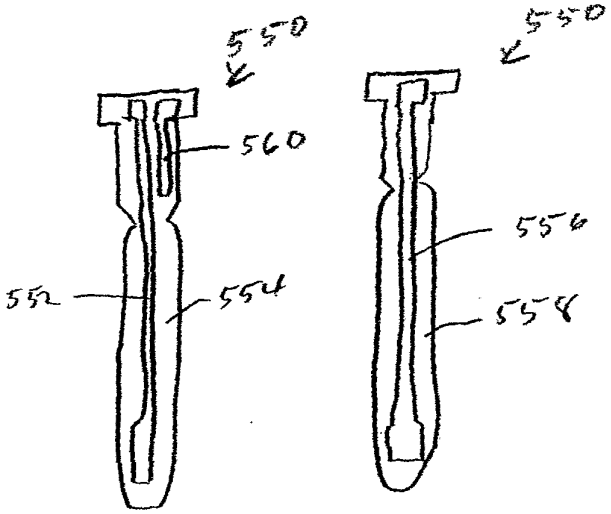


Fig. 31(a) Fig. 31(b)

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(74) Agents: **MCCLUNG, Barbara, G.**; Cygnus, Inc., 400 Penobscot Drive, Redwood City, CA 94063 et al. (US).

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 02/15778 A1

(54) Title: ANALYTE MONITORING DEVICE ALARM AUGMENTATION SYSTEM

(57) Abstract: The present invention relates to a device for augmenting an alarm signal generated by an analyte monitoring device, e.g., the Gluco Watch® (Cygnus, Inc., Redwood City, CA) biographer glucose monitoring device, for improving the alarm signal's effectiveness in alerting the user, and/or for communicating the signal to a person or person(s) other than the user, or to a trained assistance animal.

Analyte Monitoring Device Alarm Augmentation System

TECHNICAL FIELD

The present invention generally relates to a system for augmenting an alarm signal from an analyte monitoring device, e.g., the GlucoWatch® (Cygnus, Inc., Redwood City, CA) biographer glucose monitoring device.

An exemplary device for use with the present invention is the GlucoWatch biographer, a device which monitors glucose levels in an individual user and generates an aural alert signal upon sensing glucose levels outside of a predetermined range, thereby alerting the user that he or she is hypo- or hyper-glycemic, and that corrective action is necessary. Further, the device sounds an alert if glucose levels are falling too rapidly. The device comprises two primary elements, a durable element (comprising a watch-type housing, display element, microprocessor element, electrical connector elements, and may further comprise a power supply) and a consumable element (e.g., an AutoSensor component involved in sampling and signal detection).

In some cases, however, an aural signal provided by an analyte monitoring device may be inadequate to alert an individual user of an analyte monitoring device that the analyte amount or concentration is not within the normal predetermined range. For example, the user may be asleep or physically impaired. Alternately, the user may be a small child or animal who is unable to take the action required, e.g., administering glucose, insulin, or alerting an adult who may provide assistance. In a worst-case scenario, the detected analyte abnormality may render the user incapable of perceiving the signal or of seeking help, such as in the case of insulin shock or diabetic coma.

In such cases, augmentation and/or transmission of the alarm signal to another person or to emergency personnel is desirable.

However, until now, an alarm augmentation system for an analyte monitoring device, e.g., the GlucoWatch biographer, has not been described or suggested.

SUMMARY OF THE INVENTION

The present invention relates to an augmented alarm system for use with an analyte monitoring device.

In a first aspect of the invention, the augmented alarm system constitutes an improvement to a pre-existing analyte monitoring device (for example, a glucose monitoring device) that provides an alert or alarm, e.g., when analyte values (or predicted analyte values) fall outside of a predetermined range. The improvement results from modification of the device's circuitry which renders the device capable of producing a auditory, visual, tactile (or kinesthetic), olfactory, or gustatory stimulus, or variations or combinations thereof. That stimulus serves as the augmented alarm signal.

In one embodiment of this first aspect of the invention, the analyte monitoring device is the GlucoWatch biographer. Typically modification of the device's system comprises changes to the durable element of the system, although the consumable component of the Glucowatch biographer (i.e., the AutoSensor) may also be modified. For example, the iontophoretic channels of the monitoring device's durable element are modified to deliver an electrical current, typically delivered through the ionically conductive material of the consumable element, so as to provide a tactile stimulus that serves as the augmented alarm signal.

In a second aspect of the invention, the augmented alarm system constitutes an improvement to a pre-existing analyte monitoring system, for example, a glucose monitoring device. In this second aspect of the invention, the improvement results from modification of the device's circuitry, typically of the durable element, to provide a connection to a first and/or second signaling component for producing alarm signals to alert a user of the monitoring device (or to alert others) to analyte levels outside of a predetermined range.

In one embodiment of this second aspect of the invention, the analyte monitoring device is the GlucoWatch biographer glucose monitoring device. Some modifications to provide a connection to a first and/or second signaling component include, but are not limited to, modifications to the following elements of the durable component: reconfiguring the confidence loop of the analyte monitoring device, modifying the transmission and receipt lines, modifying the sweat probes, or adding a serial port, which is placed in operative communication with the analyte monitoring device. In one aspect, the connection may be via a wire-like connector or alternately, via a telemetering system. The telemetering system may take a variety of forms, including but not limited to, electromagnetic radiation,

capacitance coupling, inductive coupling, infrared coupling, and may further include variations and combinations thereof. In yet another embodiment, the first signaling component may be an auditory stimulus generator, a visual stimulus generator, a tactile stimulus generator (including but not limited to a kinesthetic stimulus generator), an olfactory stimulus generator, a gustatory stimulus generator, or variations or combinations thereof.

In a third aspect of the invention, the augmented alarm system may be an integral part of an analyte monitoring device, for example, a glucose monitoring device. The analyte monitoring device may comprise (a) an acquisition unit capable of at least sensing or detecting analyte concentrations or amounts in a subject; (b) a display unit, operably linked to said acquisition unit, wherein (i) the display unit comprises means to provide an audible alert when an analyte level, in a subject being monitored, is outside of a predetermined range, and (ii) the acquisition unit and the display units are separately housed; and (c) an alarm augmentation system comprising a first signaling component, capable of producing alarm signals to alert a subject in response to analyte levels outside of a predetermined range. The first signaling component is typically operably linked to the display unit. In this embodiment the acquisition unit and the display unit, each operably connected to the other, are typically separately housed. The augmented alarm system may be housed with the display unit, or separately housed as well. In one embodiment, the display unit comprises at least a first signaling component, operably connected to the display unit, for producing augmented alarm signals to alert a user in response to analyte levels outside of a predetermined range.

In one embodiment of this third aspect of the invention, the first signaling component is a stimulus generator capable of generating auditory, visual, tactile (including but not limited to kinesthetic), olfactory or gustatory stimuli, or variations or combinations thereof. In one exemplary embodiment, the first signaling component is an auditory stimulus generator which provides a volume control for varying the volume of auditory stimuli.

In another embodiment of this third aspect, the display unit further includes a transmitter component that is operably linked to the display unit, for transmitting alarm signals to at least one external communication target; it may also provide an operative link

between the display unit and the first signaling component. The transmitter component may take the form of a serial port and a wire-like connector, the port being capable of connecting with one or more external communication targets; alternately, the transmitter component may be a telemetering system. A variety of possible telemetering systems may be employed, which include but are not limited to electromagnetic radiation, capacitance coupling, inductive coupling, infrared coupling, and may further include variations or combinations thereof.

In yet another embodiment of the third aspect of the invention, the telemetering system may be capable of connecting with other alarm augmentation system components, including but not limited to first and/or second signaling components.

In still another embodiment, the analyte monitoring device with alarm augmentation system may further include a second signaling component, for example, operably linked to the transmitter component via a telemetering system, for producing alarm signals to alert a person or persons other than the user of the analyte monitoring device to analyte levels outside of a predetermined range. The second signaling component may be an auditory, visual, tactile (including, but not limited to kinesthetic), olfactory, or gustatory stimulus generator, or variations or combinations thereof.

In a further embodiment of the third aspect of the invention, the analyte monitoring device may further include a processor component, which is operably linked to the acquisition unit, the display unit, the transmitter component, and the first and second signaling components. The processor component may be capable of receiving and processing information received from the acquisition unit and the first and second signaling components, and may further be capable of controlling the operation of the transmitter component as well as the first and second signaling components.

These and other embodiments of the present invention will readily occur to those of ordinary skill in the art in view of the disclosure herein.

BRIEF DESCRIPTION OF THE FIGURE

Figure 1 presents a schematic of an exploded view of exemplary components comprising one embodiment of an AutoSensor for use in an analyte monitoring system.

DESCRIPTION OF THE INVENTION

1. Definitions

It is to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting. As used in this specification and the appended claims, the singular forms "a", "an" and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "a reservoir" includes a combination of two or more such reservoirs, reference to "an analyte" includes mixtures of analytes, and the like.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains. Although other methods and materials similar, or equivalent, to those described herein can be used in the practice of the present invention, the preferred materials and methods are described herein.

In describing and claiming the present invention, the following terminology will be used in accordance with the definitions set out below.

The term "microprocessor" refers to a computer processor contained on an integrated circuit chip, such a processor may also include memory and associated circuits. A microprocessor may further comprise programmed instructions to execute or control selected functions, computational methods, switching, etc. Microprocessors and associated devices are commercially available from a number of sources, including, but not limited to, Cypress Semiconductor Corporation, San Jose, CA; IBM Corporation, White Plains, New York; Applied Microsystems Corporation, Redmond, WA; Intel Corporation, Chandler, Arizona; and, National Semiconductor, Santa Clara, CA.

The terms "analyte" and "target analyte" are used to denote any physiological analyte of interest that is a specific substance or component that is being detected and/or measured in a chemical, physical, enzymatic, or optical analysis. A detectable signal (e.g., a chemical signal or electrochemical signal) can be obtained, either directly or indirectly, from such an analyte or derivatives thereof. Furthermore, the terms "analyte" and "substance" are used interchangeably herein, and are intended to have the same meaning, and thus encompass any substance of interest. In preferred embodiments, the

analyte is a physiological analyte of interest, for example, glucose, or a chemical that has a physiological action, for example, a drug or pharmacological agent.

A "sampling device," "sampling mechanism" or "sampling system" refers to any device and/or associated method for obtaining a sample from a biological system for the purpose of determining the concentration of an analyte of interest. Such "biological systems" include any biological system from which the analyte of interest can be extracted, including, but not limited to, blood, interstitial fluid, perspiration and tears. Further, a "biological system" includes both living and artificially maintained systems. The term "sampling" mechanism refers to extraction of a substance from the biological system, generally across a membrane such as the stratum corneum or mucosal membranes, wherein said sampling is invasive, minimally invasive, semi-invasive or non-invasive. The membrane can be natural or artificial, and can be of plant or animal nature, such as natural or artificial skin, blood vessel tissue, intestinal tissue, and the like. Typically, the sampling mechanism is in operative contact with a "reservoir," or "collection reservoir," wherein the sampling mechanism is used for extracting the analyte from the biological system into the reservoir to obtain the analyte in the reservoir. Non-limiting examples of sampling techniques include iontophoresis, sonophoresis (see, e.g., International Publication No. WO 91/12772, published 5 September 1991; U.S. Patent No. 5,636,632), suction, electroporation, thermal poration, passive diffusion (see, e.g., International Publication Nos.: WO 97/38126 (published 16 October 1997); WO 97/42888, WO 97/42886, WO 97/42885, and WO 97/42882 (all published 20 November 1997); and WO 97/43962 (published 27 November 1997)), microfine (miniature) lances or cannulas, biolistic (e.g., using particles accelerated to high speeds), subcutaneous implants or insertions, and laser devices (see, e.g., Jacques et al. (1978) J. Invest. Dermatology 88:88-93; International Publication WO 99/44507, published 1999 September 10; International Publication WO 99/44638, published 1999 September 10; and International Publication WO 99/40848, published 1999 August 19). Iontophoretic sampling devices are described, for example, in International Publication No. WO 97/24059, published 10 July 1997; European Patent Application EP 0942 278, published 15 September 1999; International Publication No. WO 96/00110, published 4 January 1996; International Publication No. WO 97/10499, published 2 March 1997; U.S. Patent

Numbers 5,279,543; 5,362,307; 5,730,714; 5,771,890; 5,989,409; 5,735,273; 5,827,183; 5,954,685 and 6,023,629. Further, a polymeric membrane may be used at, for example, the electrode surface to block or inhibit access of interfering species to the reactive surface of the electrode.

The term "physiological fluid" refers to any desired fluid to be sampled, and includes, but is not limited to, blood, cerebrospinal fluid, interstitial fluid, semen, sweat, saliva, urine and the like.

The term "artificial membrane" or "artificial surface," refers to, for example, a polymeric membrane, or an aggregation of cells of monolayer thickness or greater which are grown or cultured in vivo or in vitro, wherein said membrane or surface functions as a tissue of an organism but is not actually derived, or excised, from a pre-existing source or host.

A "monitoring system" or "analyte monitoring device" refer to a system useful for obtaining frequent measurements of a physiological analyte present in a biological system. Such a device is useful, for example, for monitoring the amount or concentration of an analyte in a subject. Such a system may comprise, but is not limited to, a sampling mechanism, a sensing mechanism, and a microprocessor mechanism in operative communication with the sampling mechanism and the sensing mechanism. Such a device typically provides frequent measurement or determination of analyte amount or concentration in the subject and provides an alert or alerts when levels of the analyte being monitored fall outside of a predetermined range. Such devices may comprise durable and consumable (or disposable) elements. The term "glucose monitoring device" refers to a device for monitoring the amount or concentration of glucose in a subject. Such a device typically provides a frequent measurement or determination of glucose amount or concentration in the subject and provides an alert or alerts when glucose levels fall outside of a predetermined range. One such exemplary glucose monitoring device is the GlucoWatch biographer available from Cygnus, Inc., Redwood City, CA, US. The GlucoWatch biographer comprises two primary elements, a durable element (comprising a watch-type housing, circuitry, display element, microprocessor element, electrical connector elements, and may further comprise a power supply) and a consumable, or disposable, element (e.g., an AutoSensor component involved in sampling and signal

detection, see, for example, WO 99/58190, published 18 November 1999). This and similar devices is described, for example, in the following publications: Tamada, et al., (1999) *JAMA* 282:1839-1844; U.S. Patent No. 5,771,890, issued 30 June 1998; U.S. Patent No. 5, 735,273, issued 7 April 1998; U.S. Patent No. 5,827,183, issued 27 October 1998; U.S. Patent No. 5,954,685, issued 21 September 1999; U.S. Patent No. 5,989,409, issued 23 November 1999; U.S. Patent No. 6,023,629, issued 8 February 2000; EP Patent Application EP 0 942 278 A2, published 15 Sept. 1999; PCT International Application WO 96/001100, published 4 January 1996; PCT International Application WO 99/58190, published 18 November 1999. The GlucoWatch biographer provides a device for frequent sampling of glucose from a subject the application of low intensity electric fields across the skin (iontophoresis) to enhance the transport of glucose from body tissues to a sampling chamber. In addition, when the concentration or amount of glucose has been determined to be outside of a predetermined range of values the GlucoWatch biographer produces an alert or alarm signal. Such an alert or alarm is a component of the GlucoWatch biographer.

In a further embodiment, the analyte monitoring device of the present invention may comprise an "acquisition unit" and a "display unit." An "acquisition unit" is a device that is capable of at least sensing or detecting analyte concentrations or amounts (e.g., a sensing device, or an analyte monitoring device comprising sampling and sensing devices) and of transmitting that data to a "display unit." In turn, a "display unit" is a device capable of receiving data from an acquisition unit and exhibiting that data using, e.g., an LCD screen. The acquisition unit and display unit may be contained together in a single housing, or separately housed.

The terms "alarm augmentation system," and "alarm system" are used interchangeably herein, and refer to the analyte monitoring device alarm augmentation system that is the subject of the present invention, for example, the GlucoWatch biographer provides an alert to the user and a glucose monitoring device alarm augmentation system may be used to provide an enhanced alarm as described herein.

A "component" is a conceptual part of the entire alarm augmentation system of the present invention which performs a particular function. Thus, a "component" may comprise more than one physical part or device. Similarly, a "sub-component" is a

conceptual sub-part of a component which performs a particular function. As is the case for a component, a "sub-component" may comprise more than one physical part or device.

"Signaling components" are devices capable of augmenting the analyte monitoring device alert or alarm signal, for example, the GlucoWatch biographer's alert signal, by generating a sensory stimulus, and thereby alerting persons to analyte levels outside of a predetermined range. A "first signaling component" typically serves to alert the user of the monitoring device or someone in close proximity; a "second signaling component" typically serves to alert persons other than the user. In general, signaling components are capable of generating sensory stimuli of at least one of the following types: (i) auditory; (ii) visual; (iii) tactile, including but not limited to kinesthetic; (iv) olfactory; (v) gustatory; and (vi) variations and combinations thereof.

A "transmitter component" is a device capable of communicating an alarm signal to an external communication target, and/or to first and/or second signaling components, when present.

A "processor component" refers to a component capable of integrating alarm signals received from the GlucoWatch biographer and from the other alarm system components, as well as controlling the functioning of the other components.

The term "housing" refers to a structure that physically contains a component or components of the alarm augmentation system of the present invention. The housing may be of any suitable material, including plastic. "Components within a single housing" are those contained within a single structure, as distinguished from "components within several housings" or "components each within individual housings," etc.

"Operably connected" means any kind of telemetric or hard link by which data may be communicated between or among the analyte monitoring device and/or the component(s) of the alarm augmentation system of the present invention.

The terms "wire-like," "cable-like," and "hard link" are terms that refer to tangible connections capable of transmitting data. Transmission may occur electronically or by other methods, e.g., via transmission of light pulses along fiber optic cables. In contrast, the terms "wireless" or "telemetric" intend devices capable of transmitting data without a tangible connection. Examples of telemetric communication methods include

electromagnetic waves and infrared radiation, and are further described in the subsection entitled "Intra- and inter-system communication" appearing below.

A "measurement cycle" typically comprises extraction of an analyte from a subject, using, for example, a sampling device, and sensing of the extracted analyte, for example, using a sensing device, to provide a measured signal, for example, a measured signal response curve. A complete measurement cycle may comprise one or more sets of extraction and sensing.

The term "frequent measurement" refers to a series of two or more measurements obtained from a particular biological system, which measurements are obtained using a single device maintained in operative contact with the biological system over a time period in which a series of measurements (e.g., second, minute or hour intervals) is obtained. The term thus includes continual and continuous measurements.

The term "subject" encompasses any warm-blooded animal, particularly including a member of the class Mammalia such as, without limitation, humans and nonhuman primates such as chimpanzees and other apes and monkey species; farm animals such as cattle, sheep, pigs, goats and horses; domestic mammals such as dogs and cats; laboratory animals including rodents such as mice, rats and guinea pigs, and the like. The term does not denote a particular age or sex and, thus, includes adult and newborn subjects, whether male or female. A "user" or "subject" refers to a person or animal whose analyte levels are being monitored by an analyte monitoring device. Thus, for example, a user or subject of the GlucoWatch biographer, glucose monitoring device is one whose glucose levels are being monitored by that device.

The terms "another" and "others" refer to a person or to persons, respectively, other than a "user" or "subject" as defined above. Further, these terms may refer to an animal that, for example, is trained as an assistance animal (e.g., guide dogs, service dogs, seizure alert dogs, etc.).

The term "emergency personnel" refers to persons such as paramedics, firepersons, policepersons, and others trained to respond to medical emergencies who are available to respond and who may respond upon being summoned.

An "external communication target" is an entity that is the target of data communicated by the transmitter component of the alarm system. Such targets may

include, but are not limited to, the following: (1) pagers, for example, pagers carried by a significant other, parent, relative or other care giver, or by the user's physician; (2) computers, such as the computer of the user's physician or of a health-care facility; and (3) phone lines, such as 911 emergency response lines, the phone line of a physician or of a parent, significant other, relative or care-giver. Additional targets may be apparent to persons of ordinary skill in the art, in light of the teachings of the present specification.

The term "transdermal" includes both transdermal and transmucosal techniques, i.e., extraction of a target analyte across skin, e.g., stratum corneum, or mucosal tissue. Aspects of the invention which are described herein in the context of "transdermal," unless otherwise specified, are meant to apply to both transdermal and transmucosal techniques.

The term "transdermal extraction," or "transdermally extracted" refers to any sampling method, which entails extracting and/or transporting an analyte from beneath a tissue surface across skin or mucosal tissue. The term thus includes extraction of an analyte using, for example, iontophoresis (reverse iontophoresis), electroosmosis, sonophoresis, microdialysis, suction, and passive diffusion. These methods can, of course, be coupled with application of skin penetration enhancers or skin permeability enhancing technique such as various substances or physical methods such as tape stripping or pricking with micro-needles. The term "transdermally extracted" also encompasses extraction techniques which employ thermal poration, laser microporation, electroporation, microfine lances, microfine cannulas, subcutaneous implants or insertions, combinations thereof, and the like.

The term "iontophoresis" refers to a method for transporting substances across tissue by way of an application of electrical energy to the tissue. In conventional iontophoresis, a reservoir is provided at the tissue surface to serve as a container of (or to provide containment for) material to be transported. Iontophoresis can be carried out using standard methods known to those of skill in the art, for example by establishing an electrical potential using a direct current (DC) between fixed anode and cathode "iontophoretic electrodes," alternating a direct current between anode and cathode iontophoretic electrodes, or using a more complex waveform such as applying a current with alternating polarity (AP) between iontophoretic electrodes (so that each electrode is

alternately an anode or a cathode). For example, see U.S. Patent Nos. 5,771,890 and 6,023,629 and PCT Publication No. WO 96/00109, published 4 January 1996.

The term "reverse iontophoresis" refers to the movement of a substance from a biological fluid across a membrane by way of an applied electric potential or current. In reverse iontophoresis, a reservoir is provided at the tissue surface to receive the extracted material, as used in the GlucoWatch® (Cygnus, Inc., Redwood City, CA) biographer glucose monitor (See, e.g., Tamada, et al. (1999) JAMA 282:1839-1844).

"Electroosmosis" refers to the movement of a substance through a membrane by way of an electric field-induced convective flow. The terms iontophoresis, reverse iontophoresis, and electroosmosis, will be used interchangeably herein to refer to movement of any ionically charged or uncharged substance across a membrane (e.g., an epithelial membrane) upon application of an electric potential to the membrane through an ionically conductive medium.

The term "sensing device," or "sensing mechanism," encompasses any device that can be used to measure the concentration or amount of an analyte, or derivative thereof, of interest in a subject. Preferred sensing devices for detecting analytes generally include electrochemical devices, optical and chemical devices and combinations thereof. Examples of electrochemical devices include the Clark electrode system (see, e.g., Updike, et al., (1967) Nature 214:986-988), and other amperometric, coulometric, or potentiometric electrochemical devices, as well as, optical methods, for example UV detection or infrared detection (e.g., U. S. Patent No. 5,747,806).

A "biosensor" or "biosensor device" includes, but is not limited to, a "sensor element" that includes, but is not limited to, a "biosensor electrode" or "sensing electrode" or "working electrode" which refers to the electrode that is monitored to determine the amount of electrical signal at a point in time or over a given time period, which signal is then correlated with the concentration of a chemical compound. The sensing electrode comprises a reactive surface which converts the analyte, or a derivative thereof, to electrical signal. The reactive surface can be comprised of any electrically conductive material such as, but not limited to, platinum-group metals (including, platinum, palladium, rhodium, ruthenium, osmium, and iridium), nickel, copper, and silver, as well as, oxides, and dioxides, thereof, and combinations or alloys of the

foregoing, which may include carbon as well. Some catalytic materials, membranes, and fabrication technologies suitable for the construction of amperometric biosensors are described by Newman, J.D., et al.(1995) Analytical Chemistry 67:4594-4599.

The "sensor element" can include components in addition to the sensing electrode, for example, it can include a "reference electrode" and a "counter electrode." The term "reference electrode" is used to mean an electrode that provides a reference potential, e.g., a potential can be established between a reference electrode and a working electrode. The term "counter electrode" is used to mean an electrode in an electrochemical circuit that acts as a current source or sink to complete the electrochemical circuit. Although it is not essential that a counter electrode be employed where a reference electrode is included in the circuit and the electrode is capable of performing the function of a counter electrode, it is preferred to have separate counter and reference electrodes because the reference potential provided by the reference electrode is most stable when it is at equilibrium. If the reference electrode is required to act further as a counter electrode, the current flowing through the reference electrode may disturb this equilibrium. Consequently, separate electrodes functioning as counter and reference electrodes are preferred.

In one embodiment, the "counter electrode" of the "sensor element" comprises a "bimodal electrode." The term "bimodal electrode" typically refers to an electrode which is capable of functioning non-simultaneously as, for example, both the counter electrode (of the "sensor element") and the iontophoretic electrode (of the "sampling mechanism") as described, for example, U.S. Patent No. 5,954,685.

The terms "reactive surface," and "reactive face" are used interchangeably herein to mean the surface of the sensing electrode that: (1) is in contact with the surface of an ionically conductive material which contains an analyte or through which an analyte, or a derivative thereof, flows from a source thereof; (2) is comprised of a catalytic material (e.g., a platinum group metal, platinum, palladium, rhodium, ruthenium, or nickel and/or oxides, dioxides and combinations or alloys thereof) or a material that provides sites for electrochemical reaction; (3) converts a chemical signal (for example, hydrogen peroxide) into an electrical signal (e.g., an electrical current); and (4) defines the electrode surface area that, when composed of a reactive material, is sufficient to drive

the electrochemical reaction at a rate sufficient to generate a detectable, reproducibly measurable, electrical signal that is correlatable with the amount of analyte present in the electrolyte.

An "ionically conductive material" refers to any material that provides ionic conductivity, and through which electrochemically active species can diffuse. The ionically conductive material can be, for example, a solid, liquid, or semi-solid (e.g., in the form of a gel) material that contains an electrolyte, which can be composed primarily of water and ions (e.g., sodium chloride), and generally comprises 50% or more water by weight. The material can be in the form of a hydrogel, a sponge or pad (e.g., soaked with an electrolytic solution), or any other material that can contain an electrolyte and allow passage of electrochemically active species, especially the analyte of interest. Some exemplary hydrogel formulations are described in WO 97/02811, published Jan. 30, 1997. The ionically conductive material may comprise a biocide. For example, during manufacture of an AutoSensor assembly, one or more biocides may be incorporated into the ionically conductive material. Biocides of interest include, but are not limited to, compounds such as chlorinated hydrocarbons; organometallics; hydrogen releasing compounds; metallic salts; organic sulfur compounds; phenolic compounds (including, but not limited to, a variety of Nipa Hardwicke Inc. liquid preservatives registered under the trade names Nipastat®, Nipaguard®, Phenosept®, Phenonip®, Phenoxetol®, and Nipacide®); quaternary ammonium compounds; surfactants and other membrane-disrupting agents (including, but not limited to, undecylenic acid and its salts), combinations thereof, and the like.

The term "buffer" refers to one or more components which are added to a composition in order to adjust or maintain the pH of the composition.

The term "electrolyte" refers to a component of the ionically conductive medium which allows an ionic current to flow within the medium. This component of the ionically conductive medium can be one or more salts or buffer components, but is not limited to these materials.

The term "collection reservoir" is used to describe any suitable containment method or device for containing a sample extracted from a biological system. For example, the collection reservoir can be a receptacle containing a material which is

ionically conductive (e.g., water with ions therein), or alternatively it can be a material, such as a sponge-like material or hydrophilic polymer, used to keep the water in place. Such collection reservoirs can be in the form of a hydrogel (for example, in the shape of a disk or pad). Hydrogels are typically referred to as "collection inserts." Other suitable collection reservoirs include, but are not limited to, tubes, vials, strips, capillary collection devices, cannulas, and miniaturized etched, ablated or molded flow paths.

A "collection insert layer" is a layer of an assembly or laminate comprising a collection reservoir (or collection insert) located, for example, between a mask layer and a retaining layer.

A "laminate" refers to structures comprised of, at least, two bonded layers. The layers may be bonded by welding or through the use of adhesives. Examples of welding include, but are not limited to, the following: ultrasonic welding, heat bonding, and inductively coupled localized heating followed by localized flow. Examples of common adhesives include, but are not limited to, chemical compounds such as, cyanoacrylate adhesives, and epoxies, as well as adhesives having such physical attributes as, but not limited to, the following: pressure sensitive adhesives, thermoset adhesives, contact adhesives, and heat sensitive adhesives.

A "collection assembly" refers to structures comprised of several layers, where the assembly includes at least one collection insert layer, for example a hydrogel. An example of a collection assembly as referred to in the present invention is a mask layer, collection insert layer, and a retaining layer where the layers are held in appropriate functional relationship to each other but are not necessarily a laminate (i.e., the layers may not be bonded together. The layers may, for example, be held together by interlocking geometry or friction).

The term "mask layer" refers to a component of a collection assembly that is substantially planar and typically contacts both the biological system and the collection insert layer. See, for example, U.S. Patent Nos. 5,735,273, 5,827,183, and 6,201,979.

The term "gel retaining layer" or "gel retainer" refers to a component of a collection assembly that is substantially planar and typically contacts both the collection insert layer and the electrode assembly.

The term "support tray" typically refers to a rigid, substantially planar platform and is used to support and/or align the electrode assembly and the collection assembly. The support tray provides one way of placing the electrode assembly and the collection assembly into the sampling system.

An "AutoSensor assembly" refers to a structure generally comprising a mask layer, collection insert layer, a gel retaining layer, an electrode assembly, and a support tray. The AutoSensor assembly may also include liners where the layers are held in approximate, functional relationship to each other. Exemplary collection assemblies and AutoSensor structures are described, for example, in International Publication WO 99/58190, published 18 November 1999; and U.S. Patent Numbers 5,735,273 and 5,827,183. The mask and retaining layers are preferably composed of materials that are substantially impermeable to the analyte (chemical signal) to be detected; however, the material can be permeable to other substances. By "substantially impermeable" is meant that the material reduces or eliminates chemical signal transport (e.g., by diffusion). The material can allow for a low level of chemical signal transport, with the proviso that chemical signal passing through the material does not cause significant edge effects at the sensing electrode.

The terms "about" or "approximately" when associated with a numeric value refers to that numeric value plus or minus 10 units of measure (i.e. percent, grams, degrees or volts), preferably plus or minus 5 units of measure, more preferably plus or minus 2 units of measure, most preferably plus or minus 1 unit of measure.

By the term "printed" is meant a substantially uniform deposition of an electrode formulation onto one surface of a substrate (i.e., the base support). It will be appreciated by those skilled in the art that a variety of techniques may be used to effect substantially uniform deposition of a material onto a substrate, e.g., Gravure-type printing, extrusion coating, screen coating, spraying, painting, electroplating, laminating, or the like.

The term "physiological effect" encompasses effects produced in the subject that achieve the intended purpose of a therapy. In preferred embodiments, a physiological effect means that the symptoms of the subject being treated are prevented or alleviated. For example, a physiological effect would be one that results in the prolongation of survival in a patient.

"Parameter" refers to an arbitrary constant or variable so appearing in a mathematical expression that changing it give various cases of the phenomenon represented (McGraw-Hill Dictionary of Scientific and Technical Terms, S.P. Parker, ed., Fifth Edition, McGraw-Hill Inc., 1994). In the context of the GlucoWatch biographer, a parameter is a variable that influences the value of the blood glucose level as calculated by an algorithm.

"Decay" refers to a gradual reduction in the magnitude of a quantity, for example, a current detected using a sensor electrode where the current is correlated to the concentration of a particular analyte and where the detected current gradually reduces but the concentration of the analyte does not.

2. Modes of Carrying Out the Invention

Before describing the present invention in detail, it is to be understood that this invention is not limited to particular combinations or process parameters, as such may, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments of the invention only, and is not intended to be limiting.

2A. General Overview of the Invention

The present invention relates to a system for augmenting an alert or alarm signal from an analyte monitoring device, in particular, a glucose monitoring device, wherein the improvement comprises an augmented alarm system. Embodiments of the augmented alarm system may comprise at least (a) a first signaling device, for producing an augmented alarm signal and thereby improving the effectiveness of the GlucoWatch biographer in alerting the user. Embodiments may additionally include (b) a transmitter component, for transmitting an augmented alarm signal to external communication targets and to the first signaling component. These individual components are described in further detail below, as are specific embodiments of an enhanced GlucoWatch biographer of the present invention. Modifications of the GlucoWatch biographer are typically, but not necessarily, made to the durable element of the system. In some aspects of the present invention modifications are made to the circuitry of the durable element of the system.

In the enhanced GlucoWatch biographer of the present invention, the first signaling component and the transmitter component are in operative communication with the GlucoWatch biographer and with each other, either by hardware or telemetric device(s). Details of inter- and intra-system communication are described in further detail below.

The present invention further relates to an alarm augmentation system for an analyte monitoring device, wherein the analyte monitoring device comprises an acquisition and a display unit. The alarm augmentation system comprises at least (a) a first signaling component for producing an alarm signal to alert the user of the analyte monitoring device to analyte levels outside of a predetermined range, and/or (b) a transmitter component for transmitting an alarm signal to external communication targets and to the first signaling component, when present. Some embodiments may include both.

Other embodiments may also include (c) a second signaling component, for producing alarm signals to alert a person or persons other than the user of said analyte monitoring device to analyte levels outside of a predetermined range. Further embodiments may additionally comprise (d) a processor component for receiving and integrating information received from both the analyte monitoring device and from the other components of the augmented alarm system, and for controlling the operation of those components. Specific embodiments of the augmented alarm system are described in further detail below.

The components of the augmented alarm system are in operative communication with each other and with the analyte monitoring device; further, the transmitter component, when present, is in operative communication with external communication targets. The specifics of these intra- and inter-system communications are described in further detail below.

2A(i). First Signaling Component and Second Signaling Component

Embodiments of the present invention may include a first signaling component and/or a second signaling component. Preferred embodiments may include at least a first signaling component, and may further include both.

The first signaling component comprises a sensory stimulus generator for generating an augmented alarm signal and thereby improving the effectiveness of the alarm signal

generated by the analyte monitoring device (e.g. the alert signal of the GlucoWatch biographer) in alerting a user. Similarly, the second signaling component comprises a sensory stimulus generator for alerting a person or persons other than the user.

Both the first and second signaling components comprise at least one sensory stimulus generator, including but not limited to the following:

1) an aural stimulus generator, which may merely amplify the alarm sound produced by the analyte monitoring device (e.g., the alert signal of the GlucoWatch biographer) or alternately generate sounds different from those produced by the device;

2) a visual stimulus generator, for example, one which turns on or flashes the lights in the room where the user of the GlucoWatch biographer is located, or which independently produces colored or flashing light;

3) a tactile stimulus generator, which, for example, generates pressure, vibration, changes in temperature or mild electrical shocks. Such a tactile stimulus generator may comprise a kinesthetic stimulus generator, which produces movement of the user relative to his/her surroundings. An example would be a vibrator which causes vibration of a chair or bed in which the user is sitting or reclining;

4) an olfactory stimulus generator, which releases various odorant compounds; and

5) a gustatory stimulus generator, which causes the release of salty, sweet, sour or bitter compounds in the mouth, or a combination of those compounds.

Both the first and second signaling components, when present, are in operative communication with the analyte monitoring device, and with the other alarm augmentation system components, either directly and/or via a processor component when such is present.

For example, in embodiments of the analyte monitoring device of the present invention wherein the display unit of that device comprises a first signaling component, that component may be in direct operative communication with the acquisition unit. In embodiments wherein the display unit comprises both a transmitter component and a first signaling component, the first signaling component may be in direct operative communication with both the acquisition device and the transmitter component; alternately, there may be a serial connection from the acquisition unit to the transmitting component to the first signaling component. Communication may be either uni- or bi-directional between these various components.

Similarly, in embodiments comprising a second signaling component in addition to a transmitting component and a first signaling component , the second signaling component may be in operative communication with both the acquisition unit and the first signaling component, directly and/or indirectly, for example, by virtue of a connection from the acquisition unit to the transmitter component, and subsequent parallel connections between the transmitting component and the first and second signaling components.

In general, communication between the signaling component(s) and the analyte monitoring device, as well as among the signaling component(s) and the other alarm augmentation system components, may be mediated either by hardware (e.g., a port and a wire-like connector) or by intangible, telemetric device(s) as described in greater detail in the sub-section entitled "Intra- and Inter-System Communication" appearing below.

Both the first and second signaling components may be responsive to alarm signals generated by the analyte monitoring device via the operative connections just described.

For example, in one embodiment, the first signaling component comprises a sound amplifier which directly detects an audio alert or alarm signal generated by the analyte monitoring device, e.g., via a microphone component. The microphone may further include a filtering sub-component that limits the range of audio alarm signals detectable by the amplifier's microphone.

Alternately, there may be an intermediate processor component that receives input from the analyte monitoring device, integrates that input, and on the basis of a predetermined hierarchy of response, activates, for example, one, both or neither of a first signaling component and a second signaling component.

The signaling components may also be responsive to user inputs. For example, both the first and second signaling components may further comprise an alarm turn-off mechanism, which provides a way for input from the user or others to indicate that responsive action has been taken. In this regard, the alarm signal of both the first and second signaling components may be graded, and may increase in intensity and/or frequency if not answered. In some embodiments, a processor sub-component may be present that is capable of monitoring whether the user (in the case of the first signaling component) and/or person(s) other than the user (in the case of the second signaling

component) has activated the turn-off mechanism, and increasing the alarm frequency and/or intensity if the user/other has failed to do so.

Activity of the signaling component(s) may be simultaneous with the monitoring device's alarm, may occur sequentially, or in any predetermined sequence. Similarly, when both a first and a second component are present, either one or both may be active; when both are active, their activity may be either simultaneous or sequential.

2A(ii). Transmitter Component

Some embodiments of the alarm augmentation system of the present invention comprise a transmitter component for communicating the alarm signal to external communication targets. In some embodiments, the transmitter component may further communicate alarm signals to the first and second signaling components, when such components are present.

The transmitter component is in operative communication with the analyte monitoring device and with the other components of the alarm augmentation system, when such are present, either directly or via an intermediate processor component when present. Modes of communication between the analyte monitoring device and the transmitter component, as well as between the transmitter and other components of the alarm augmentation system of the present invention, are discussed in further detail.

The transmitter component is responsive to alarm signals generated by the analyte monitoring device, via the operative links referred to above, either directly, via a receiver sub-component of the transmitter; alternately, it may be detected initially by another component of the alarm system and subsequently communicated to the transmitter component.

The transmitter component may comprise at least one of a variety of different types of devices, including but not limited to the following: (1) a wire or wire-like connection such as a cable; (2) a modem, (3) a radio transmitter; (4) a microwave transmitter; (5) a sound transmitter (subsonic, sonic, or ultrasonic); and (6) an infrared (IR) transmitter. Other suitable devices may be apparent to persons of ordinary skill in the art, in light of the teachings of the present specification.

In response to an alarm signal, the transmitter component contacts an external

communication target (e.g., a first and/or second signaling component). External communication targets may include, but are not limited to, the following: (1) pagers, for example, pagers carried by a significant other, parent, other relative or care giver, or the user's physician; (2) computers, such as the computer of the user's physician or of a health-care facility; and (3) phone lines, such as 911 emergency response lines, the phone line of a physician or of a parent, significant other, relative or care-giver. Additional targets may be apparent to persons of ordinary skill in the art, in light of the teachings of the present specification.

In some embodiments of the invention, the transmitter component may further be capable of receiving input from remote sources, such as a telephone line or computer, and communicating them to the other components of the alarm augmentation system, either directly or via a processor component, when one is present.

Modes of communication between the transmitter component of the alarm augmentation system and external communication targets, and between remote sources of input and the transmitter, are discussed in further detail below.

In another embodiment of the present invention, the alarm augmentation system comprises a transmitting component capable of relaying the initial alarm signal to a second signaling component remote from the analyte monitoring device. Upon receipt of that signal, the second signaling component produces an augmented alarm at the remote location. For example, a relay unit (comprising the transmitting component) may be placed proximal to the acquisition unit. The acquisition unit emits an alert or alarm signal, this signal is communicated (for example, by a wire or wire-like connection such as a cable; a modem, a radio transmitter; a microwave transmitter; a sound transmitter (subsonic, sonic, or ultrasonic); and/or an infrared (IR) transmitter) to the relay unit. The relay unit then communicates the signal to a second, remote, signaling component (which may also include a display unit to show, for example, the analyte amount or concentration or a trend of analyte amount or concentration, e.g., a hyper- or hypo-glycemic trend). Communication with the second signaling component may be via any of the above described modes, as well as via, for example, phone lines, the internet, and/or an intranet. The second signaling component may, for example, be used to alert a doctor, home practitioner, parent, significant other, or medical emergency personnel.

2A(iii). Processor Component

Some embodiments of the alarm augmentation system of the present invention also comprise a processor component, e.g., for evaluating the incoming alarm signal, integrating user inputs, coordinating the alarm augmentation system's response to the alarm signal, and controlling the other alarm system components.

The processor component may comprise a variety of devices, including but not limited to one or more microprocessors.

The processor component is typically responsive to the alarm signal generated by the analyte monitoring device . As discussed above, the GlucoWatch biographer alert signal may be detected by the processor component directly, via a receiver sub-component of the processor, or it may be detected initially by another component of the alarm system and subsequently communicated to the transmitter component. Modes of communication between the GlucoWatch biographer and the processor component, as well as between the processor component and other components of the alarm augmentation system of the present invention, are discussed in further detail below.

Further, the processor component is typically capable of receiving and integrating a variety of inputs in addition to the analyte monitoring device alarm signal, including but not limited to the following: (1) inputs from the other alarm augmentation system components, including user inputs made into those other components; (2) user inputs made directly into the processor component, e.g., via sensitivity controls; and (3) inputs from remote sources, either via the transmitter component or alternately directly via a second receiver sub-component . Other possibilities may be apparent to persons of ordinary skill in the art, in light of the teachings of the present specification.

The processor component may further be capable of controlling the other components of the alarm augmentation system, including but not limited to the following capabilities: (1) determining which of the various components to activate, and the order in which they are activated; and (2) controlling the functioning of the various components, including (a) the frequency and/or intensity of the augmented alarm signals generated by the signaling components; (b) determining whether the transmitter component may communicate with external communication targets, which targets the transmitter component may communicate with, the order in which the communication may occur, and the nature of

the communication; (c) determining whether the transmitter component may receive inputs from external sources; and (d) controlling the sensitivity of the system to the analyte monitoring device alarm signal. Other capabilities may be apparent to persons of ordinary skill in the art, in light of the teachings of the present specification.

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2A(iv). Intra- and Inter-System Communication

The analyte monitoring device is in operative communication with the alarm augmentation system. Likewise, in embodiments of the alarm augmentation system comprising more than one component, the components are in operative communication with
10 each other. In turn, in embodiments of the invention comprising a transmitter component, the alarm augmentation system is in operative communication with external communication targets, and may further be able to receive input from remote data sources.

With respect to those embodiments that do not possess a processor component, the analyte monitoring device is in direct operative communication with the signaling and/or
15 transmitter components included in specific embodiments. In those embodiments which do include the processor component, the GlucoWatch biographer is in direct operative communication with the processor component, which in turn is in operative communication with the remaining component or components. Alternately, it is also possible for the analyte monitoring device to be in simultaneous communication with the processor component and
20 with the signaling and/or transmitter components.

The operative communication can include, for example, the following: both one-way and bi-directional communication from the analyte monitoring device to the alarm augmentation system, and both one-way and bi-directional communication among the various components of the alarm augmentation system. There may further be both one-way
25 and bi-directional communication among the alarm augmentation system components, and between external communication targets and external data sources, e.g., healthcare providers, 911 emergency services telephone lines, emergency transport services, pagers, computers, etc.

Communication between the acquisition unit (e.g., the analyte monitoring device)
30 and the alarm augmentation system of the present invention, among the system components, between the system and external communication targets, and between external data sources

and the system, may be via a wire or cable-like connection and/or via a telemetric connection. Communications between the various components described herein may, for example, be:

1) One-way communication from the analyte monitoring device to the alarm augmentation system and/or among the alarm augmentation system components. The alarm augmentation system can include components for data storage, user inputs, and the ability to upload information to a host computer, i.e., the system can include a processor component, e.g., one or more microprocessor and associated algorithms or protocols, and a transmitter component, e.g., a modem. Alternately, one or more of the individual system components may include a processor sub-component capable of performing those functions.

2) Two-way communications (send and receive) between the analyte monitoring device and the alarm augmentation system, and/or among the alarm components or components, where data storage, user inputs, and upload to a remote computer can be divided in any combination among the monitor device and the components.

3) A mixture of one-way and two-way (i.e., unidirectional and bi-directional) communication among components. For example, communication between the analyte monitoring device, a processor component, and a first signaling component may be bi-directional and communication between the processor component and a transmitter component in operative communication with a second signaling component may be unidirectional.

4) uni- and/or bi-directional communication, with wireless communications link between the analyte monitoring device and the alarm system, and/or among the alarm system components.

5) uni- and/or bi-directional communication, with wired or wireless communications to a remote communication target, e.g., for data upload or automatic reporting to healthcare provider via telephone, Internet, or wireless communications. For example, the alarm system may include a transmitter component, e.g., a bedside receiver/radio transmitter that automatically reports to a patient's personal physician. Alternately, the transmitter component may be a telephonic or wireless modem that performs this function.

Examples of wireless communications technologies include, but are not limited to the following (for example, short range communication, i.e., less than or equal to 3 meters, or longer range):

- Low frequency electromagnetic waves (frequency range about 1 Hz - 1 Mega Hz);
- Medium frequency electromagnetic waves (frequency range about 1 Mega Hz - 500 Mega Hz);
- High frequency electromagnetic waves (frequency range about 500 Mega Hz - 5 Giga Hz);
- Capacitance coupling between, for example, a subject's body and the environment/air (frequency range about 1 Hz - 1 Mega Hz);
- Inductive coupling (i.e., time varying magnetic field; not freely propagating electromagnetic wave);
- Close coupled inductive (i.e., inductive but so weak that it works only at very short range). This would likely require bringing the two components (e.g., a display device and sensor electronics) in close proximity whenever the data needs to be displayed.
- Brief electrical contact whenever data is needed at the display.
- Infrared coupling (using infrared light, e.g., as in low speed communications links to computers and personal digital assistants), and
- High frequency acoustic energy, as well as,
- Combinations and modifications of the above.

One embodiment of the alarm augmentation system of the present invention comprises, a glucose monitoring device, a processing component, a first signaling component, a second signaling component, and a transmitter component. Upon detection of abnormal glucose levels or trends, an alarm signal is generated by the glucose monitoring device, which signal is then be communicated to the alarm augmentation system. The alarm signal may initially be communicated to the processor component. The processor component may subsequently communicate with the first signaling component and cause it to generate an augmented alarm signal in order to alert the user. The user may then press a button on the first signaling component, which turns off the augmented alarm signal.

After a time period, which may have either been preset or previously determined by user input, receipt of additional alarm signals from the analyte monitoring device may again

cause the processor to communicate with the first signaling component, and again cause it to generate an augmented alarm signal. It may further communicate with the second signaling component and cause it to communicate the alarm signal to a person or persons other than the user. It may further communicate with the transmitter component, which may then communicate the alarm signal to remote targets, e.g., the user's physician, emergency medical personnel, etc.

Alternately, the user may fail to respond to the initial augmented alarm signal. The user's failure to turn off the first signaling component may be communicated to the processor component, which may then communicate to the second signaling component, causing an augmented alarm signal to be generated in order to alert a person or persons other than the user. The processor may also communicate with the transmitter component, which may in turn communicate with remote targets, e.g., the user's physician, emergency personnel, etc.

In a further embodiment, the processor component may additionally be capable of receiving data from the analyte monitoring device , of storing the data, and of communicating the data to the transmitter component. In addition, the processor component may be capable of performing further functions, such as data analysis, to, for example, predict trends based on the data provided by the analyte monitoring device. Further, the transmitter component may be capable of transmitting the data to remote targets, and of uploading the data to remote targets such as a pager device or a computer.

In one embodiment, the wireless connection or link may be established using a technology called Personal Area Network (PAN; WO 96/36134, N. Gershenfeld, et al., published 14 November 1996). This technology is an example of capacitance coupling involving the use of the human body to carry current, and thus information, from one device to another. These devices have to be either in direct contact, or in close proximity, to the body. A low frequency carrier is used to transmit the information.

Other examples may be apparent to persons of ordinary skill in the art, in light of the teachings of the present specification.

2A(v). Housings for the Alarm Augmentation System Components

The components of an alarm augmentation system of the present invention may be

contained in separate and independent housings. Alternately, the components may be contained within a single housing. In some embodiments, the alarm augmentation system may have a modular character, and be capable of accommodating a variable number of processing, signaling and transmitter components; in such embodiments, each of the components can be housed independently. In all cases, the components may be in operative communication (i.e., operatively connected) with each other as described above.

In one embodiment, both the analyte monitoring device and the components of the alarm augmentation system of the present invention may all be contained in a single housing. In another embodiment, the analyte monitoring device may be in close proximity to the alarm augmentation system, for example, the analyte monitoring device may be a watch-like device and the alarm augmentation system (or components thereof) may be worn as a similar device adjacent to the analyte monitoring device. In yet another embodiment, the alarm augmentation system may be worn on a different part of the body. In a further embodiment, the alarm augmentation system may be remote to the analyte monitoring device, for example, at a fixed location in the home.

The housings may comprise a variety of materials known in the art, including but not limited to the following: a wide variety of plastic polymers; metals and metal alloys; fiberglass; ceramic materials; and composite materials such as plastic polymers impregnated with graphite or silicon nitride fibers.

2B. Exemplary Monitoring Systems and Analytes

2B(i). Exemplary Analyte Monitoring Systems

Numerous analyte monitoring systems can be used in the practice of the present invention. Typically, the analyte monitoring system used to monitor the level of a selected analyte in a target system comprises a sampling device, which provides a sample comprising the analyte, and a sensing device, which detects the amount or concentration of the analyte or a signal associated with the analyte amount or concentration in the sample.

One exemplary analyte monitoring system (the GlucoWatch biographer) is described herein for monitoring glucose levels in a biological system via the transdermal extraction of glucose from the biological system, particularly an animal subject, and then

detection of signal corresponding to the amount or concentration of the extracted glucose. Transdermal extraction is carried out by applying an electrical current or ultrasonic radiation to a tissue surface at a collection site. The electrical current is used to extract small amounts of glucose from the subject into a collection reservoir. The collection reservoir is in contact with a sensor element (e.g., a biosensor) which provides for measurement of glucose concentration in the subject. As glucose is transdermally extracted into the collection reservoir, the analyte reacts with the glucose oxidase within the reservoir to produce hydrogen peroxide. The presence of hydrogen peroxide generates a current at the biosensor electrode that is directly proportional to the amount of hydrogen peroxide in the reservoir. This current provides a signal which can be detected and interpreted (for example, employing a selected algorithm) by an associated system controller to provide a glucose concentration value or amount for display.

In the use of the sampling system, a collection reservoir is contacted with a tissue surface, for example, on the stratum corneum of a subject's skin. An electrical current is then applied to the tissue surface in order to extract glucose from the tissue into the collection reservoir. Extraction is carried out, for example, frequently over a selected period of time. The collection reservoir is analyzed, at least periodically and typically frequently, to measure glucose concentration therein. The measured value correlates with the subject's blood glucose level.

To sample the analyte, one or more collection reservoirs are placed in contact with a tissue surface on a subject. The ionically conductive material within the collection reservoir is also in contact with an electrode (for reverse iontophoretic extraction) which generates a current sufficient to extract glucose from the tissue into the collection reservoir. Referring to Figure 1, an exploded view of exemplary components comprising one embodiment of an AutoSensor for use in an iontophoretic sampling system is presented. The AutoSensor components include two biosensor/iontophoretic electrode assemblies, **104** and **106**, each of which have an annular iontophoretic electrode, respectively indicated at **108** and **110**, which encircles a biosensor electrode **112** and **114**. The electrode assemblies **104** and **106** are printed onto a polymeric substrate **116** which is maintained within a sensor tray **118**. A collection reservoir assembly **120** is arranged over the electrode assemblies, wherein the collection reservoir assembly comprises two

hydrogel inserts **122** and **124** retained by a gel retaining layer **126** and mask layer **128**. Further release liners may be included in the assembly, for example, a patient liner **130**, and a plow-fold liner **132**. In one embodiment, the electrode assemblies include bimodal electrodes. A mask layer **128** (for example, as described in PCT Publication No. WO 97/10356, published 20 March 1997, and US Patent Nos. 5,735,273, 5,827,183, 6,141,573, and 6,201,979) may be present. Other AutoSensor embodiments are described in WO 99/58190, published 18 November 1999.

The mask and retaining layers are preferably composed of materials that are substantially impermeable to the analyte (e.g., glucose) to be detected (see, for example, U.S. Patent Nos. 5,735,273, and 5,827,183). By "substantially impermeable" is meant that the material reduces or eliminates analyte transport (e.g., by diffusion). The material can allow for a low level of analyte transport, with the proviso that the analyte that passes through the material does not cause significant edge effects at the sensing electrode used in conjunction with the mask and retaining layers. Examples of materials that can be used to form the layers include, but are not limited to, polyester, polyester derivatives, other polyester-like materials, polyurethane, polyurethane derivatives and other polyurethane-like materials.

The components shown in exploded view in Figure 1 (i.e., an exemplary AutoSensor) are intended for use in a automatic sampling system which is configured to be worn like an ordinary wristwatch, as described, for example, in PCT Publication No. WO 96/00110, published 4 January 1996. The AutoSensor in this case is a consumable element. A durable element, that is the wristwatch housing into which the AutoSensor is inserted, is also provided. The durable element can further include suitable electronics (e.g., one or more microprocessor(s), memory, display and other circuit components) and power sources, for example, for operating the automatic sampling system. The durable element also provides means to provide an audible alert when glucose levels in a subject being monitored are outside of a predetermined range. The one or more microprocessors may control a variety of functions, including, but not limited to, control of a sampling device, a sensing device, aspects of the measurement cycle (for example, timing of sampling and sensing, and alternating polarity between electrodes), connectivity, computational methods, different aspects of data manipulation (for example, acquisition,

recording, recalling, comparing, and reporting), etc. The durable component of the GlucoWatch biographer provides a variety of electronic configurations (i.e., circuitry) that may be modified to accommodate components of the alarm augmentation system of the present invention. Such modifications include but are not limited to (a) reconfiguring the confidence loop circuitry of the GlucoWatch biographer; (b) modifying the transmission and receipt lines or transmission and receipt line circuitry of the GlucoWatch biographer, and (c) modifying the sweat probe or sweat probe circuitry of the GlucoWatch biographer. Other modifications may be apparent to persons of ordinary skill in the art in light of the teachings of the present invention.

The sensing electrode can be, for example, a Pt-comprising electrode configured to provide a geometric surface area of about 0.1 to 3 cm^2, preferably about 0.5 to 2 cm^2, and more preferably about 1 cm^2. This particular configuration is scaled in proportion to the collection area of the collection reservoir used in the sampling system of the present invention, throughout which the extracted analyte and/or its reaction products will be present. The electrode composition is formulated using analytical- or electronic-grade reagents and solvents which ensure that electrochemical and/or other residual contaminants are avoided in the final composition, significantly reducing the background noise inherent in the resultant electrode. In particular, the reagents and solvents used in the formulation of the electrode are selected so as to be substantially free of electrochemically active contaminants (e.g., anti-oxidants), and the solvents in particular are selected for high volatility in order to reduce washing and cure times. Some electrode embodiments are described in European Patent Publication 0 942 278 A2, published Sept. 15, 1999.

The reactive surface of the sensing electrode can be comprised of any electrically conductive material such as, but not limited to, platinum-group metals (including, platinum, palladium, rhodium, ruthenium, osmium, and iridium), nickel, copper, silver, and carbon, as well as, oxides, dioxides, combinations or alloys thereof. Some catalytic materials, membranes, and fabrication technologies suitable for the construction of amperometric biosensors were described by Newman, J.D., et al. (Analytical Chemistry 67(24), 4594-4599, 1995).

Any suitable iontophoretic electrode system can be employed, an exemplary system uses a silver/silver chloride (Ag/AgCl) electrode system. The iontophoretic electrodes are formulated typically using two performance criteria: (1) the electrodes are capable of operation for extended periods, preferably periods of up to 24 hours or longer; and (2) the electrodes are formulated to have high electrochemical purity in order to operate within the present system which requires extremely low background noise levels. The electrodes must also be capable of passing a large amount of charge over the life of the electrodes. With regard to operation for extended periods of time, Ag/AgCl electrodes are capable of repeatedly forming a reversible couple which operates without unwanted electrochemical side reactions (which could give rise to changes in pH, and liberation of hydrogen and oxygen due to water hydrolysis). The Ag/AgCl electrode is thus formulated to withstand repeated cycles of current passage in the range of about 0.01 to 1.0 mA per cm^2 of electrode area. With regard to high electrochemical purity, the Ag/AgCl components are dispersed within a suitable polymer binder to provide an electrode composition which is not susceptible to attack (e.g., plasticization) by components in the collection reservoir, e.g., the hydrogel composition. The electrode compositions are also typically formulated using analytical- or electronic-grade reagents and solvents, and the polymer binder composition is selected to be free of electrochemically active contaminants which could diffuse to the biosensor to produce a background current.

The automatic sampling system can transdermally extract the sample over the course of a selected period of time using reverse iontophoresis. The collection reservoir comprises an ionically conductive medium, preferably the hydrogel medium described hereinabove. A first iontophoresis electrode is contacted with the collection reservoir (which is typically in contact with a target, subject tissue surface), and a second iontophoresis electrode is contacted with either a second collection reservoir in contact with the tissue surface, or some other ionically conductive medium in contact with the tissue. A power source provides an electrical potential between the two electrodes to perform reverse iontophoresis in a manner known in the art. As discussed above, the biosensor selected to detect the presence, and possibly the level, of the target analyte (for example, glucose) within a reservoir is also in contact with the reservoir. Typically, there

are two collections reservoirs, each comprising glucose oxidase, and each in operative contact with iontophoretic electrode and a sensing electrode. The iontophoretic electrode may be a bimodal electrode that also serves, non-concurrently, as a counter electrode to the sensing electrode (see, for example, U.S. Patent No. 5,954,685).

In practice, an electric potential (either direct current or a more complex waveform) is applied between the two iontophoresis electrodes such that current flows from the first electrode through the first conductive medium into the skin, and back out from the skin through the second conductive medium to the second electrode. This current flow extracts substances through the skin into the one or more collection reservoirs through the process of reverse iontophoresis or electroosmosis. The electric potential may be applied as described in PCT Publication No. WO 96/00110, published 4 January 1996. Typically, the electrical potential is alternated between two reservoirs to provide extraction of analyte into each reservoir in an alternating fashion (see, for example, U.S. Patent Nos. 6,023,629, 5,954,685). Analyte is also typically detected in each reservoir.

As an example, to extract glucose, the applied electrical current density on the skin or tissue can be in the range of about 0.01 to about 2 mA/cm^2. In order to facilitate the extraction of glucose, electrical energy can be applied to the electrodes, and the polarity of the electrodes can be, for example, alternated so that each electrode is alternately a cathode or an anode. The polarity switching can be manual or automatic. A device and method for sampling of substances using alternating polarity is described in U.S. Patent No. 5,771,890, issued June 30, 1998.

When a bimodal electrode is used (e.g., U.S. Patent No. 5,954,685, issued Sept. 21, 1999), during the reverse iontophoretic phase, a power source provides a current flow to the first bimodal electrode to facilitate the extraction of the chemical signal into the reservoir. During the sensing phase, a separate power source is used to provide voltage to the first sensing electrode to drive the conversion of chemical signal retained in reservoir to electrical signal at the catalytic face of the sensing electrode. The separate power source also maintains a fixed potential at the electrode where, for example hydrogen peroxide is converted to molecular oxygen, hydrogen ions, and electrons, which is compared with the potential of the reference electrode during the sensing phase.

While one sensing electrode is operating in the sensing mode it is electrically connected to the adjacent bimodal electrode which acts as a counter electrode at which electrons generated at the sensing electrode are consumed.

The electrode subassembly can be operated by electrically connecting the bimodal electrodes such that each electrode is capable of functioning as both an iontophoretic electrode and counter electrode along with appropriate sensing electrode(s) and reference electrode(s).

A potentiostat is an electrical circuit used in electrochemical measurements in three electrode electrochemical cells. A potential is applied between the reference electrode and the sensing electrode. The current generated at the sensing electrode flows through circuitry to the counter electrode (i.e., no current flows through the reference electrode to alter its equilibrium potential). Two independent potentiostat circuits can be used to operate the two biosensors. For the purpose of the present invention, the electrical current measured at the sensing electrode subassembly is the current that is correlated with an amount of chemical signal corresponding to the analyte.

The detected current can be correlated with the subject's blood glucose concentration (e.g., using a statistical technique or algorithm or combination of techniques) so that the system controller may display the subject's actual blood glucose concentration as measured by the sampling system. Such statistical techniques can be formulated as algorithm(s) and incorporated in one or more microprocessor(s) associated with the sampling system. Exemplary signal processing applications include, but are not limited to, those taught in the following U.S. Patent Nos. 6,144,869, 6,233,471, 6,180,416.

In a further aspect of the present invention, the sampling/sensing mechanism and user interface may be found on separate components. Thus, the monitoring system can comprise at least two components, in which a first component comprises sampling mechanism and sensing mechanism that are used to extract and detect an analyte, for example, glucose, and a second component that receives the analyte data from the first component, conducts data processing on the analyte data to determine an analyte concentration and then displays the analyte concentration data. Typically, microprocessor functions (e.g., control of a sampling device, a sensing device, aspects of

the measurement cycle, computational methods, different aspects of data manipulation or recording, etc.) are found in both components. Alternatively, microprocessing components may be located in one or the other of the at least two components. The second component of the monitoring system can assume many forms, including, but not limited to, the following: a watch, a credit card-shaped device (e.g., a "smart card" or "universal card" having a built-in microprocessor as described for example in U.S. Patent No. 5,892,661), a pager-like device, cell phone-like device, or other such device that communicates information to the user visually, audibly, or kinesthetically.

Further, additional components may be added to the system, for example, a third component comprising a display of analyte values or an alarm related to analyte concentration, may be employed. In certain embodiments, a delivery unit is included in the system. An exemplary delivery unit is an insulin delivery unit. Insulin delivery units, both implantable and external, are known in the art and described, for example, in U.S. Patent Numbers 5,995,860; 5,112,614 and 5,062,841. Preferably, when included as a component of the present invention, the delivery unit is in communication (e.g., wire-like or wireless communication) with the extracting and/or sensing mechanism such that the sensing mechanism can control the insulin pump and regulate delivery of a suitable amount of insulin to the subject.

Advantages of separating the first component (e.g., including the biosensor and iontophoresis functions) from the second component (e.g., including some microprocessor and display functions) include greater flexibility, discretion, privacy and convenience to the user. Having a small and lightweight measurement unit allows placement of the two components of the system on a wider range of body sites, for example, the first component may be placed on the abdomen or upper arm. This wider range of placement options may improve the accuracy through optimal extraction site selection (e.g., torso rather than extremities) and greater temperature stability (e.g., via the insulating effects of clothing). Thus, the collection and sensing assembly will be able to be placed on a greater range of body sites. Similarly, a smaller and less obtrusive microprocessor and display unit (the second component) provides a convenient and discrete system by which to monitor analytes. The biosensor readouts and control signals will be relayed via wire-like or wireless technology between the collection and sensing

assembly and the display unit which could take the form of a small watch, a pager, or a credit card-sized device. This system also provides the ability to relay an alert message or signal during nighttime use, for example, to a site remote from the subject being monitored.

In one embodiment, the two components of the device can be in operative communication via a wire or cable-like connection. Operative communications between the components can be wireless link or connection, i.e. provided by a "virtual cable," for example, a telemetry link. This wireless link can be uni- or bi-directional between the two components. In the case of more than two components, links can be a combination of wire-like and wireless.

2B(ii). Exemplary Analytes

The analyte can be any one or more specific substance, component, or combinations thereof that one is desirous of detecting and/or measuring in a chemical, physical, enzymatic, or optical analysis.

Analytes that can be measured using the methods of the present invention include, but are not limited to, amino acids, enzyme substrates or products indicating a disease state or condition, other markers of disease states or conditions, drugs of abuse (e.g., ethanol, cocaine), therapeutic and/or pharmacologic agents (e.g., theophylline, anti-HIV drugs, lithium, anti-epileptic drugs, cyclosporin, chemotherapeutics), electrolytes, physiological analytes of interest (e.g., urate/uric acid, carbonate, calcium, potassium, sodium, chloride, bicarbonate (CO_2), glucose, urea (blood urea nitrogen), lactate and/or lactic acid, hydroxybutyrate, cholesterol, triglycerides, creatine, creatinine, insulin, hematocrit, and hemoglobin), blood gases (carbon dioxide, oxygen, pH), lipids, heavy metals (e.g., lead, copper), and the like. Analytes in non-biological systems may also be evaluated using the methods of the present invention.

In preferred embodiments, the analyte is a physiological analyte of interest, for example glucose, or a chemical that has a physiological action, for example a drug or pharmacological agent.

In order to facilitate detection of the analyte, an enzyme (or enzymes) can be disposed within the one or more collection reservoirs. The selected enzyme is capable of

catalyzing a reaction with the extracted analyte to the extent that a product of this reaction can be sensed, e.g., can be detected electrochemically from the generation of a current which current is detectable and proportional to the amount of the analyte which is reacted. In one embodiment of the present invention, a suitable enzyme is glucose oxidase, which oxidizes glucose to gluconic acid and hydrogen peroxide. The subsequent detection of hydrogen peroxide on an appropriate biosensor electrode generates two electrons per hydrogen peroxide molecule creating a current that can be detected and related to the amount of glucose entering the device. Glucose oxidase (GOx) is readily available commercially and has well known catalytic characteristics. However, other enzymes can also be used singly (for detection of individual analytes) or together (for detection of multiple analytes), as long as they specifically catalyze a reaction with an analyte or substance of interest to generate a detectable product in proportion to the amount of analyte so reacted.

In like manner, a number of other analyte-specific enzyme systems can be used in the invention, which enzyme systems operate on much the same general techniques. For example, a biosensor electrode that detects hydrogen peroxide can be used to detect ethanol using an alcohol oxidase enzyme system, or similarly uric acid with urate oxidase system, cholesterol with a cholesterol oxidase system, and theophylline with a xanthine oxidase system.

In addition, the oxidase enzyme (used for hydrogen peroxidase-based detection) can be replaced or complemented with another redox system, for example, the dehydrogenase-enzyme NAD-NADH, which offers a separate route to detecting additional analytes. Dehydrogenase-based sensors can use working electrodes made of gold or carbon (via mediated chemistry). Examples of analytes suitable for this type of monitoring include, but are not limited to, cholesterol, ethanol, hydroxybutyrate, phenylalanine, triglycerides, and urea.

Further, the enzyme can be eliminated and detection can rely on direct electrochemical or potentiometric detection of an analyte. Such analytes include, without limitation, heavy metals (e.g., cobalt, iron, lead, nickel, zinc), oxygen, carbonate/carbon dioxide, chloride, fluoride, lithium, pH, potassium, sodium, and urea. Also, the sampling system described herein can be used for therapeutic drug monitoring, for example,

monitoring anti-epileptic drugs (e.g., phenytoin), chemotherapy (e.g., adriamycin), hyperactivity (e.g., ritalin), and anti-organ-rejection (e.g., cyclosporin).

Preferably, a sensor electrode is able to detect the analyte that has been extracted into the one or more collection reservoirs when present at nominal concentration levels. Suitable exemplary biosensor electrodes and associated sampling systems as described in are described in PCT Publication Nos. WO 97/10499, published 20 March 1997 and WO 98/42252, published 1 October 1998.

A single sensor may detect multiple analytes and/or reaction products of analytes. For example, a platinum sensor could be used to detect tyrosine and glucose in a single sample. The tyrosine is detected, for example, by direct electrochemical oxidation at a suitable electrode potential (e.g., approximately 0.6V vs. Ag/AgCl). The glucose is detected, e.g., using glucose oxidase and detecting the hydrogen peroxide reaction product.

Different sensing devices and/or sensing systems can be employed as well to distinguish between signals. For example, a first gel containing glucose oxidase associated with a first platinum sensor can be used for the detection of glucose, while a second gel containing uricase associated with a second platinum sensor can be used for the detection of urea.

2C. Exemplary Embodiments of the Alarm Augmentation System

The alarm augmentation system of the present invention may exist as a singe unit device, or alternatively, may comprise multiple units.

2C(i). Single Unit Devices

The augmented alarm system may exist as a single unit device combined with an analyte monitoring device.

In an exemplary device, the alarm augmentation system is incorporated into a durable element of the analyte monitoring device. In one embodiment of this exemplary device, an aspect of the durable element of the GlucoWatch biographer circuitry is modified to provide an augmented alarm signal, which may be (i) auditory, (ii) visual, (iii) tactile, including but not limited to kinesthetic, (iv) olfactory, (v) gustatory, and also be (vi)

variations and combinations thereof. Other types of signals, sensory or otherwise, are also possible. For example, the iontophoretic channels (or leads) of the durable component of GlucoWatch biographer are modified so as to be capable of delivering an electrical current to provide a tactile stimulus to the user. Corresponding modifications to the consumable element of the GlucoWatch biographer may be made as well, for example, increasing the size or surface area of the hydrogels in order to provide a suitable stimulus to the user. Further, the consumable component of the GlucoWatch biographer (i.e., an AutoSensor, or similar structures in other analyte monitoring devices) may be modified to include components of an alarm augmentation system, for example, including a speaker device capable of providing an amplified signal in the AutoSensor assembly. Exemplary AutoSensor assemblies are described, for example, in WO 99/58190, published 18 November 1999. Other modifications are also possible, and may be apparent to persons of ordinary skill in the art in light of the teachings of the present specification.

In the case of an augmented alarm system and an analyte monitoring device within a single housing, the analyte monitoring device typically comprises an acquisition unit and a display unit, which are contained within a single housing. The display unit may further comprise a first signaling component; in some embodiments, the first signaling component may be an aural stimulus generator. Preferably, the display unit may further comprise a volume control for varying the intensity of the aural alarm signal.

Other embodiments may be apparent to persons of ordinary skill in the art in light of the teachings of the present specification.

2C(ii). Multiple Unit Systems

Some embodiments of the augmented alarm system of the present invention may have a modular character, and be capable of accommodating a variable number of processing, signaling and transmitter components. In such embodiments, at least one of the components may be housed independently of the acquisition unit (e.g., an analyte monitoring device) and/or of other components comprising the alarm augmentation system. In all cases, the components may be in operative communication with each other as described above.

Multiple-unit alarm augmentation systems for use with an enhanced GlucoWatch biographer include but are not limited to the following examples. In some exemplary embodiments, the enhanced GlucoWatch biographer may comprise a transmitter component, wherein the transmitter itself may comprise a port that provides a connection to a first signaling component of an alarm augmentation system. The first signaling component of this exemplary embodiment may comprise an auditory stimulus generator, and preferably one with a volume control.

The port may comprise a serial port that is added to the GlucoWatch biographer, being placed in operative connection therewith, and a wire-like or cable-like connector for connecting the GlucoWatch biographer and a first signaling component. Alternately, the port may comprise a modification to some aspect of the GlucoWatch biographer's circuitry. Such modifications include but are not limited to (a) reconfiguring the confidence loop circuitry of the GlucoWatch biographer; (b) modifying the transmission and receipt lines or transmission and receipt line circuitry of the GlucoWatch biographer, and (c) modifying the sweat probe or sweat probe circuitry of the GlucoWatch biographer. Other modifications may be apparent to persons of ordinary skill in the art in light of the teachings of the present invention.

Multiple-unit versions of the augmented alarm system for an analyte monitoring device include but are not limited to the following. Common to the embodiments of this aspect of the invention is an analyte monitoring device that comprises an analyte monitoring unit and a display unit. Such units (or components) of an analyte monitoring device may be contained within a single housing; or in another aspect, they are contained in different housings, and operably connected by either hardware or telemetric device(s), preferably telemetric. The GlucoWatch biographer is an example of an analyte monitoring device where the sampling device, sensing device, microprocessors, controls, and display are combined into a single unit to worn like a wrist watch. Examples of multi-component analyte monitoring devices are provided in WO 00/47109, published 17 August 2000. In one exemplary embodiment, the acquisition unit is worn by the user, and the display unit is separable, so that it may be placed, for example, at a different physical location on the user, on a night stand, or a desk, etc. Such a display unit may comprise at least either (a) a

transmitting component or (b) a first signaling component. More preferred embodiments may include both.

In an exemplary embodiment, the acquisition unit, the display unit and the transmitting component may all be contained within a single housing, while the first signaling component may be contained in an independent housing. The user may therefore place the first signaling component in a location that maximizes the effectiveness of the alarm signal in alerting him or her to the existence of abnormal analyte levels. For example, in cases where the first signaling component generates a sound alarm signal, it may be placed on a night stand nearer to the user's ears.

In another exemplary embodiment, the acquisition unit, the display unit and the transmitting component may all be contained within a single housing while both the first signaling component and the second signaling component may each be contained within separate independent housings. Thus, it is possible to place the second signaling component in a location remote from the user where it can alert a person or person(s) other than the user (e.g., a significant other, parent, other family member, or caretaker) to the existence of abnormal analyte levels.

In still another alternate embodiment, the augmented alarm system may further comprise a processor component. In one example of these embodiments, the processor component may be contained within a single housing along with the acquisition unit, the display unit and the transmitter component, while the first and second signaling components may be housed separately, as described above.

As is apparent to one of skill in the art, various modification and variations of the above embodiments can be made without departing from the spirit and scope of this invention. Such modifications and variations are within the scope of this invention.

What is Claimed Is:

1. An improved glucose monitoring device, said device comprising a durable element and a consumable element, said durable element comprising circuitry and means to provide an audible alert when glucose levels in a subject being monitored are outside of a predetermined range, wherein the improvement comprises modification of the circuitry of the durable element of said device to provide an augmented alarm signal capable of alerting a user of said device to glucose levels outside of a predetermined range, said alarm signal selected from the group consisting of (i) tactile stimulus, (ii) auditory stimulus, (iii) visual stimulus, and (iv) variations and combinations thereof.

2. The improved glucose monitoring device of claim 1, wherein said glucose monitoring device comprises a transdermal sampling device, a sensing device, a display, and means to provide an audible alert when glucose levels in a subject being monitored are outside of a predetermined range.

3. The improved glucose monitoring device of claim 1, further comprising said durable element operably linked to said consumable element.

4. The improved glucose monitoring device of claim 3, wherein said consumable element is an AutoSensor.

5. The improved glucose monitoring device of any of claims 1-4, wherein said device comprises iontophoretic channels, and said iontophoretic channels are modified to be capable of delivering an electrical current to provide a tactile stimulus.

6. An improved glucose monitoring device, said device comprising a durable element and a consumable element, said durable element comprising circuitry and means to provide an audible alert when glucose levels in a subject being monitored are outside of a predetermined range, wherein the improvement comprises modification of the circuitry of the durable element of said device to provide a connection to a first signaling component for

producing alarm signals capable of alerting a user of said device to glucose levels outside of the predetermined range.

7. The improved glucose monitoring device of claim 6, wherein said glucose monitoring device comprises a transdermal sampling device, a sensing device, a display, and means to provide an audible alert when glucose levels in a subject being monitored are outside of a predetermined range.

8. The improved glucose monitoring device of claim 6, further comprising said durable element operably linked to the consumable element.

9. The improved glucose monitoring device of claim 8, wherein said consumable element is an AutoSensor.

10. The improved glucose monitoring device of any of claims 6-9, wherein said glucose monitoring device comprises confidence loop circuitry and said modification comprises reconfiguring the confidence loop circuitry of said glucose monitoring device to provide said connection.

11. The improved glucose monitoring device of any of claims 6-9, wherein said glucose monitoring device comprises transmission and receipt lines, and said modification comprises modifying the transmission and receipt lines of said glucose monitoring device to provide said connection.

12. The improved glucose monitoring device of any of claims 6-9, wherein said glucose monitoring device comprises a sweat probe, and said modification comprises modifying the sweat probe of said glucose monitoring device to provide said connection.

13. The improved glucose monitoring device of any of claims 6-9, wherein said modification comprises adding a serial port to said glucose monitoring device, said port

being in operative communication with said glucose monitoring device and providing said connection.

14. The improved glucose monitoring device of any of claims 6-9, wherein the connection is via a wire-like connector.

15. The improved glucose monitoring device of any of claims 6-9, wherein the connection is via a telemetering system, wherein said telemetering system is selected from the group consisting of (i) electromagnetic radiation; (ii) capacitance coupling; (iii) inductive coupling; (iv) infrared coupling; and (v) variations and combinations thereof.

16. The improved glucose monitoring device of any of claims 6-9, wherein said first signaling component is selected from the group consisting of (i) an auditory stimulus generator; (ii) a visual stimulus generator; (iii) a tactile stimulus generator; (iv) an olfactory stimulus generator; and (v) variations and combinations thereof.

17. An alarm augmentation system for an analyte monitoring device, comprising

an analyte monitoring device, said analyte monitoring device comprising

an acquisition unit capable of at least sensing or detecting analyte concentrations or amounts in a subject; and

a display unit, operably linked to said acquisition unit, wherein (i) said display unit comprises means to provide an audible alert when an analyte level, in a subject being monitored, is outside of a predetermined range, and (ii) said acquisition unit and said display units are separately housed; and

an alarm augmentation system comprising a first signaling component, capable of producing alarm signals to alert a subject in response to analyte levels outside of a predetermined range, said first signaling component operably linked to said display unit.

18. The alarm augmentation system of claim 17, wherein said first signaling component is selected from the group consisting of (i) an auditory stimulus generator; (ii) a

visual stimulus generator; (iii) a tactile stimulus generator; (iv) an olfactory stimulus generator; (v) a gustatory stimulus generator; and (vi) variations and combinations thereof.

19. The alarm augmentation system of claim 17, wherein said first signaling component comprises an auditory stimulus generator, and said auditory stimulus generator provides a volume control for varying the volume of auditory stimuli generated thereby.

20. The alarm augmentation system of claim 17, further comprising a transmitter component, operably linked to said display unit, said transmitter component capable of transmitting alarm signals to at least one external communication target.

21. The alarm augmentation system of claim 20, wherein said transmitter further provides an operative link between said display unit and said first signaling component.

22. The alarm augmentation system of claim 20, wherein said transmitter component comprises a serial port and a wire-like connector, said port and said connector capable of connecting with at least one external communication target.

23. The alarm augmentation system of claim 20, wherein said transmitter component comprises a telemetering system selected from the group consisting of (i) electromagnetic radiation; (ii) capacitance coupling; (iii) inductive coupling; (iv) infrared coupling; and (v) combinations and variations thereof.

24. The alarm augmentation system of claim 23, wherein said telemetering system is capable of connecting with said first signaling component and said external communication target.

25. The alarm augmentation system of claim 23, wherein (a) said external communication target is a second signaling component, capable of producing alarm signals to alert a person or persons other than the user of said analyte monitoring device to analyte levels outside of the predetermined range, (b) said second signaling component is selected

from the group consisting of (i) an auditory stimulus generator; (ii) a visual stimulus generator; (iii) a tactile stimulus generator; (iv) an olfactory stimulus generator; (v) a gustatory stimulus generator; and (vi) variations and combinations thereof, and (c) said second signaling component is operably linked to said transmitter component via said telemetering system.

26. The alarm augmentation system of claim 25, further comprising

a processor component, wherein said processor component is (i) operably linked to said display unit, said acquisition unit, said transmitter component, and said first and second signaling components, (ii) capable of receiving and processing information received from said display unit, said acquisition unit, and said first and second signaling components, and (iii) capable of controlling the operation of said transmitter component and said first and second signaling components.

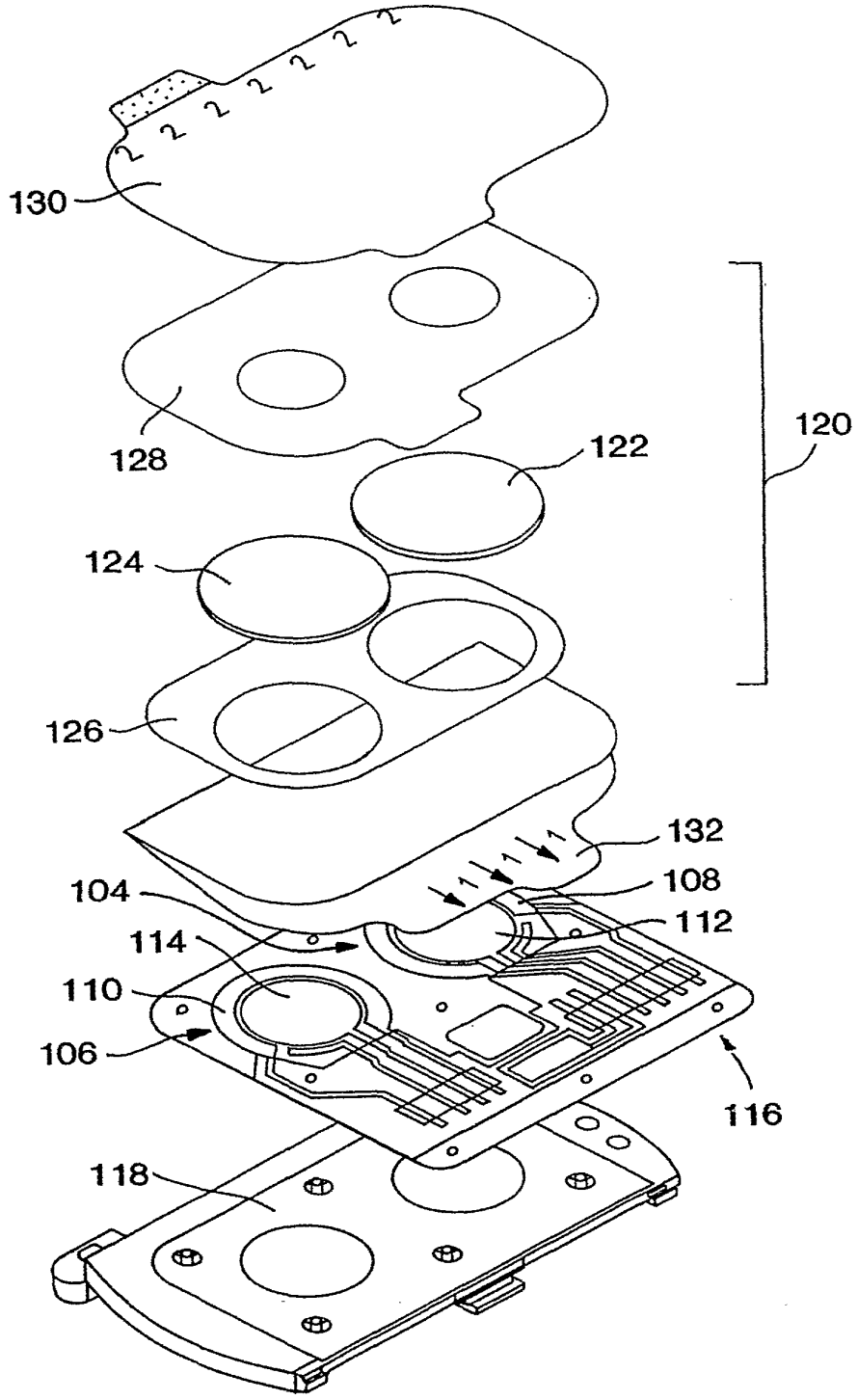


FIG. 1

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/US 01/25152

A. CLASSIFICATION OF SUBJECT MATTER
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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)
IPC 7 A61B

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, PAJ, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 96 00110 A (CYGNUS THERAPEUTIC SYSTEMS) 4 January 1996 (1996-01-04) page 18, line 18-25 page 30, line 33 -page 31, line 12	1,6,17
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A	US 4 178 916 A (MCNAMARA ELGER W) 18 December 1979 (1979-12-18)	

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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(54) Title: MICRO-BAND ELECTRODE

(57) Abstract: The invention concerns an electrochemical cell which, either alone or together which a substrate onto which it is placed, is in the form of a receptacle. The electrochemical cell contains a working electrode and a counter electrode, the working electrode being in a wall of the receptacle. At least one of the electrodes has at least one dimension of less than 50μm. The electrochemical cell is principally intended for use as a micro-electrode suitable for screening water, blood, urine or other biological or non-biological fluids.

MICRO-BAND ELECTRODE

Field of the Invention

The present invention relates to an electrochemical cell, typically a micro-electrode for electrochemical detection, a process for manufacturing such a cell and a method for electrochemically testing a substance using the micro-electrode.

Background to the Invention

Micro-electrodes are used for the electrochemical detection of various parameters of a substance. For example, a micro-electrode may be used to detect, or measure the concentration of, a particular compound in a test substance. Typically, micro-electrodes contain an electrode which has at least one dimension which is equal to or less than 50μm, and frequently a dimension of from 1 to 25μm. The use of these systems as sampling devices brings a number of potential benefits including speed of operation, accuracy and minimal sample requirement.

The common forms of large scale production fabricated micro-electrodes are either micro-disc, micro-band or interdigitated electrodes. A micro-disc electrode is a plate like electrode with a diameter of less than about 25μm whereas the micro-band electrode consists of a stripe with a thickness or smallest dimension of less than about 25μm. The interdigitated electrode has a more complex form of two combs with their teeth inter meshed.

By using these micro-electrodes in conjunction with enzymes or other electro-active substances it is possible to create sensors that provide quantitative measurement of target parameters through reactions with the corresponding electro-active substance.

However, several problems occur when using the micro-electrodes known in the art in conjunction with an electro-active substance. Firstly, difficulties are frequently experienced in fixing the electro-active substance to the electrodes and movement of

the substance away from its desired location is often seen. Systems containing several micro-electrodes on a single substrate are particularly susceptible to problems in this regard, since enzymes which are not sufficiently attached to their electrode become loose and migrate from one sensor to another causing cross-contamination. This type of problem is exacerbated by the effect of the sample flowing over the micro-electrode, which tends to wash the electro-active substance off the electrode.

A common manner of immobilizing the electro-active substance, at least to some extent, is to dry it in position on the electrode. However, this is typically not sufficient to hold the electro-active substance in place. Furthermore, drying the electro-active substance on top of the micro-electrode can cause electrical fouling of the electrode.

It is therefore an object of the present invention to provide a micro-electrode which is capable of holding an electro-active substance at the electrode ready for sample testing and which will restrict movement of any such electro-active substance whilst the sample flows over the micro-electrode. It is also desired that the problems of electrode fouling which occur when an electro-active substance is dried to the electrodes will be avoided or reduced.

Summary of the Invention

The present inventors have found that the problems discussed above can be minimised when the micro-electrode is in the form of a receptacle. The receptacle comprises a working electrode in the wall of the receptacle, typically having a small surface area. A counter electrode is also present, this electrode typically having a much larger surface area than that of the working electrode, generally a surface area which is at least an order of magnitude larger than that of the working electrode. The electro-active substance may be placed into the receptacle and is optionally dried into position. The sample is then applied to the receptacle in order that testing can be carried out.

Such a micro-electrode is thus ideally suited to containing the electro-active substance and preventing its movement away from the electrodes. Furthermore, the effect of the sample flowing over the micro-electrode is much reduced and is unlikely to cause the enzyme to be washed away from its position in the base of the receptacle.

The electro-active substance will typically not contact the working electrode in the wall of the receptacle during storage and therefore fouling of this electrode is minimised. Furthermore, the electro-active substance will typically contact only a small proportion of the counter electrode and in some embodiments (discussed below) contact with the counter electrode can be totally avoided. Therefore, if fouling does occur, this will only be to a relatively small area of the electrode. The remaining, unaffected areas of the counter electrode may still operate as normal.

Accordingly the present invention provides an electrochemical cell which, either alone or in combination with a substrate onto which it is placed, is in the form of a receptacle, said cell comprising a counter electrode and a working electrode, wherein at least one electrode has at least one dimension not exceeding 50μm, the working electrode being in a wall of the receptacle. The present invention in particular provides an electrochemical cell in the form of a receptacle, said cell comprising a counter electrode and a working electrode, wherein at least one electrode has at least one dimension not exceeding 50μm, the working electrode being in a wall of the receptacle.

The present invention also provides a process for producing an electrochemical cell such as is described above, which process comprises the steps of:

(a) forming a first part comprising an insulating material which is optionally coated with a counter electrode layer;

(b) forming a second part comprising a laminate of a working electrode layer between two layers of an insulating material;

(c) creating a hole in the second part; and

(d) bonding said first part to said second part to form a receptacle.

Where a counter electrode layer is present in the first part, step (d) comprises bonding the counter electrode layer of said first part to said second part to form a receptacle.

The process of the invention provides a simple and efficient way of producing the micro-electrodes of the invention. Furthermore, the step of creating a hole in the part containing the working electrode may eliminate the need for a separate step to activate the carbon, or other working electrode.

The present invention also provides a multi-analyte device which comprises a plurality of micro-electrodes in a single device. This device enables different types of measurement to be taken for a single sample by using different electro-active substances in the various micro-electrodes. Alternatively, the multi-analyte device can be used to carry out the same test on a single sample several times in order to detect or eliminate errors in results. The multi-analyte device of the present invention also ensures complete segregation of different electro-active substances since each micro-electrode is self-contained.

The present invention also provides a method of electrochemically testing a substance, the method comprising the steps of:

(a) inserting the sample into an electrochemical cell or multi-analyte device of the invention;

(b) applying a voltage or a current between the working and counter electrodes of the micro-electrode; and

(c) measuring the resulting current, voltage or charge across the micro-electrode.

Brief Description of the Figures

Figure 1 depicts an electrochemical cell according to a first embodiment of the invention;

Figure 2 depicts an electrochemical cell containing separate counter and reference electrodes in accordance with a second embodiment of the invention;

Figure 3 depicts an electrochemical cell having multiple working electrodes in accordance with a third embodiment of the invention;

Figure 4 depicts an electrochemical cell having capiliary flow channels in accordance with a fourth embodiment of the invention;

Figure 5 depicts an electrochemical cell in which the counter electrode is in a wall or walls of the cell;

Figure 6 depicts an alternative embodiment of the invention in which the cell itself is not in the form of a receptacle but forms a receptacle when placed on a substrate;

Figures 7, 8 and 9 show a multi-analyte device containing four electrochemical cells of the present invention;

Figure 10 illustrates a process for producing the electrochemical cells of the invention;

Figure 11 illustrates a modified process for producing the electrochemical cells of the invention; and

Figures 12 to 20 illustrate the results of amperometric and cyclic voltammetric experiments carried out using electrochemical cells according to the invention.

Detailed Description of the Invention

An electrochemical cell comprises a working electrode and a counter electrode which are connected to one another electrically. When in use, electrochemical reactions occurring at each of the electrodes cause electrons to flow to and from the electrodes, thus generating a current. An electrochemical cell can be set-up either to harness the electrical current produced, for example in the form of a battery, or to detect electrochemical reactions which are induced by an applied current or voltage.

Embodiment 1

A first embodiment of the present invention is depicted in Figure 1. In this embodiment, the electrochemical cell has a micro-electrode. A micro-electrode has at least one dimension not exceeding 50μm. Microelectrodes exhibit a typical microelectrode response when using cyclic voltammetry. The microelectrodes of the invention may have one or more dimensions which are macro in size, i.e. which are greater than 50μm. Due to these macro dimensions, the electrochemical cells of the invention may exhibit some characteristics which are not usually associated with microelectrodes. For example, the electrochemical cells of the invention may exhibit some degree of Cottrell current. For the purposes of the present specification therefore, the term microelectrode is taken to include any electrode have at least one dimension not exceeding 50μm.

Typically, the micro-electrode will be suitable for screening water (such as river water), blood, urine or other biological fluids or liquids such as beer and wine for determination of their contents. The cell is in the form of a receptacle or a container. The receptacle may be in any shape as long as it is capable of containing a liquid which is placed into it. For example, the receptacle may be cylindrical. Generally, a receptacle will contain a base 1 and a wall or walls 2 which surround the base. In one embodiment of the invention, which is described further below, the cell itself does not have a base and thus is not, alone, a receptacle. However, the cell is designed such that when placed against a separate substrate, the cell together with the

substrate forms a receptacle. In this embodiment, the cell comprises a wall or walls 2 which surround an open "base". The open "base" may be placed against the substrate to form a receptacle, such that the substrate forms the true base of the receptacle thus formed.

Typically, the receptacle will have a depth (i.e. from top to base) of from 50 to 1000μm, preferably from 200 to 800μm, for example from 300 to 600μm. The length and width (i.e. from wall to wall), or in the case of a cylindrical receptacle the diameter, of the receptacle is typically from 0.1 to 5mm, for example 0.5 to 1.5mm, such as 1mm.

The open end of the receptacle 3 may be partially covered by an impermeable material as long as at least part of the open end is uncovered, or covered by a permeable material, such as a permeable membrane. Preferably, the open end of the receptacle is substantially covered with a permeable membrane 4. The membrane 4 serves to prevent dust or other contaminants from entering the receptacle, and helps to keep any electro-active substance which might be inserted into the receptacle in position.

The membrane 4 is preferably made of a material through which the sample to be tested can pass. For example, if the sample is a blood sample, the membrane should be permeable to blood. Suitable materials for use as the membrane include polyester, cellulose nitrate, polycarbonate, polysulfone, microporous polyethersulfone films, PET, cotton and nylon woven fabrics, coated glass fibres and polyacrylonitrile fabrics. These fabrics may optionally undergo a hydrophilic or hydrophobic treatment prior to use. Other surface characteristics of the membrane may also be altered if desired. For example, treatments to modify the membrane's contact angle in water may be used in order to facilitate flow of the desired sample through the membrane. The membrane may comprise one, two or more layers of material, each of which may be the same or different. For example, conventional double layer

membranes comprising two layers of different membrane materials may be used.

The membrane may also be used to filter out some components of the sample which are not desired to enter the cell. For example, some blood products such as red blood cells or erythrocytes may be separated out in this manner such that these particles do not enter the cell. Suitable filtration membranes, including blood filtration membranes, are known in the art. An example of a blood filtration membrane is Presence 200 of Pall filtration.

The electrochemical cell of the invention contains a working electrode 5 which is situated in a wall of the receptacle. The working electrode is, for example, in the form of a continuous band around the wall(s) of the receptacle. The thickness of the working electrode is typically from 0.01 to 25 μm, preferably from 0.05 to 15μm, for example 0.1 to 20μm, more preferably from 0.1 to 10μm. Thicker working electrodes are also envisaged, for example electrodes having a thickness of from 0.1 to 50 μm, preferably from 5 to 20 μm. The thickness of the working electrode is its dimension in a vertical direction when the receptacle is placed on its base. The working electrode is preferably formed from carbon, palladium, gold or platinum, for example in the form of a conductive ink. The conductive ink may be a modified ink containing additional materials, for example platinum and/or graphite. Two or more layers may be used to form the working electrode, the layers being formed of the same or different materials. For example, a layer of Ag/AgCl may be present beneath the working electrode layer.

The counter electrode 6 typically forms at least a part of either the base or the top of the receptacle, although the counter electrode may also be present in the wall or walls of the receptacle. In the present embodiment, the counter electrode 6 forms the base of the receptacle. The counter electrode is typically made from $Ag/AgSO_4$ carbon, Ag/AgCl, palladium, gold, platinum, $Cu/CuSO_4$, $Hg/HgCl_2$ or $Hg/HgSO_4$. It is preferably made from carbon, Ag/AgCl, palladium, gold, platinum, $Cu/CuSO_4$,

$Hg/HgCl_2$ or $Hg/HgSO_4$. Each of these materials may be provided in the form of a conductive ink. The conductive ink may be a modified ink containing additional materials, for example platinum and/or graphite. Typically, the electrochemical cell of the invention contains only one counter electrode.

The counter electrode 6 typically has a surface area which is of a similar size to, or which is larger than, for example substantially larger than, that of the working electrode 5. Typically, the ratio of the surface area of the counter electrode to that of the working electrode is at least 1:1, such as at least 5:1, 10:1, preferably at least 20:1, more preferably at least 25:1. The counter electrode may, for example, be a macroelectrode. Preferred counter electrodes have a dimension of 0.01mm or greater, for example 0.1mm or greater. This may be, for example, a diameter of 0.1mm or greater. Typical areas of the counter electrode are from $0.001mm^2$ to $10mm^2$, preferably about $5mm^2$. The minimum distance between the working electrode and the counter electrode is preferably from 10 to 1000μm, for example from 10 to 300μm.

In a typical cell according to the invention, each electrode will be separated from the neighbouring electrode by a distance of from 10 to 1000μm, for example from 50 to 200μm or from 75 to 150μm. In order that the cell can operate, the electrodes must each be separated by an insulating material 7. The insulating material is typically a polymer, for example, an acrylate, polyurethane, PET, polyolefin, polyester or any other stable insulating material. Polycarbonate and other plastics and ceramics are also suitable insulating materials. The insulating layer may be formed by solvent evaporation from a polymer solution. Liquids which harden after application may also be used, for example varnishes. Alternatively, cross-linkable polymer solutions may be used which are, for example, cross-linked by exposure to heat or UV or by mixing together the active parts of a two-component cross-linkable system. Dielectric inks may also be used to form insulating layers where appropriate.

The electrodes of the electrochemical cell may be connected to one another and to any required measuring instruments by any suitable means. Typically, the electrodes will be connected to electrically conducting tracks which are themselves connected to one another and to the required measuring instruments.

The cell of the present invention may contain an electro-active substance 8. The electro-active substance 8 may be any substance which is capable of causing an electrochemical reaction when it comes into contact with a sample. Thus, on insertion of the sample into the cell and contact of the sample with the electro-active substance, electrochemical reaction may occur and a measurable current, voltage or charge may occur in the cell.

The electro-active substance 8 comprises an electrocatalyst. Typically the electro-active substance 8 comprises an electrocatalyst and a mediator. A mediator is a chemical species that has two or more oxidation states of distinct electro-active potentials that allow a reversible mechanism of transferring electrons/charge to an electrode. The mediator reacts with the sample in the electrochemical reaction, the reaction being catalysed by the electro-catalyst. Typical examples of an electro-catalyst are enzymes, for example lactate oxidase, cholesterol dehydrogenase, lactate dehydrogenase, glycerol kinase, glycerol-III-phosphate oxidase and cholesterol oxidase. Ionic species and metal ions, for example cobalt, may also be used as the electrocatalyst. Examples of suitable mediators are ferricyanide, ferrocyanide and ruthenium compounds such as ruthenium (III) hexamine.

The electro-active substance 8 is typically inserted into the receptacle in such a position that the electro-active substance is not in contact with the working electrode. This ensures that fouling of the working electrode is minimised or avoided. The electro-active substance may be dried to ensure that it remains in position. In a preferred embodiment of the invention, the electro-active substance is pre-coated onto the substrate which forms the base of the receptacle. This may be done either

by directly coating the electro-active substance onto a flat substrate, or by forming a well in the substrate and dispensing an electro-active substance into the well. Typically, the electro-active substance is then dried into position and the thus-coated substrate is joined to the walls of the receptacle. Where the electro-active substance is inserted into a well in the substrate, the well typically has a cross-section which is identical to that of the final electrochemical cell. Thus, the well creates the bottom part of the receptacle formed by the electrochemical cell. Where the counter electrode is on the base of the receptacle, the electro-active substance is pre-coated onto the counter electrode layer.

This embodiment has the advantage that the electro-active substance is kept remote from the working electrode at all times during manufacture of the cell. Contact between electro-active substance and working electrode is therefore minimised before the cell is used. This in turn minimises fouling of the working electrode.

In an alternative preferred embodiment, the electro-active substance is impregnated into a membrane which is placed onto the substrate either before or after, preferably before, the substrate is joined to the walls of the receptacle. The electro-active substance may equally be impregnated into the membrane 4 which covers the cell. This embodiment also avoids contact between the electro-active substance and the working electrode and minimises fouling.

The receptacle forming the micro-electrode of the present invention may, for example, contain one or more small air-holes in its base or its wall or walls (not depicted in Figure 1). These holes allow air to escape from the receptacle when sample enters the receptacle. If such air-holes are not present, the sample may not enter the receptacle when it flows over the open end, or it may enter the receptacle only with difficulty. The air holes typically have capiliary dimensions, for example, they may have an approximate diameter of 1-25μm. Typically, from 1 to 4 air holes may be present.

Embodiment 2

A second embodiment of the invention, which is the same as the first embodiment except as described below, is depicted in Figure 2. In this embodiment, the cell contains one or more reference electrodes 9 in addition to the working and counter electrodes. In the case that no reference electrode is present (as in the first embodiment described above), the counter electrode acts as a reference or pseudo reference electrode. Typically, the reference electrode will be located in a wall of the receptacle 2. For example, the reference electrode may be in the form of a continuous band. The counter and working electrodes 6 and 5 may be positioned such that the reference electrode 9 is located between them, as is depicted in Figure 2, or the counter and working electrodes 6 and 5 may be adjacent. The reference electrode is typically made from $Ag/AgSO_4$, carbon, Ag/AgCl, palladium, gold, platinum, $Cu/CuSO_4$, $Hg/HgCl_2$ or $Hg/HgSO_4$. It is preferably made from carbon, Ag/AgCl, palladium, gold, platinum, $Cu/CuSO_4$, $Hg/HgCl_2$ or $Hg/HgSO_4$. Each of these materials may be provided in the form of a conductive ink. The conductive ink may be a modified ink containing additional materials, for example platinum and graphite.

Embodiment 3

A third embodiment of the invention, which is the same as either the first or second embodiments except as described below, is depicted in Figure 3. This embodiment of the invention is a multi-ring electrode which contains one or more further electrodes 10, 10' in addition to the working, counter and optionally reference electrodes. The one or more further electrodes 10, 10' typically act as additional working electrodes. Preferably, the counter electrode 6 acts as both the counter and the reference electrode and a separate reference electrode, as described in embodiment 2, is not present.

Typically, the receptacle comprises no more than 10 electrodes in total, including

working, counter and reference electrodes. Preferably no more than 7 electrodes, more preferably no more than 5 electrodes are present. More preferred receptacles contain 2, 3 or 4 electrodes. Where more than one working and/or reference electrode is present, these are typically located one above the other in the wall(s) of the receptacle.

The additional working electrodes 10, 10' allow different measurements to be carried out simultaneously on the same sample by applying different potentials across two or more of the working/counter electrode pairs. Alternatively, the same potential may be applied to each working electrode and the same measurement recorded several times for the same sample. This helps to eliminate or detect errors in the measurements taken.

In one particular example of this embodiment, one of the working electrodes is present on the base of the receptacle, i.e. in the position in which the counter electrode 6 is depicted in Figure 3. In this case, the counter electrode is present either in the wall(s) of the receptacle as described below with reference to embodiment 5, or in the top of the receptacle as described below with reference to embodiment 4.

Embodiment 4

A fourth embodiment of the invention, which is the same as the first, second or third embodiments except as described below, is depicted in Figure 4. In this embodiment, the cell comprises one or more capiliary channels 11 to allow sample to enter the receptacle. The capiliary channels are, for example, covered by a capiliary film. Examples of suitable capillary films are PET films such as Melinex or ARcare®, adhesive coated films by Adhesive Research, and hydrophilic coated films such as ARcare® 8877, which can offer better capillary performance. In this embodiment, the receptacle is preferably covered by a substantially impermeable material 12. The impermeable material 12 is typically a capiliary film as described

above. One or more capiliary channels 11 are provided, for example in a wall or walls of the receptacle 2, through which the sample may enter the receptacle. Typically, as is depicted in Figure 4, the capiliary channel 11 is located at the point where the wall 2 meets the impermeable material 12.

In order that air can escape from the receptacle and allow the sample liquid to enter, one or more air holes must be present in this embodiment. Typically, an air hole will be positioned at the point where the base meets the wall of the receptacle, as indicated by the label 12a in Figure 4. The air hole(s) preferably have the dimensions described above and preferably from 1 to 4 air holes are present.

This embodiment has the advantage that the top of the receptacle is closed and thus the counter electrode may either be located at the top 3, at the base 1, or in the wall(s) 2 of the receptacle. The counter electrode 6 is depicted at the top of the receptacle in Figure 4. This is achieved by bonding the counter electrode 6 to the impermeable material 12 prior to its attachment to the receptacle. In this way, the electro-active substance 8, which is typically located on the base 1 of the receptacle, is not in contact with either the working or the counter electrodes and thus electrode fouling is significantly reduced or eliminated. It is possible to locate the electro-active substance on the top 3 of the receptacle, typically by pre-coating the substance onto the substrate which is to form the top 3 prior to its attachment to the receptacle.

A further advantage of placing the counter electrode at the top of the receptacle is that the base of the receptacle may be coated, or adapted in another way, to make it more suitable to receive the electro-active substance which is typically dried onto the base. For example, the base may be made of a particular material, such as carbon (provided that the carbon is electrically insulated from the electrodes), which is suitable for depositing enzymes on. Alternatively, the base may be coated with a hydrophilic coating.

If desired, the base of the cell may be formed from a permeable membrane which may be of the same type as the membrane 4 discussed above. The membrane is typically impregnated with an electro-active substance prior to attachment to the cell. This avoids electrode-fouling caused by contact between electro-active substance and working electrode during insertion of the electro-active substance.

Embodiment 5

An alternative embodiment of the invention is depicted in Figure 5. This embodiment is the same as any one of embodiments 1 to 4 discussed above except as described below. The counter electrode 6 in the cell of this embodiment is located in a wall or walls 2 of the receptacle. The counter electrode is, for example, in the form of a continuous band around the wall(s) of the receptacle.

The thickness of the counter electrode in this embodiment is typically from 0.1 μm to 1 mm, preferably from 5 to 500μm, for example from 5 to 100μm, more preferably from 5 to 50μm. The thickness of the counter electrode in this embodiment is its dimension in a vertical direction when the receptacle is placed on its base. The ratio of the surface area of the counter electrode to that of the working electrode may, in this embodiment, be less than the preferred value of 25:1 which applies for counter electrodes located in the base or top of the receptacle. Preferred ratios for this embodiment are in the range 1:1 to 10:1, preferably 2:1 to 5:1.

Embodiment 6

A further embodiment of the invention, which is depicted in Figure 6, relates to a modification of the above described electrochemical cell in which the receptacle is completed when the cell is placed on a substrate 21. In this manner, the substrate 21 forms the base of the receptacle. The cell of this embodiment alone is not necessarily in the form of a receptacle since it has an opening at the position of the base 1. However, when placed onto a separate substrate 21, the cell together with the substrate forms a receptacle.

This embodiment therefore relates to an electrochemical cell comprising a counter electrode and a working electrode, wherein at least one electrode has a dimension of less than 50 μm, and wherein the cell has a shape such that, when placed on a substrate, the cell, together with the substrate on which it is placed, forms a receptacle, the working electrode being in a wall of the receptacle.

The electrochemical cell of this embodiment is at least partially open at its base 1. In this context, the term "open" includes a total absence of a base material and also the presence of a material which allows sample liquid to pass through it. Typically, the cell's base 1 is either at least partially uncovered or at least partially covered with a permeable membrane. The permeable membrane is optionally impregnated with an electro-active substance prior to its attachment to the walls of the receptacle.

The top of the cell 3 may be totally or partially covered with a permeable membrane 4 (as depicted) or with an impermeable material. If the cell is at least partially covered with an impermeable material, the counter electrode may be located at the top of the cell coated onto the impermeable material as described with reference to embodiment 4 above. This is achieved by bonding the counter electrode 6 to the impermeable material 12 prior to its attachment to the walls of the receptacle. An electro-active substance (not depicted), as described above, may also be bound to the counter electrode prior to its attachment to the walls of the receptacle. If the cell is totally covered with an impermeable material, air-holes, as described with reference to embodiment 4, are preferably present in order to facilitate entry of a sample liquid into the cell. Alternatively, the counter electrode 6 may be located in the wall(s) of the cell as described in embodiment 5 above and as depicted in Figure 6. Where the top of the cell 3 is open or covered only with a permeable membrane, the counter electrode is located in the wall(s) of the cell as here depicted.

The sample liquid to be tested enters the cell either through the top of the receptacle (where the top is not totally covered by an impermeable membrane), or, more

usually, through the open base. This is typically achieved by placing the cell onto a substrate which is already coated with the sample liquid. Alternatively, the cell may be placed onto the substrate, either directly or through a permeable membrane, and the substrate then pierced within the receptacle in order to introduce a liquid sample present under the substrate surface into the receptacle. For example, the substrate may be the skin and the sample liquid blood. Alternatively, the substrate may be a pre-packaged container in which a sample liquid is present, the sample liquid being released when the container is pierced.

A non-limiting example of a use of the cell of this embodiment is as a self-testing blood analysis kit. A diabetic user for example might employ such a cell to carry out glucose analysis tests on samples of their blood. This can be done by (i) piercing the skin, e.g. a finger, which is optionally covered with a permeable membrane, (ii) placing the cell over the blood spot produced such that the skin, or the permeable membrane as relevant, together with the cell form a receptacle, and (iii) operating the cell in the usual manner. Alternatively, the cell may first be placed onto the skin or permeable membrane and the skin subsequently pierced through an open part of the receptacle. In the same manner, the cell can also be used for other types of blood test.

The remaining features of the cell are typically as described above with regard to the other embodiments of the invention.

Multi-analyte Device

The present invention also provides a multi-analyte device which comprises two or more micro-electrodes of this invention, for example in accordance with any one of embodiments 1 to 6 above. The micro-electrodes of the multi-analyte device may each be of the same or different designs. Typical multi-analyte devices according to the invention are described in Figures 7, 8 and 9. The multi-analyte device will typically comprise a plate or strip 14 which contains one or more micro-electrodes

13a, b, c and d. Each micro-electrode may contain the same or different electro-active substances such that when a sample is inserted into each receptacle, several different tests may be carried out or the same test may be repeated several times in order to detect or eliminate errors in the measurements taken. Furthermore, the micro-electrodes may be set at different potentials, again providing different measurements for the same sample.

The micro-electrodes are typically separated by a distance of from 250μm to 550μm, for example from 250μm to 425μm.

A multi-analyte device can also be made with a "vertical" arrangement of cells as an alternative to Embodiment 3.

In this arrangement the sample in the first micro-electrode passes to a further micro-electrode below it, for example, using a permeable membrane in the base of the first micro-electrode, for a determination of a different component in the sample. The permeable membrane may be impregnated with an electro-active substance.

The electrical tracks 15 of the multi-analyte device are typically on the top surface of the device. Filled vias are used to connect the counter, optional reference and working electrodes to the surface tracks 15 which then mate with a measuring instrument 16, or the laminated back/counter can be arranged to mate with the instrument directly.

The multi-analyte device may contain one or more blank electrodes 17 as is depicted in Figure 8. The blank electrode(s) do not contain a counter electrode. This embodiment may, for example, be useful where the electro-active substance has a working potential which conflicts with that of the counter electrode system. In this situation, reduction or oxidation of the mediator contained in the electro-active substance may occur. Thus, for example, where the counter electrode is a Ag/AgCl

couple and the mediator is ferricyanide, the redox state of the mediator is such that it interacts with the Ag/ACl, forming a battery system or galvanic cell in which reactions occur spontaneously as soon as there is liquid connection between them.

The multi-analyte device may also comprise capiliary channels 18 as are depicted in Figure 9. These capiliary channels are preferably of the type described in embodiment 4 above. Thus, each receptacle is provided with a capiliary channel which may optionally be connected to a single channel from which the sample is drawn.

Process for Producing Electrochemical Cells

A process for producing the electrochemical cells of the first embodiment of the present invention is depicted in Figure 10. The cells may be produced by a process which comprises the steps of:

(a) forming a first part 18 comprising an insulating material 18a which is optionally coated with a counter electrode layer 18b;

(b) forming a second part 19 comprising a laminate of a working electrode layer 19a between two layers 19b and c of an insulating material;

(c) creating a hole 19d in the second part; and

(d) bonding said first part 18 to said second part 19 to form a receptacle.

The materials, dimensions and other properties of the electrochemical cell are as described above.

Where the counter electrode is in the base of the receptacle, the first part comprises an insulating material 18a which is coated with a counter electrode layer 18b as depicted in Figure 10. In this case, step (d) comprises bonding the counter electrode layer 18b of said first part 18 to said second part 19 to form a receptacle.

Alternatively, when the counter electrode is in a wall or walls of the electrode as

described in embodiment 5 above, the counter electrode layer may be absent from the first part and the second part comprises a counter electrode layer between two layers of insulating material.

Step (c) in which a hole is created in the second part may be carried out by any suitable means. For example, the hole may be punched or drilled or formed by die-cutting, ultra-sonic cutting or laser drilling. This step has the advantage that the electrode surfaces are automatically cleaned by the action of creating the hole, thus reducing the requirement for a separate step of cleaning the electrodes.

A suitable technique for creating the hole is to punch the second part with a pneumatic or hydraulic press tool. Holes of 0.1 to 5mm, preferably 0.5 to 1.5, more preferably about 1mm diameter are preferred. The hole should extend down through all of the printed layers and the substrate. The punching tool can be coated with hardening materials such as titanium and may or may not have an angled cutting edge. For example, the tool may be Ti coated with a 2° angle from the horizontal cutting edge.

The bonding step (d) may be carried out by any suitable bonding technique. For example, bonding may be performed using pressurized rollers. A heat sensitive adhesive may be used, in which case an elevated temperature is needed. Room temperature can be used for pressure sensitive adhesive.

If desired, air channels may be created in the micro-electrode at the joint between the first part 18 and the second part 19. This can be achieved, for example, by creating grooves in either the bottom side of the second part 19b or the top side of the first part 18a prior to bonding these two parts together.

Carbon or other inks may, for example, be printed onto the insulating material 18a, 19b, 19c using a screen printing, ink jet printing, thermal transfer or lithographic or

gravure printing technique, for example the techniques described in GB 0106417.9. The insulating layer 19c may also be formed by printing an insulating material onto the working electrode layer. Other techniques for forming the insulating layer include solvent evaporation of a solution of the insulating material or formation of an insulating polymer by a cross-linking mechanism.

Each electrode is typically printed, or otherwise coated, onto the relevant insulating layer in a chosen pattern. For the working electrode or other electrodes which are to be formed in the wall of the receptacle, the pattern selected should be such that at least a part of the electrode layer is exposed when hole 19d is created. Preferably the pattern chosen is such that the electrode layer is exposed around the whole perimeter of hole 19d.

In one embodiment, two or more printing or other coating steps are carried out to create an electrode layer. One or more steps, preferably one step, uses a pattern which deposits conductive material in the area which will form the perimeter of hole 19d as well as, for example, areas which are to form conductive tracks. This layer is exposed when hole 19d is created and forms the electrode. One or more further steps uses a pattern which deposits conductive material, for example, in areas which are to form conductive tracks but deposits no material in the area which will form the perimeter of hole 19d. These areas are not exposed when hole 19d is made. Thus, a thin electrode layer is formed around hole 19d, leading to a thin electrode in the wall of the finished receptacle, whilst a thicker layer is formed away from hole 19d. This thicker layer has a lower resistance and thus leads to a more efficient functioning of the electrochemical cell. This use of a double layer is particularly preferred with regard to the working electrode.

If desired, the one or more layers may be formed of different materials. For example, the layer which will be exposed at hole 19d may be formed of carbon whilst a further layer, for example a sub-layer, of a different material may be used.

The working electrode, counter electrode and reference electrode may all be produced by printing ink containing the desired material onto the substrate. Insulating layers may also be produced in this manner by printing an ink containing an insulating material onto a substrate or onto a conductive layer. Screen printing is a preferred manner in which this is carried out. Typically, a conductive layer will be printed onto a substrate and a dielectric layer will be printed onto the conductive layer.

Screen printing is generally carried out on polyester, polycarbonate, or other plastic/ceramic substrate. Types of substrates used are for example, DuPont films of Mylar A, Mylar ADS, Melinex, Kaladex, Tejin Tetoron, Purex, Teonex. Substrates used are preferably surface treated to improve adhesion of the ink to the substrate, for example by corona discharge or chemical modification. Substrates are also preferably laminated on one side, for example with either heat sensitive or pressure sensitive adhesive in the thickness range 20μm to 200μm, preferably about 40μm. A preferred embodiment employs 250μm thick Mylar ST535 with 40μm thermally activated adhesive laminate as a substrate.

A screen is selected from stock with the carbon stencil defined with photosensitive emulsion with a thickness of 10μm to 20μm, preferably about 13μm. The required thickness of the print is determined by the mesh count of the screen. Typically this is within the range of 83t/inch to 330t/inch, preferably 305t/inch for both carbon Ag/AgCl inks, and about 195t/inch for dielectric ink. The ink is typically forced through the mesh using a squeegee rubber of 65 to 85 shore hardness, preferably 75-shore hardness.

Suitable mesh counts are as follows:

Approx thickness of print when using 330t/inch / = 7μm

305t/inch / 120t/cm = 10μm
195t/inch / 77t/cm = 15μm
156t/inch / 61t/cm = 20μm
83t/inch / = 25μm

The printed layer is typically dried using the ink manufacturer recommendations. It is typically stoved in an oven for 2 minutes to 4 hours, preferably 1 hour, at about 70-130°C. Air drying, or air forced tunnel drying for 2-3 minutes at 90-130°C may also be used.

The screen printed dielectric layer can be replaced by a laminate of polyester, polycarbonate or similar (preferably Mylar ST535) which covers the carbon layer and with thickness in the range 10μm to 200μm, preferably 10μm to 30μm.

Suitable inks for use in the screen printing processes are as follows:

Carbon Inks:

1. Coates carbon 26-8203
2. Ercon G449
3. Du-pont L881

Dielectric Inks:

1. Ronseal ultra tough hardglaze clear varnish.
2. Ercon E6165-116 blue insulator.
3. Du-Pont 5036 encapsulant
4. Coates screen flex coverlay.

Silver/Silver chloride Inks:

1. Gem ag/agcl
2. Ercon E0430-128

3. Du-Pont 5874 conductor

After forming the receptacle, an electro-active substance as described above may be inserted into the micro-electrode, for example, using micropipetting or enzyme jet printing. The electro-active substance may then be dried by any suitable technique. Alternatively, the electro-active substance may be pre-coated onto the base before bonding step (d) takes place. To achieve this, the electro-active substance is typically coated onto layer 18b, dried into position and subsequently parts 18 and 19 are bonded together as described above. A further option is to impregnate the electro-active substance into a membrane which can be placed on, or fixed onto, layer 18b prior to or after bonding step (d).

If desired, a permeable membrane may then be placed over the receptacle (as in Figure 1). Membrane structures are applied to the top surface of the device using double sided adhesive or screen printed pressure sensitive adhesive. Attachment of the membrane 20 may, for example, be carried out by using a pressure sensitive adhesive (which has been cast) that has been die cut to remove the adhesive in the area over the receptacle. In the embodiments in which the electro-active substance is impregnated into membrane 4, impregnation of the desired substance is typically carried out before the membrane is attached to the receptacle.

If one or more capiliary channels are desired, these are preferably formed by creating one or more grooves in the top of the second part 19c, the grooves being connected to the hole 19d, or the top of the receptacle. The grooves may conveniently be created during the same process as creating the hole in the second part. For example, using a technique of pressing, punching, die-cutting, ultra-sonic cutting or other suitable film fabrication technique. The second part may then be coated with an impermeable material, for example a capiliary film as described above, thus creating a capiliary channel connected to the receptacle and which allows a sample to enter the receptacle.

A modified process may be used when the electro-active substance is to be pre-coated into a well in the substrate which forms the base of the receptacle. This modified process is depicted in Figure 11.

In this process, step (a) comprises, if desired, coating insulating layer 18a with counter electrode layer 18b as described above. A further insulating layer 18c is provided which has a pre-formed hole 18d. Hole 18d is typically of the same size as hole 19d and may be formed by the techniques mentioned above with reference to hole 19d. Insulating layer 18c is bonded to layer 18b thus creating a well in the position of hole 18d. An electro-active substance is then dispensed into this well, for example using micro-pipetting or enzyme jet printing. The electro-active substance may then be dried by any suitable technique. Following addition of the electro-active substance, Part B (18) may be used in bonding step (d) in the manner described above.

An alternative process may be used when the invention is to be produced in accordance with embodiment 4 above. In this embodiment, the process comprises the steps of:

(a) forming a first part comprising an insulating material;

(b) forming a second part comprising a laminate of a working electrode layer between two layers of an insulating material;

(c) creating, in the second part, a hole and a capiliary channel to allow a sample to enter said hole;

(d) bonding said first part to said second part to form a receptacle;

(e) placing an electro-active substance as described above into the receptacle and optionally drying the electro-active substance; and

(f) bonding to the open end of said receptacle a layer which is optionally coated with a counter electrode material.

The materials, dimensions and other properties of the electrochemical cell are as described above. Step (c), comprising forming a hole and a capiliary channel in the second part may be carried out as described above. In this process, the impermeable

material or capiliary film is typically coated on the underside with a counter electrode material before it is bonded. Thus, when this layer is coated to the top of the receptacle, a counter electrode is formed. Alternatively, when the counter electrode is in a wall or walls of the electrode as described in embodiment 5 above, the counter electrode layer may be absent from the layer used in step (f) and instead the second part comprises a counter electrode layer between two layers of insulting material.

In a modification of the above process, the electro-active substance may be pre-coated onto either the base or the top of the receptacle by any desired technique, for example those discussed above, thereby eliminating the need for step (e). Thus, an alternative preferred process comprises steps (a), (b), (c), (d) and (f) above and employs (i) a first part which comprises an electro-active substance on its surface and/or (ii) a layer for use in step (f) comprising an electro-active substance on its surface. Where said layer for use in step (f) comprises a counter electrode layer, the electro-active substance is typically coated onto the counter electrode layer. Following bonding step (f), a receptacle is thus formed having an electro-active substance coated to the interior surface of either the base or the top. If desired, the electro-active substance may be placed into a well in the substrate as discussed above in relation to Figure 11.

In one embodiment, the insulating material of the first part is a permeable membrane as described above. The membrane is optionally impregnated with an electro-active substance prior to bonding step (d).

In order to form the electrochemical cell described in Embodiment 6 above, a modified version of any of the above described processes is used in which the step of bonding the first part to the second part is omitted. Thus, the process comprises :

(a) forming a second part 19 comprising a laminate of a working electrode layer 19a between two layers 19b and c of an insulating material;

(b) creating a hole 19d in the second part; and optionally

(c) bonding to said second part a layer which is coated with a counter electrode

material.

Steps (a) and (b) are carried out as described above with reference to corresponding steps. The process may optionally comprise a further step, which may be carried out before or after step (c), of attaching to the bottom of the second part a permeable membrane which may optionally have an electro-active substance impregnated into it. If the counter electrode is present in the top of the cell, step (c) above is carried out. If the counter electrode is present in a wall of the cell, step (c) may be omitted and the second part additionally comprises a layer of counter electrode material between two layers of insulating material.

An electro-active substance may be coated onto the counter electrode layer, if desired and alternatively or additionally to the electro-active substance bound to any permeable membrane present. This coating process may be carried out as described above.

In order to form the multi-analyte devices of the present invention, the step (c) described in one of the two processes above is extended to include the formation of two or more holes in the second part. Thus, when the bonding step (d) is carried out, two or more receptacles are formed. Where capiliary channels are used, these may be formed as described above at each of the receptacles. Thus, samples may be drawn into each micro-electrode by capiliary action.

Typical Uses of the Electrochemical Cell

The electrochemical cell of the present invention is intended principally for use as a micro-electrode for screening purposes, i.e. for screening liquid samples. For example, the cell may be used for determining the content of various substances in water, beer, wine, blood or urine samples, or samples of other biological or non-biological fluids. The cells may, for example, be used to determine the pentachlorophenol content of a sample for environmental assessment; to measure cholesterol, HDL, LDL and triglyceride levels for use in analysing cardiac risk, or for measuring glucose levels, for

example for use by diabetics. A further example of a suitable use for the cells of the invention is as a renal monitor for measuring the condition of a patient suffering from kidney disease. In this case, the cells could be used to monitor the levels of creatinine urea, potassium and sodium in the urine.

Whilst the major use envisaged for the electrochemical cells of the invention is as a microsensor, the cells may also be used for any other purpose in which electrochemical measurement or the harnessing of electrochemical energy takes place. For example, the electrochemical cell of the invention may be used as a battery. The cell may also be used to process an electro-active substance such as an intercalating material used for detection of electrolytes such as sodium, potassium, calcium and phosphates. Such processing may involve electro-cycling of the substance in order to develop a consistent thin layer on the electrodes.

Examples

Example 1: Manufacture of Electrochemical Cell

A base film of 125μm thick PET was printed with the counter / reference electrode using a silver/silver chloride printing ink, and then dried at 90°C for 30 minutes.

A middle film of 250μm PET was coated with heat seal. The film was then printed on the reverse side to the heat seal coating with a conductive carbon ink in a pattern that defines the conductive tracks. This was then dried at 90°C for 1 hour. The carbon ink print was subsequently over printed with a dielectric ink, except for the part of the tracks that were required to mate with the connector in the measuring instrument, where over printing was not carried out. The dielectric ink was then dried at 60°C for 20 minutes.

Several holes were then formed in the middle layer using a punch that forms the holes using a shearing action. This punch comprised metal dies or pins having a diameter

equal to that of the required holes. The metal dies or pins were used to shear the film which was supported by metal or wooden plates having holes that match the formation of the punch in order to allow the punch to slide.

Following punching of the holes, the middle film was laminated to the base film using heat. During the heating step, the heat seal on the underside of the middle film melts and bonds to the base film.

The desired electro-active substances were then dispensed into the wells formed. The substances were then dried using room temperature airflow over the surface.

Over some of the wells, a blood separation membrane was added that is capable of removing the larger cellular particles from whole blood. For these electrodes, a blood separation membrane such as Presence 200 by Pall filtration was attached to the top most surface of the electrodes covering the wells. Attachment of the membranes was accomplished by using a screen printed pressure sensitive adhesive cast around the wells onto the middle layer.

Example 2: Use of Electrochemical Cell

Electrodes were constructed from a 250 μm PET layer on which a 15 μm Coates carbon ink 26-8203 layer had been screen-printed followed by a 30 μm layer of Ronseal ultra tough hardglaze clear varnish (a polyurethane bsed on Baxenden trixine containing polyurethane and isocyanates). This layer was punched to produce a 1 mm diameter hole. A PET base layer was produced consisting of a 125 μm PET layer having a common Ag/AgCl counter reference on the top. The PET base layer was then adhered to the punched layer using ARcare 7841 sheet adhesive. Various tests were carried out using this electrochemical cell as described below at Examples 2a to 2f.

Example 2a

Cyclic voltammetric current was measured at -0.45 V vs. Ag/AgCl after addition of concentrations of 2, 5, 10, 15 and 20 mmol dm^{-3} ruthenium hexaamine in 0.1 mol dm^3 Tris buffer at pH 9 containing 0.1 mol dm^{-3} KCl. Results are shown in Figure 12.

Example 2b

Amperometric current was measured 1 second after the application of a -0.50 V vs. Ag/AgCl potential step after addition of concentrations of 2, 5, 10, 15 and 20 mmol dm^{-3} ruthenium hexaamine in 0.1 mol dm^{-3} Tris buffer at pH 9 containing 0.1 mol dm^{-3} KCl. Results are shown in Figure 13.

Example 2c

Cyclic voltammetric current was measured at 0.15 V vs. Ag/AgCl immediately after addition of 2, 4, 6, 8 and 10 mmol dm^{-3} NADH in 0.1 mol dm^{-3} Tris buffer at pH 9 containing 0.1 mol dm^{-3} KCl to electrodes on which 0.2 mL of a solution containing 0.2 mol dm^{-3} ruthenium hexaamine and 650 KU /mL putadiaredoxin reductase has been dried. Results are shown in Figure 14.

Example 2d

Amperometric current was measured 1 second after the application 0.15 V vs. Ag/AgCl on the addition of 2, 4, 6, 8 and 10 mmol dm^{-3} NADH in 0.1 mol dm^{-3} Tris buffer at pH 9 containing 0.1 mol dm^{-3} KCl to electrodes on which 0.2 mL of a solution containing 0.2 mol dm^{-3} ruthenium hexaamine and 650 KU/mL putadiaredoxin reductase has been dried. Results are shown in Figure 15.

Example 2e

Amperometric current was measured 60 seconds after the application of a 0.20 V vs. Ag/AgCl potential step after addition of concentrations of 2, 5, 7.5, 10, 12.5 and 15 mmol dm^{-3} glycerol in 0.1 mol dm^{-3} Tris buffer at pH 9 containing 0.1 mol dm^{-3} KCl

obtained at electrodes on which 0.3 mL of a solution containing 150 U/mL glycerol dehydrogenase, 100 mmol dm^{-3} of NAD, 100 mmol dm^{-3} of ruthenium hexaamine, 100 mmol dm^{-3} of ammonium sulphate, 100 mmol dm^{-3} of potassium chloride has been dried. Results are shown in Figure 16.

Example 2f

Ratio of amperometric current was measured 60 seconds after the application of a -0.50 V vs. Ag/AgCl potential step after addition of concentrations of 2, 5, 7.5, 10, 12.5 and 15 mmol dm^{-3} glycerol in 0.1 mol dm^{-3} Tris buffer at pH 9 containing 0.1 mol dm^{-3} KCl obtained at electrodes on which 0.3 mL of a solution containing 150 U/mL glycerol dehydrogenase, 100 mmol dm^{-3} of NAD, 100 mmol dm^{-3} of ruthenium hexaamine, 100 mmol dm^{-3} of ammonium sulphate, 100 mmol dm^{-3} of potassium chloride has been dried. Results are shown in Figure 17.

Example 3

Electrodes were constructed from a 250 μm PET layer on which a 7 μm Coates carbon ink 26-8203 layer had been screen-printed followed by a 30 μm Ronseal layer. This layer was punched to produce a 1 mm diameter hole. A base layer was formed by printing a 10 μm Ag/AgCl layer onto a 125 μm PET base layer. The base layer was then adhered to the punched layer using ARcare 7841 sheet adhesive. Various tests were carried out using this electrochemical cell which are described in Examples 3a and 3b below.

Example 3a

Amperometric current was measured 120 sec after the application of a -0.25 V vs. Ag/AgCl potential step. Showing the effect of additions of 1.5, 2.25, 3.0, 4.5, 6.0 mmol dm^{-3} cholesterol to a solution comprising 1 KU/mL cholesterol oxidase, 200 KU/mL horseradish peroxidase, 33 mmol dm^{-3} potassium ferrocyanide in 0.1 mol dm^{-3} potassium phosphate buffer at pH 7.4 containing 0.1 mol dm^{-3} KCl to electrodes

with a common counter/reference electrode configured at the bottom of the well. Results are shown in Figure 18.

Example 3b

Amperometric current was measured 120 sec after the application of a -0.25 V vs. Ag/AgCl potential step. Showing the effect of additions of 1.5, 2.25, 3.0, 4.5, 6.0 mmol dm^{-3} cholesterol to a solution comprising 1KU/mL cholesterol oxidase, 200KU/mL horseradish peroxidase, 33 mmol dm^{-3} potassium ferrocyanide in 0.1 mol dm^{-3} potassium phosphate buffer at pH 7.4 containing 0.1 mol dm^{-3} KCl to electrodes with a common counter/reference electrode configured on the top of the strip. Results are shown in Figure 19.

Example 4

Electrodes were constructed from a 250 µm PET layer on which a 7 µm Ercon carbon ink G449C layer had been screen-printed followed by a 30 µm Ercon E65615-116D dielectric layer. This was then punched to produce a 1 mm diameter hole. A 125 µm PET base layer was coated with a common Ag/AgCl counter reference layer (using Ercon E6165-128). The base layer as formed was then adhered to the punched layer using heat lamination.

Amperometric current was measured 1 second after the application 0.15 V vs. Ag/AgCl on the addition of 2, 4, 6, 8 and 10 mmol dm^{-3} NADH in 0.1 mol dm^{-3} Tris buffer at pH 9 containing 0.1 mol dm^{-3} KCl to electrodes on which 0.2 mL of a solution containing 0.2 mol dm^{-3} ruthenium hexaamine and 650 KU/mL putadiaredoxin reductase has been dried. Results are shown in Figure 20.

CLAIMS

1. An electrochemical cell which, either alone or in combination with a substrate onto which it is placed, is in the form of a receptacle, said cell comprising a counter electrode and a working electrode, wherein at least one electrode has at least one dimension of less than 50μm, the working electrode being in a wall of the receptacle.

2. An electrochemical cell according to claim 1 which is in the form of a receptacle.

3. An electrochemical cell according to claim 1 or 2, wherein the working electrode is in the form of a continuous band.

4. An electrochemical cell according to any one of the preceding claims, which further comprises a reference electrode.

5. An electrochemical cell according to any one of the preceding claims, wherein the ratio of the surface area of the counter electrode to the surface area of the working electrode is at least 25:1.

6. An electrochemical cell according to any one of the preceding claims, wherein the working electrode has at least one dimension in the range of 0.1 to 20μm.

7. An electrochemical cell according to any one of the preceding claims, wherein the receptacle has a width of from 0.1 to 5mm.

8. An electrochemical cell according to any one of the preceding claims, wherein the minimum distance between the counter electrode and the working electrode is from 10 to 1000μm.

9. An electrochemical cell according to any one of the preceding claims, wherein a base and/or a wall or walls of the receptacle contain one or more air-outlet channels.

10. An electrochemical cell according to any one of the preceding claims, wherein the receptacle contains an electro-active substance.

11. An electrochemical cell according to claim 10, wherein the electro-active substance has been dried.

12. An electrochemical cell according to claim 10 or 11, wherein the electro-active substance comprises an enzyme.

13. An electrochemical cell according to any one of claims 10 to 12, wherein the base of the receptacle comprises an electro-active substance.

14. An electrochemical cell according to any one of claims 10 to 12, wherein the base of the receptacle comprises a membrane, said membrane comprising an electro-active substance.

15. An electrochemical cell according to any one of the preceding claims, wherein the open end of the receptacle is at least partly covered by a permeable membrane.

16. An electrochemical cell according to claim 15 wherein the permeable membrane comprises an electro-active substance.

17. An electrochemical cell according to any one of the preceding claims, wherein the receptacle comprises one or more capiliary flow channels through which a sample may enter.

18. An electrochemical cell according to any one of the preceding claims, wherein the counter electrode forms at least a part of a base of the receptacle.

19. An electrochemical cell according to claim 17, wherein the receptacle is covered by a layer containing the counter electrode.

20. An electrochemical cell according to any one of claims 1 to 17, wherein the counter electrode is in a wall or walls of the receptacle.

21. An electrochemical cell according to any one of the preceding claims which is suitable for screening liquid samples.

22. A multi-analyte device comprising a plurality of electrochemical cells according to any one of claims 1 to 21.

23. A process for producing an electrochemical cell according to any one of claims 1 to 22, which process comprises the steps of:

(a) forming a first part comprising an insulating material which is optionally coated with a counter electrode layer;
(b) forming a second part comprising a laminate of a working electrode layer between two layers of an insulating material;
(c) creating a hole in the second part; and
(d) bonding said first part to said second part to form a receptacle.

24. A process according to claim 23 wherein the second part comprises a laminate of a counter electrode layer between two layers of insulating material.

25. A process according to claim 23 wherein the first part comprises an electro-active substance.

26. A process according to claim 23 or 24 which further comprises placing an electro-active substance as defined in claim 10 or 12 into the receptacle and optionally drying the electro-active substance.

27. A process according to any one of claims 23 to 26, which further comprises placing a membrane over at least a part of the open end of the receptacle.

28. A process according to any one of claims 23 to 27, wherein step (c) comprises forming two or more holes in said second part, in order to form a multi-analyte device.

29. A process for producing an electrochemical cell according to any one of claims 1 to 22, which comprises the steps of:

(a) forming a second part comprising a laminate of a working electrode layer between two layers of an insulating material;

(b) creating a hole in the second part; and optionally

(c) bonding to said second part a layer which is coated with a counter electrode material.

30. A process according to claim 29, wherein the second part comprises a laminate of a counter electrode layer between two layers of insulating material.

31. A process according to claim 23 or 24 which comprises the steps of:

(a) forming a first part comprising an insulating material;

(b) forming a second part comprising a laminate of a working electrode layer between two layers of an insulating material;

(c) creating, in the second part, a hole and a capiliary channel to allow a sample to enter said hole;

(d) bonding said first part to said second part to form a receptacle;

(e) placing an electro-active substance into the receptacle and optionally drying the electro-active substance; and

(f) bonding to the open end of said receptacle a layer which is optionally coated with a counter electrode material.

32. A process according to claim 31, wherein step (c) comprises forming, in said second part, two or more holes and two or more capiliary channels to allow a sample to enter said two or more holes, and wherein step (e) comprises inserting an electro-active substance, which may be identical or different, into one or more of the receptacles formed in step (d), in order to form a multi-analyte device.

33. A modification of the process of claim 31 or claim 32 which comprises the steps (a), (b), (c), (d) and (f) as defined in claim 31 or claim 32 and in which the first part comprises an electro-active substance.

34. A process according to any one of claims 23 to 33, wherein one or more of the electrodes is formed by screen or inkjet printing onto a substrate.

35. A method of electrochemically testing one or more compounds of a sample, the method comprising the steps of:

(a) inserting the sample into an electrochemical cell according to any one of claims 1 to 21 or a multi-analyte device according to claim 22;

(b) applying a voltage or a current between the working and counter electrodes of the micro-electrode; and

(c) measuring the resulting current, voltage or charge across the micro-electrode.

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FIG. 1

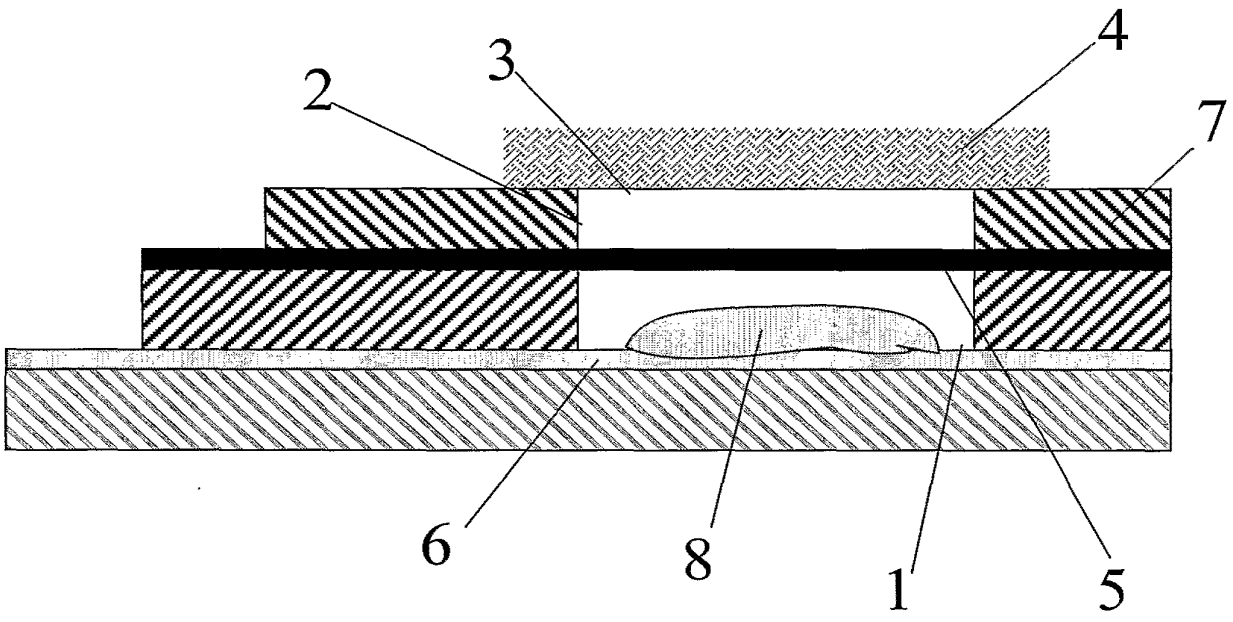


FIG. 2

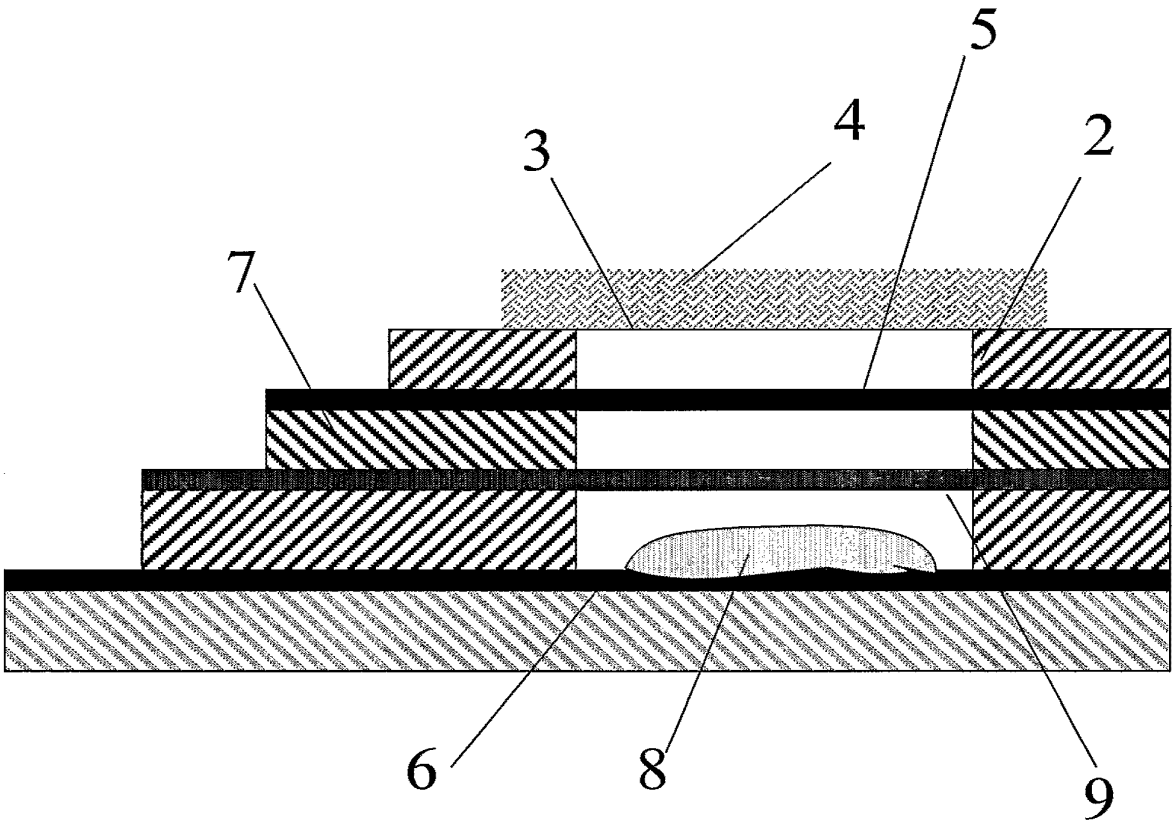


FIG. 3

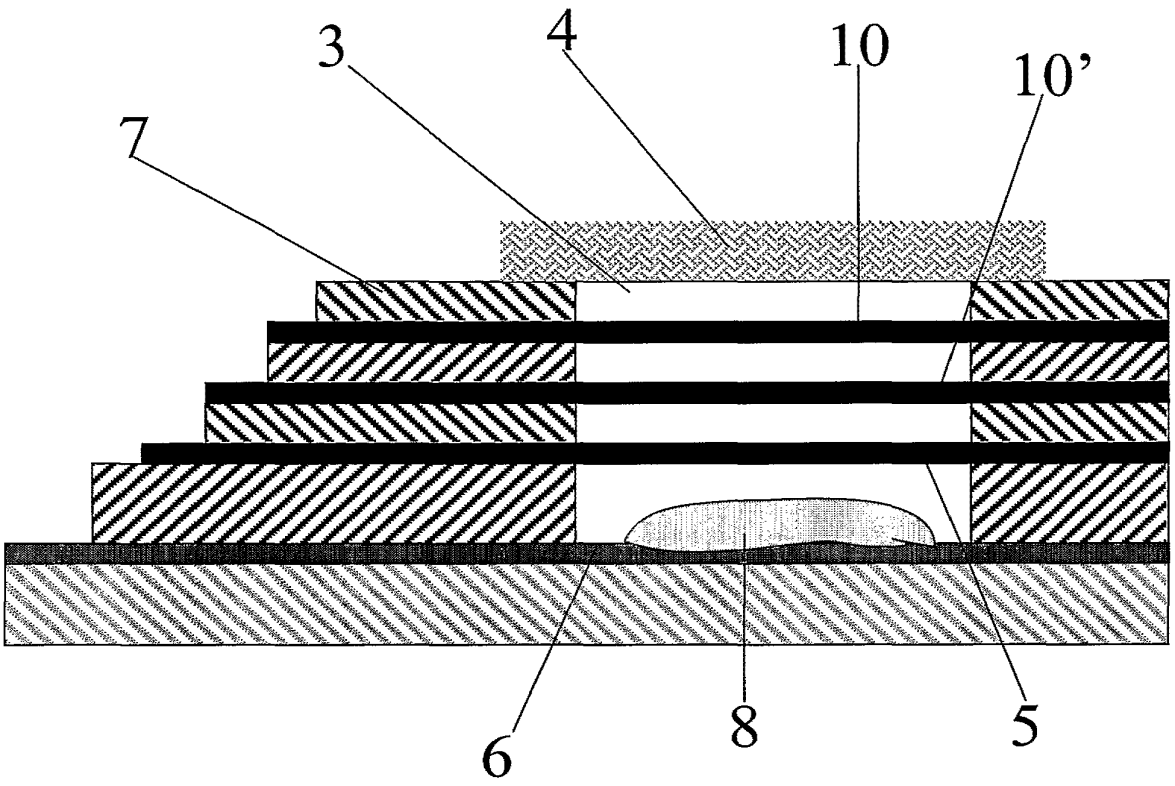


FIG. 4

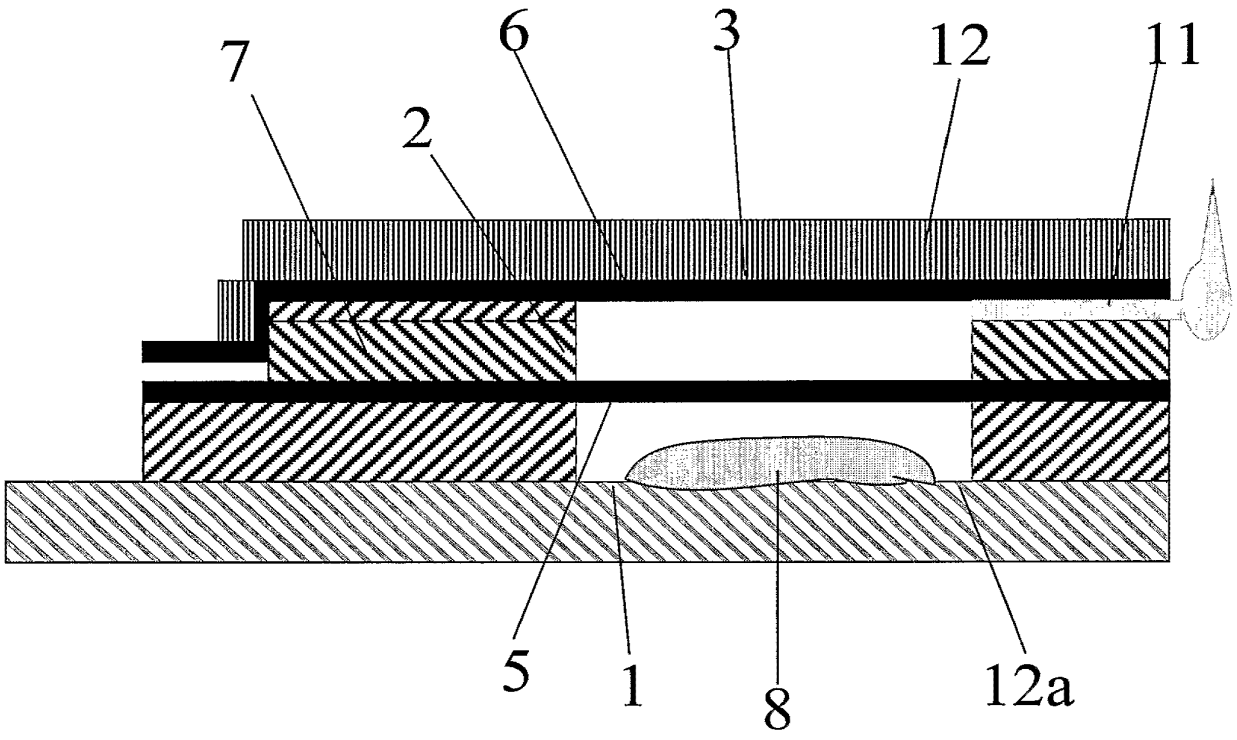


FIG. 5

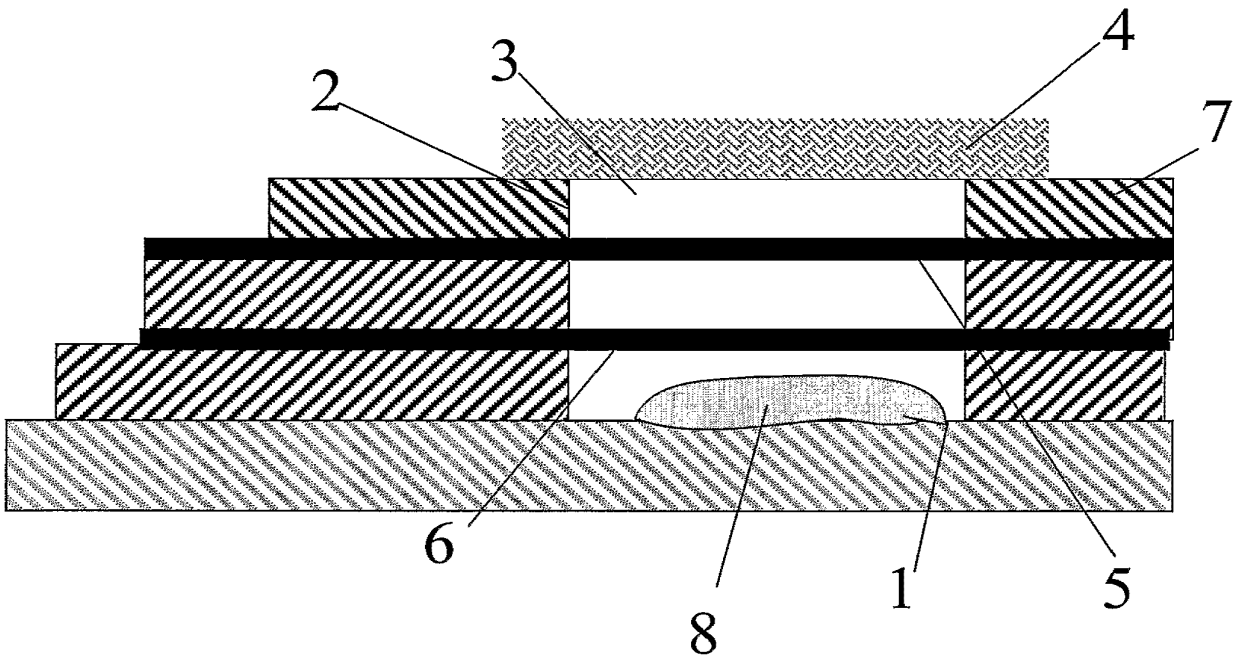


FIG. 6

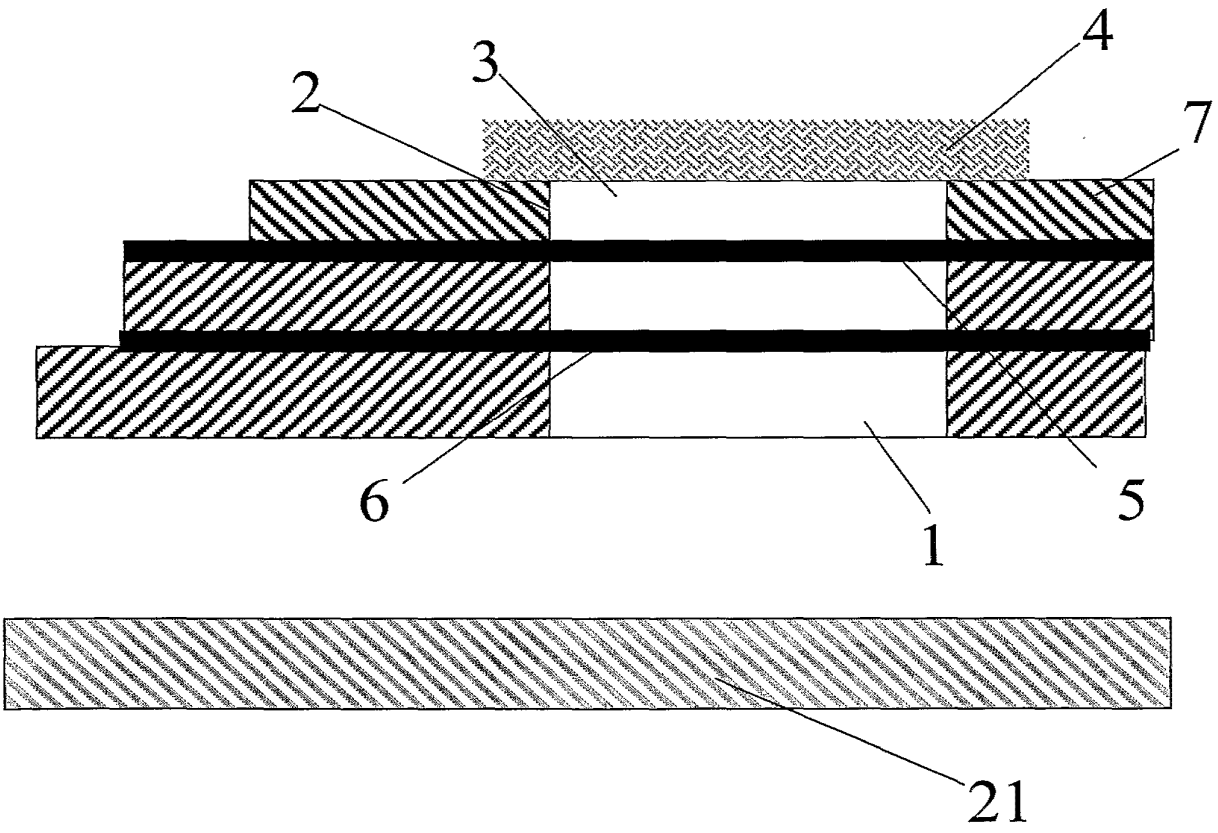
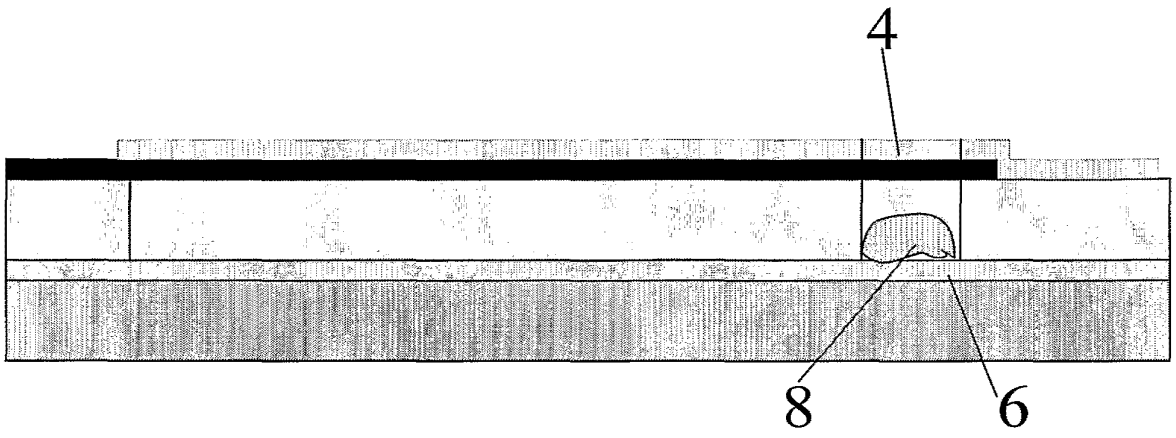


FIG. 7



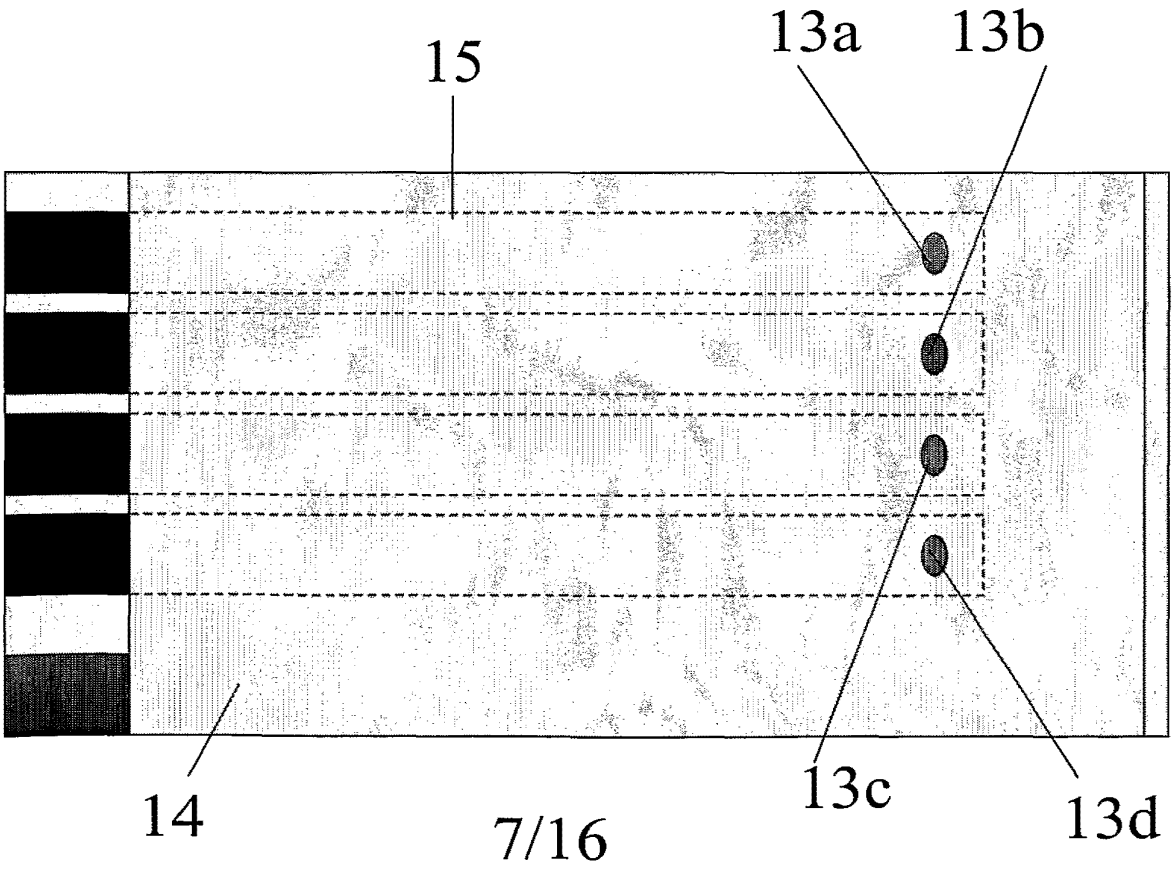


FIG. 8

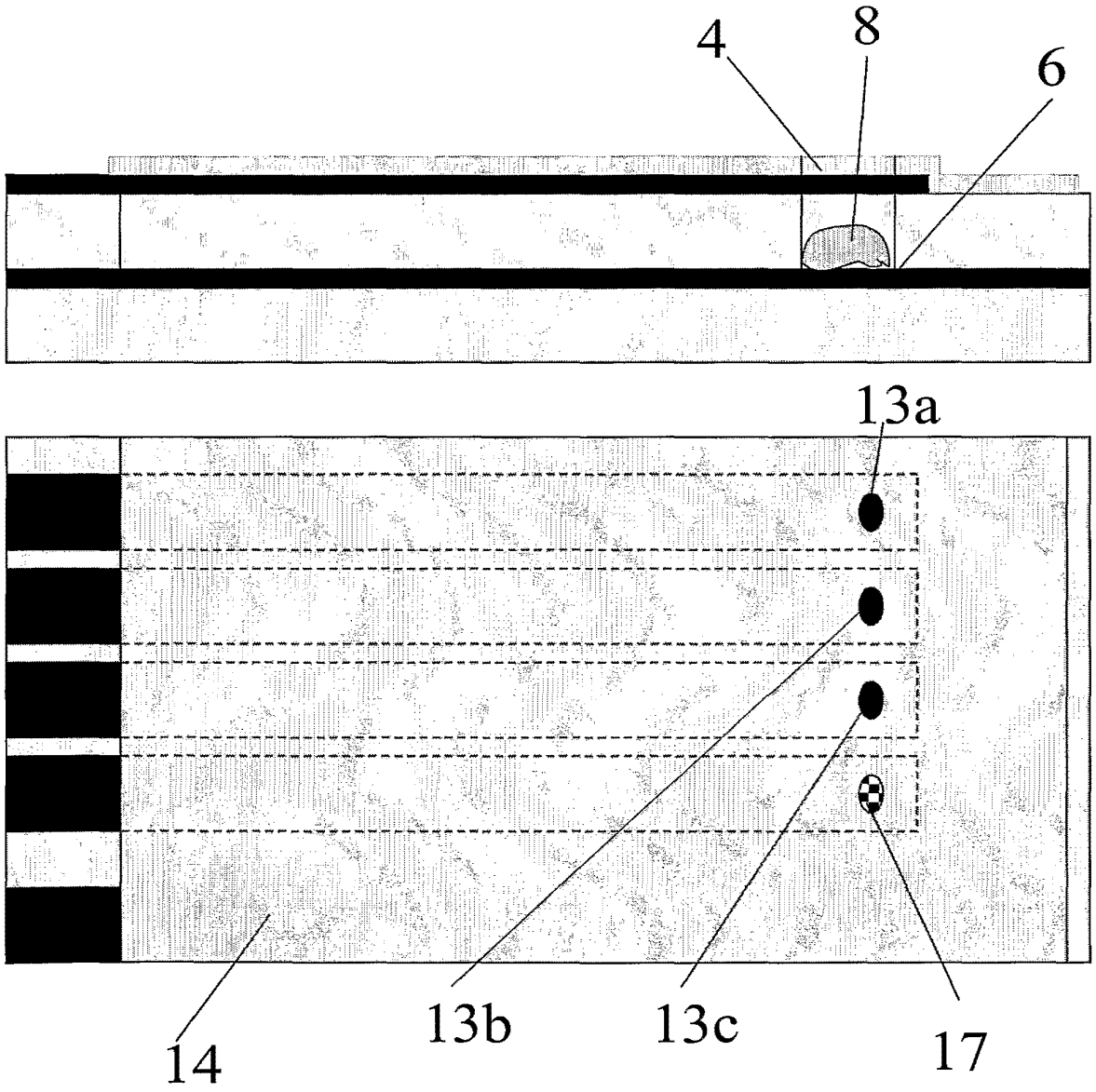


FIG. 9

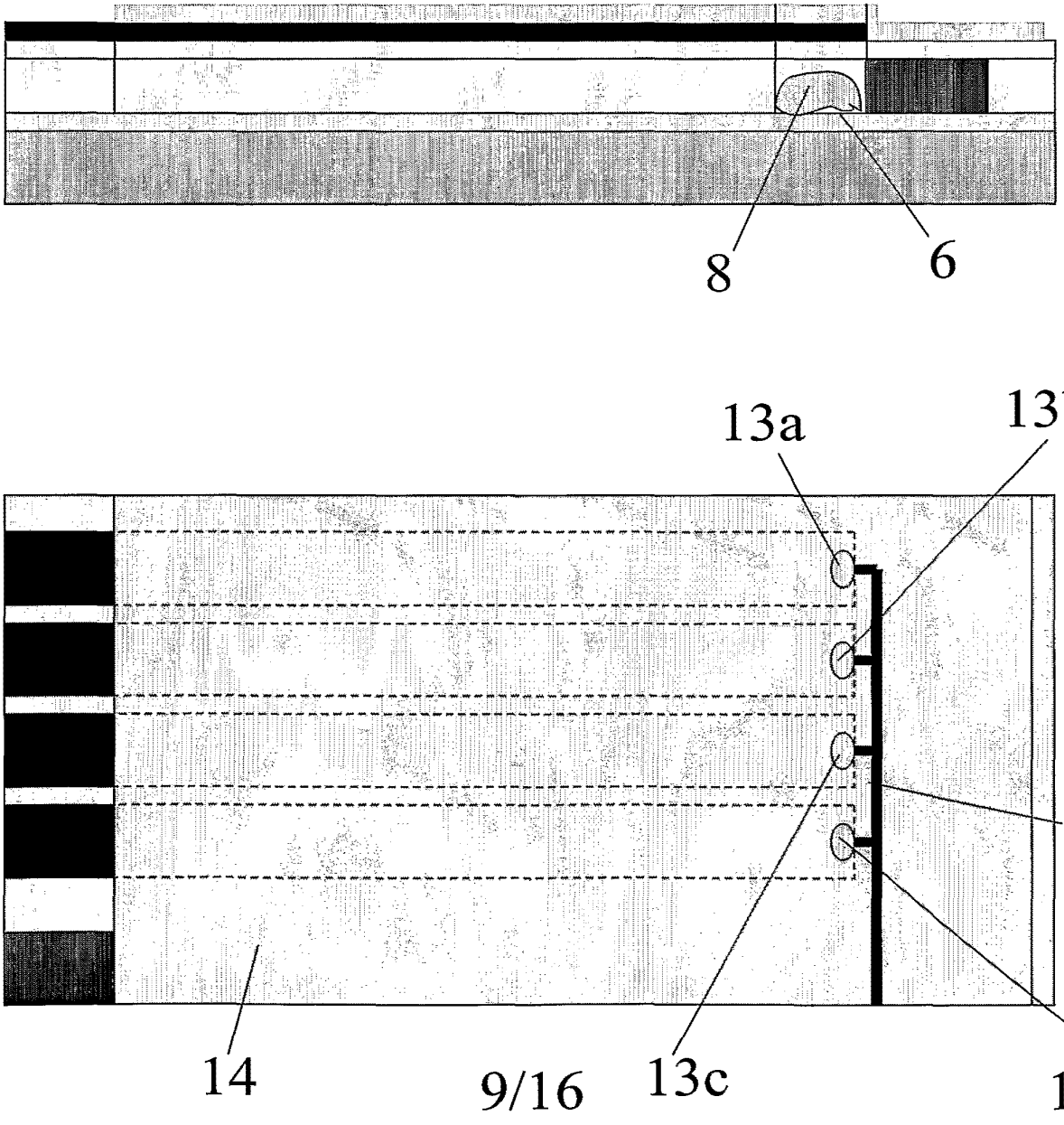


FIG. 10

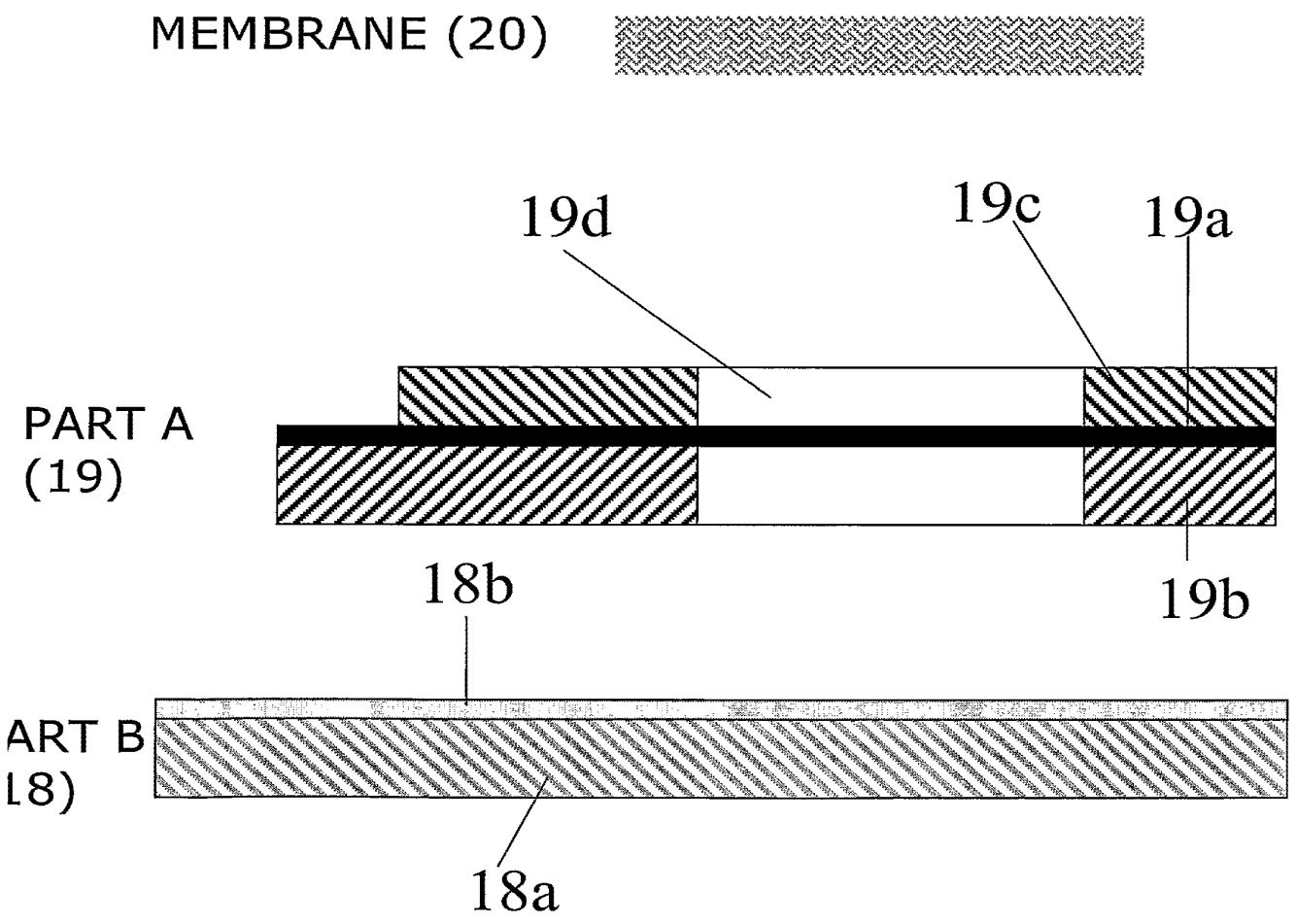
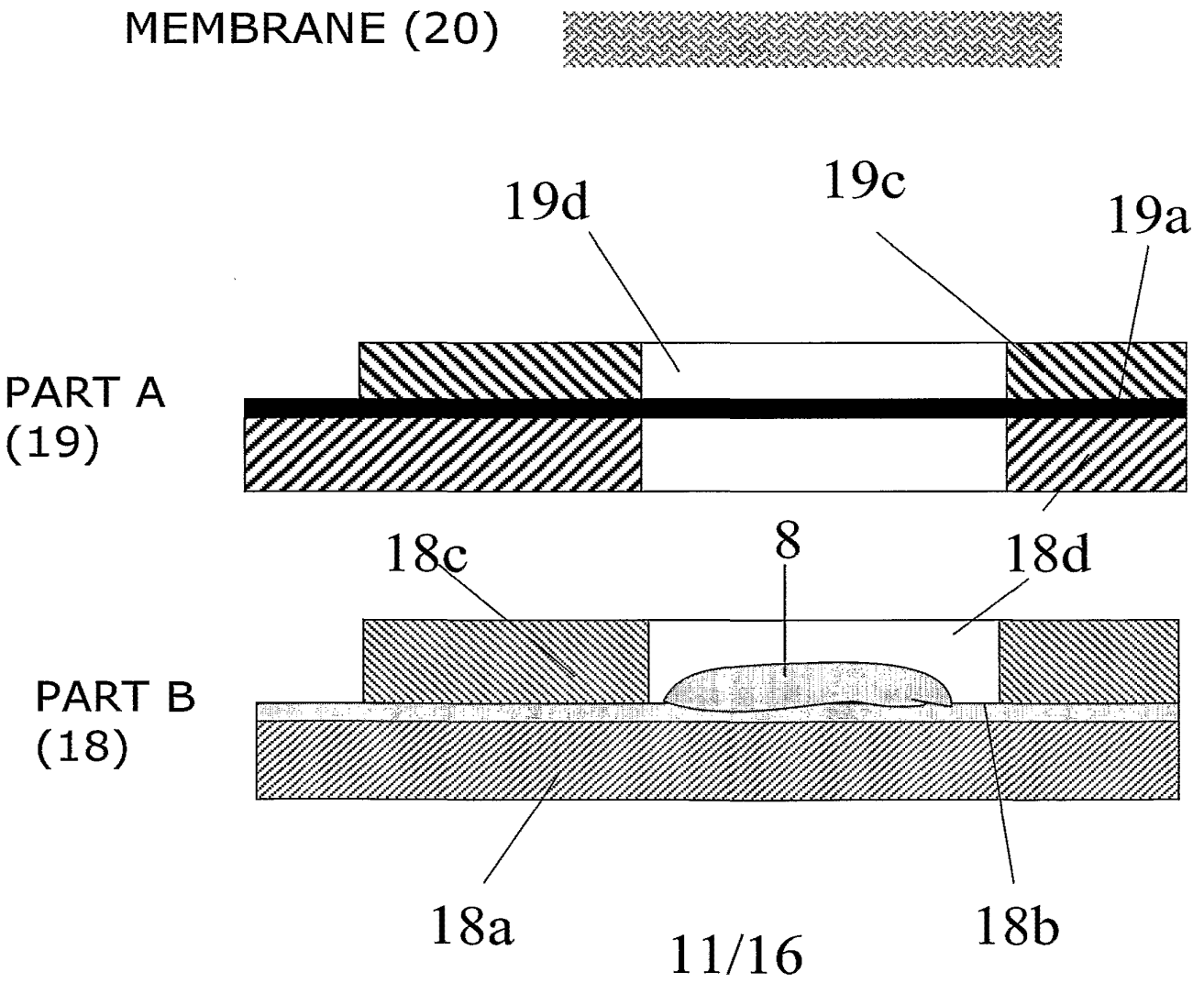


FIG. 11



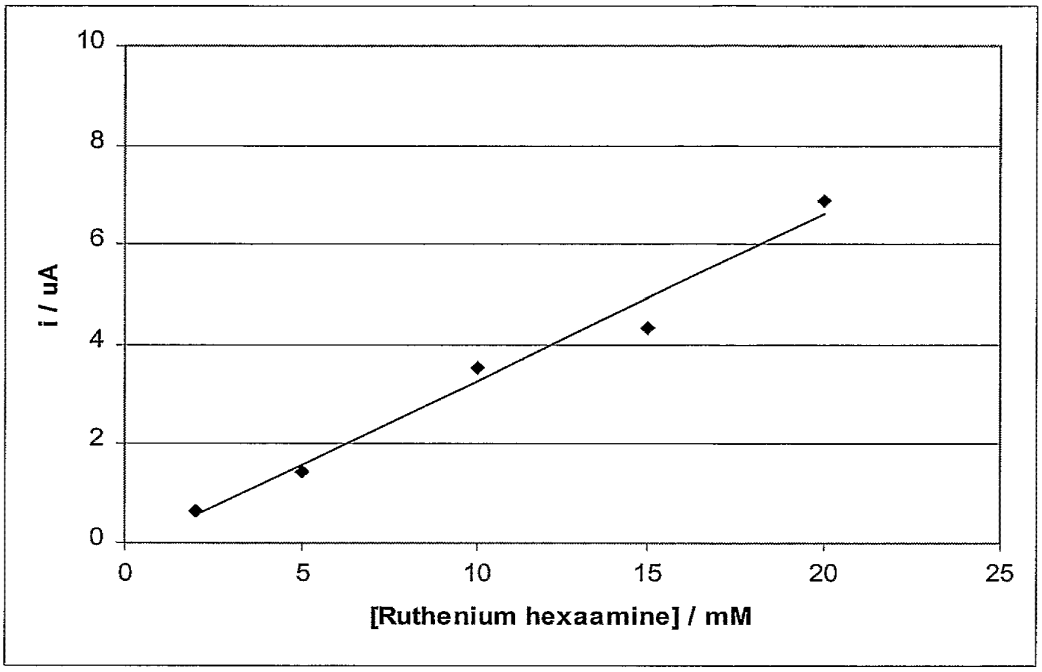


Figure 12

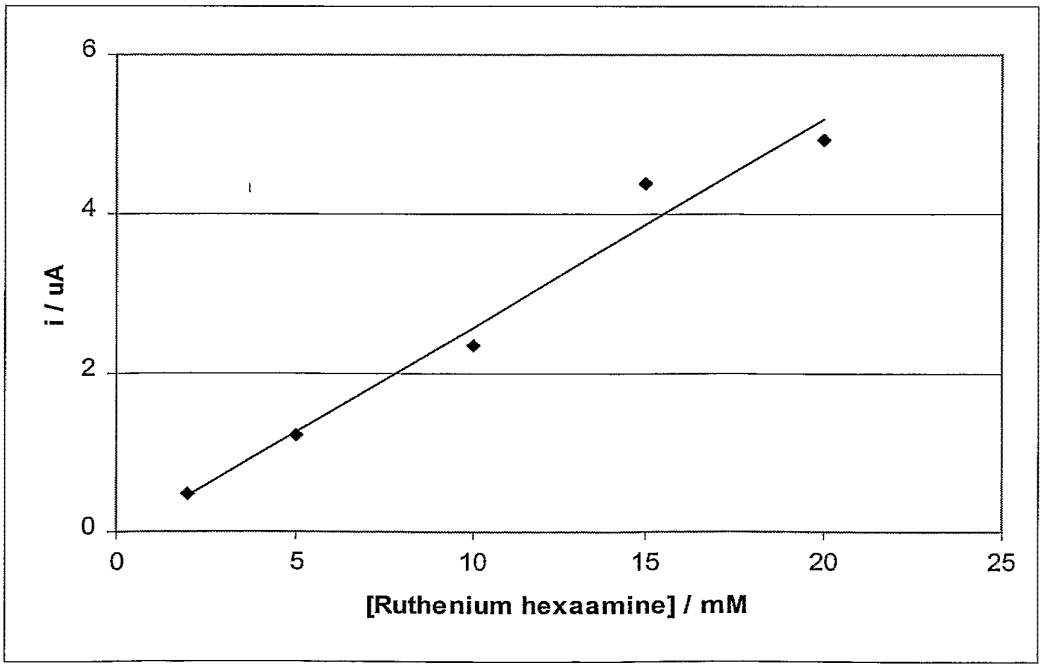


Figure 13

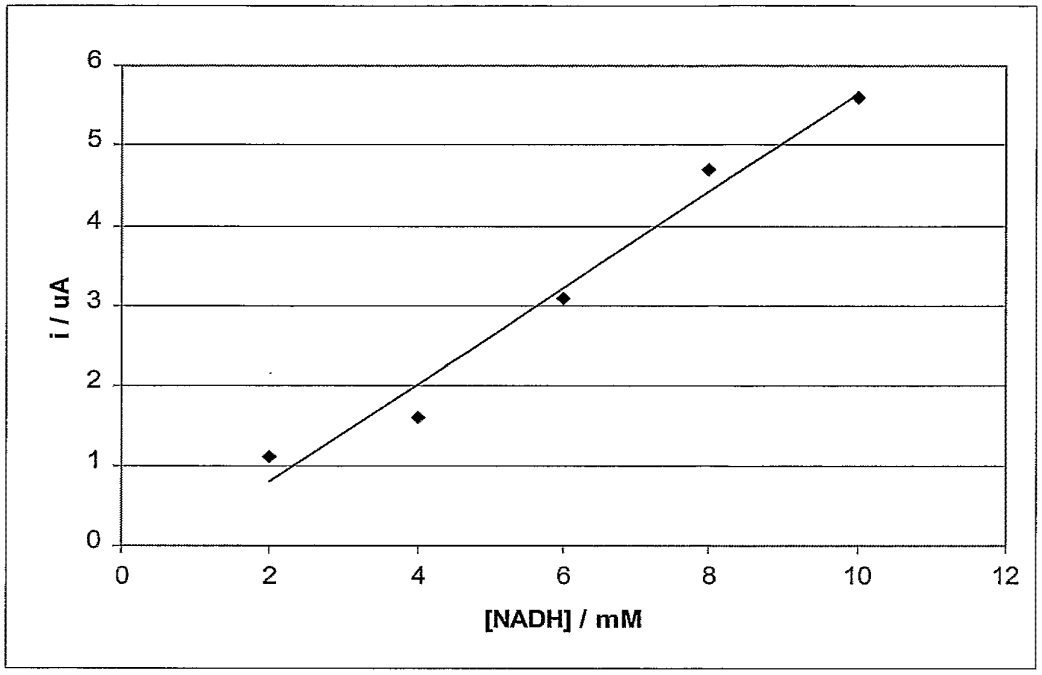


Figure 14

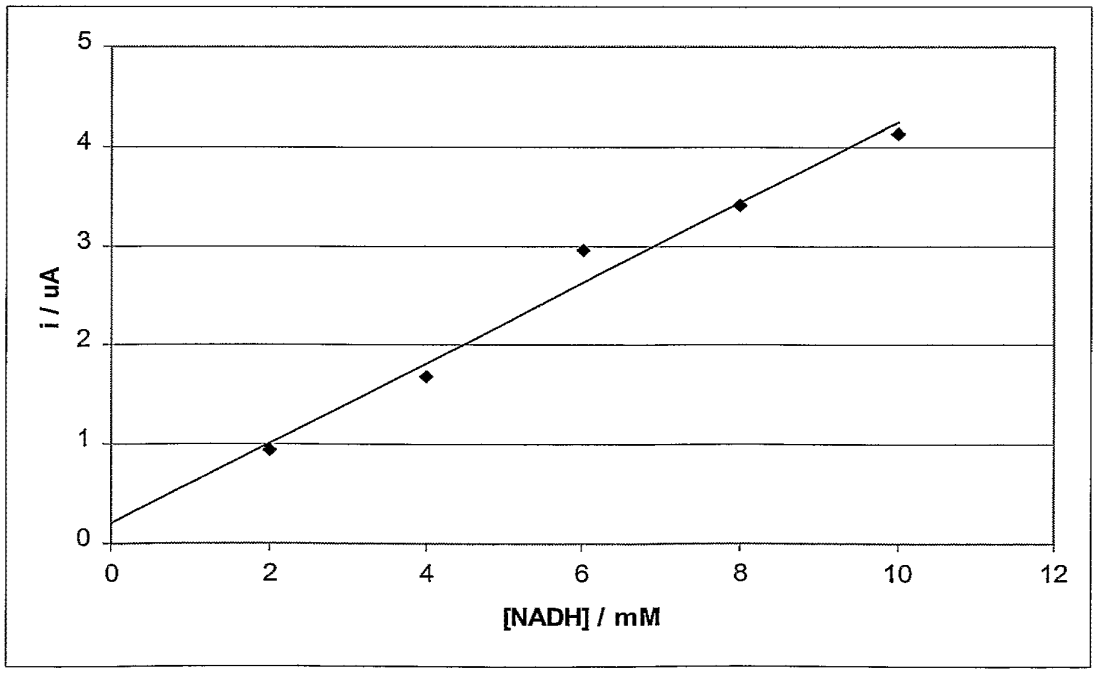


Figure 15

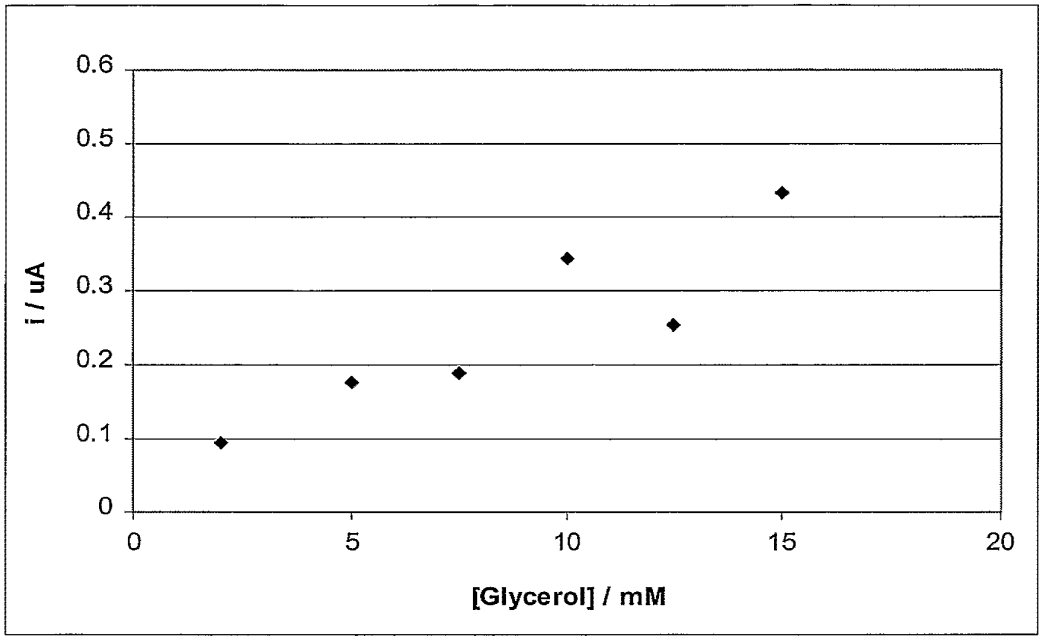


Figure 16

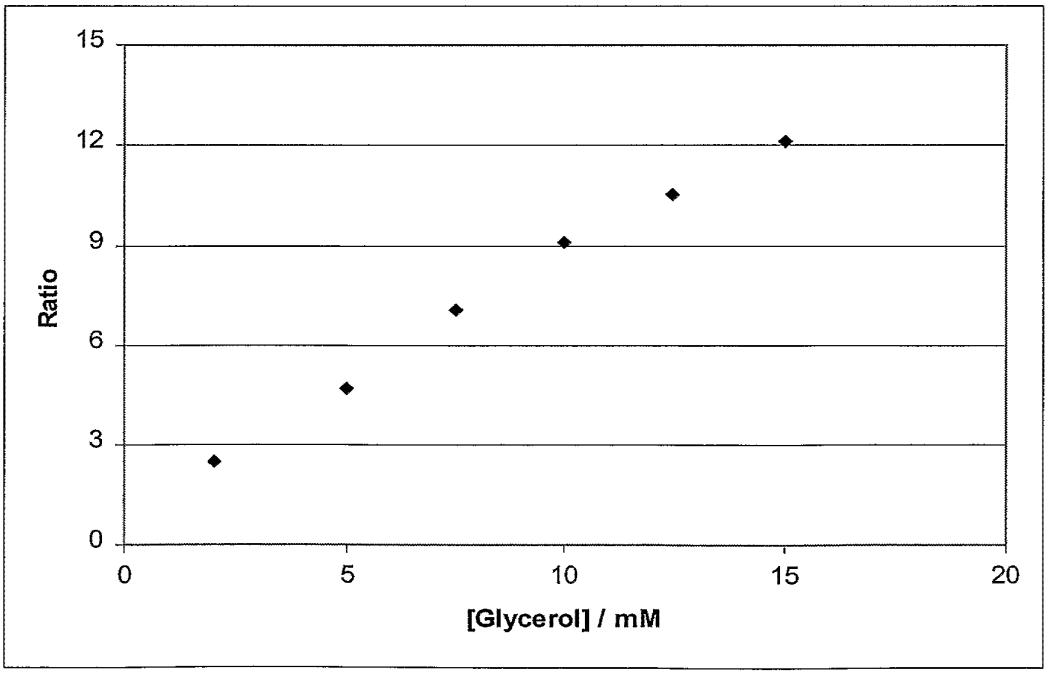


Figure 17

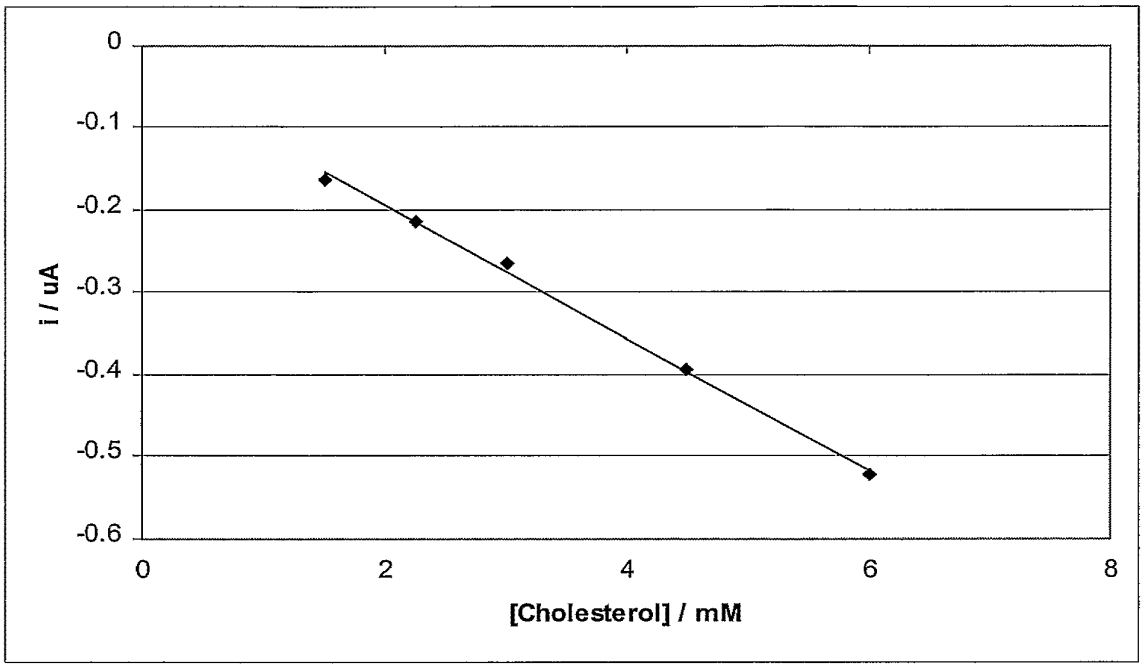


Figure 18

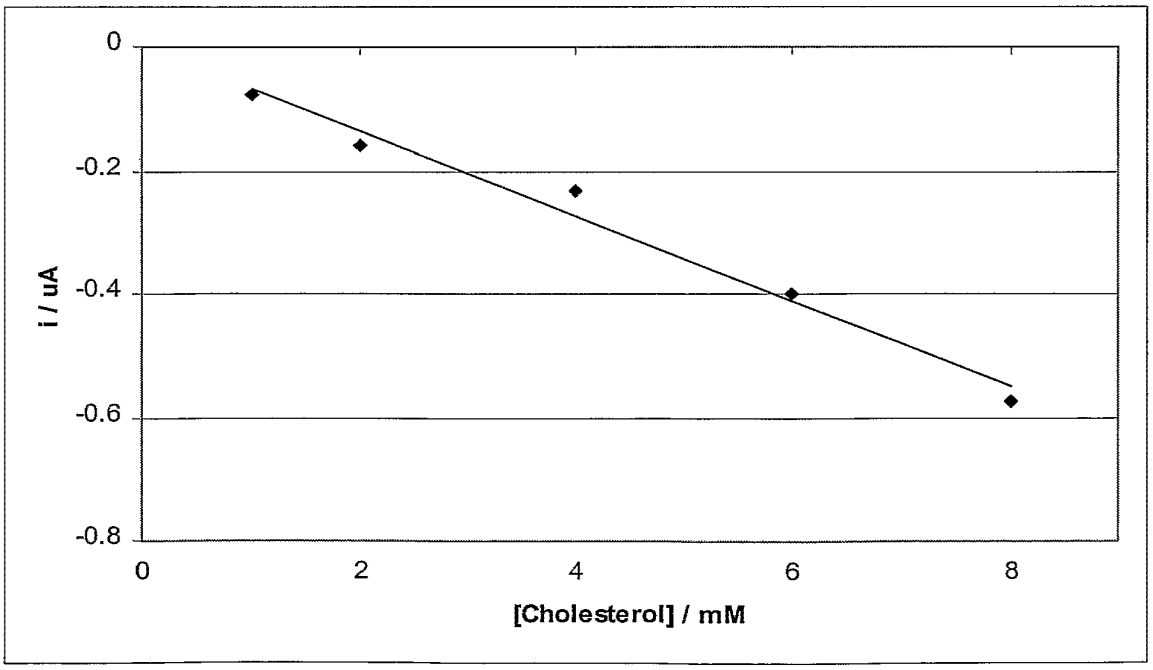


Figure 19

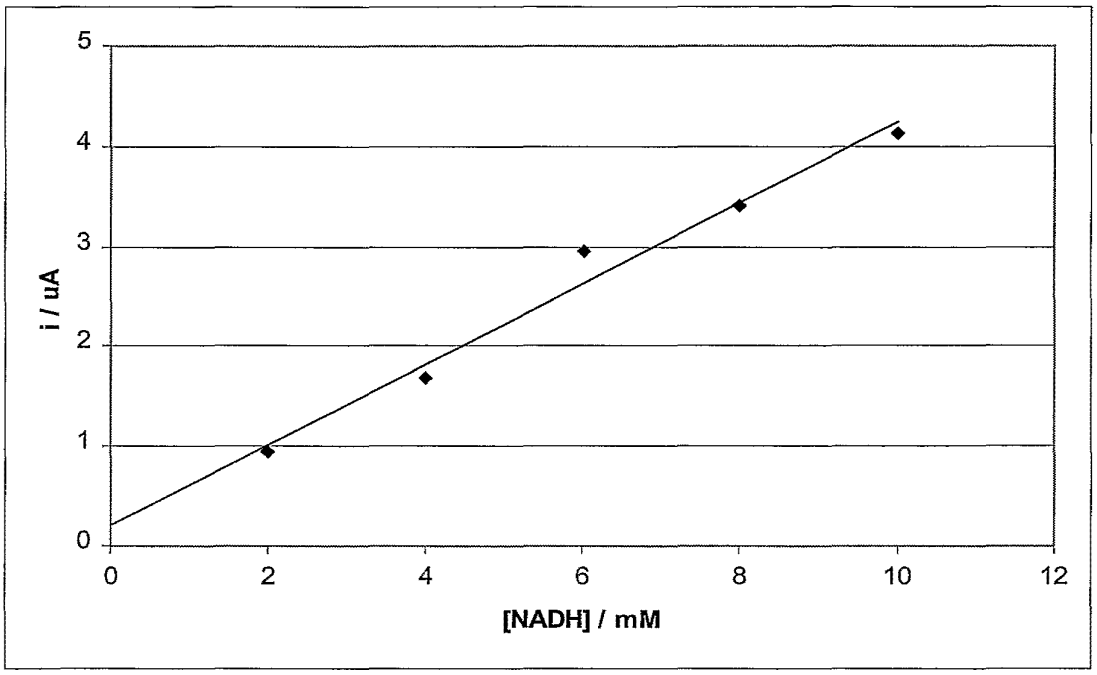


Figure 20

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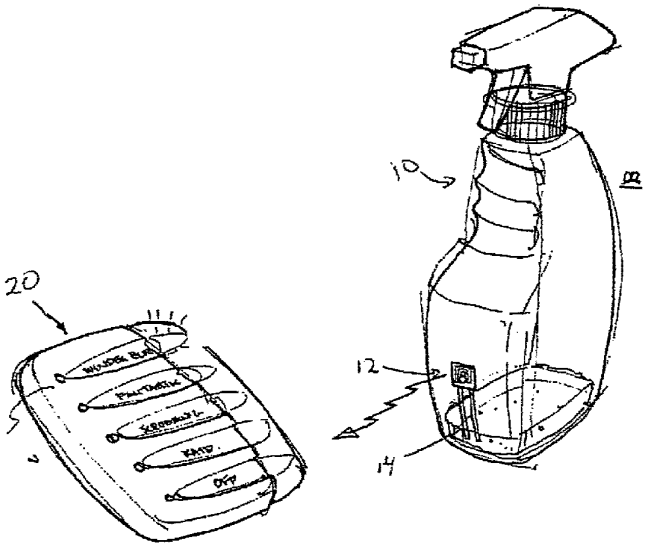
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(54) Title: PRODUCTS HAVING RFID TAGS TO PROVIDE INFORMATION TO PRODUCT CONSUMERS



(57) Abstract: RFID tags attached to a product contain information regarding the product and communicate this information to a reader. This information can include the age of the product, the amount of product left and preparation or care instructions for the product. To record the age of a product, a timer is initiated in the RFID tag. Thereafter, the elapsed time on the timer can be read and displayed by the reader. For other products, the RFID tag can have contacts monitoring the level of remaining product. Once the contacts sense that the amount of product is low, this information can be transmitted and communicated by the reader. Preparation and care instructions are prerecorded on the tag. Instructions can also be communicated between a product and a base, such as a heater.

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PRODUCTS HAVING RFID TAGS TO PROVIDE INFORMATION TO PRODUCT CONSUMERS

[0001] The instant application is based upon U.S. Provisional Patent Applications Serial No. 60/427,934, filed November 21, 2002, Serial No. 60/430,101, filed December 2, 2002, Serial No. 60/430,102, filed December 2, 2002 and Serial No. 60/482,867.

BACKGROUND OF THE INVENTION

[0002] Consumers often desire to know information regarding the many products in the household but the large number of consumer products makes keeping track of the condition of all products infeasible. Conditions that consumers often wish to know include age and time before replacement is necessary. At present, consumers often need to write a date on a product to keep track of its age of or continually check the amount remaining to estimate the time before replacement.

[0003] Many devices designed to dispense actives (also variously called dispensers) use refillable cartridges. Such devices include air fragrance dispensers. One problem encountered with such dispensers is that the cartridges are relatively long-lasting and when they finally do run out of product, the consumer is caught unprepared to replace the cartridge or they forget. Other products are used out of plain sight of the consumer. These devices include insect baits and traps. The consumer places them in hidden locations and may be unaware of whether they are being effective in controlling insects.

[0004] Consumers can place dates on products to know their age. Many freezer bags are provided with an area for marking the contents of the bag. To retrieve this information, the user needs to remove the bag from the freezer and read the information that has been imprinted on the bag and back compute the age from the date marked on the bag.

[0005] There is a need in the prior art for a single system able to track all products in a household and give information regarding the condition of the products, including age and amount of time before replacement.

[0006] It is an object of the invention to provide consumer items able to record and communicate condition of the product.

[0007] It is another object of the invention to provide products with RFID tags and a reader for storing information regarding the products and a reader for communicating this information to the consumer.

[0008] It is another object of the invention to provide a system for recording and communicating condition of a large number of items.

[0009] It is still another object of the invention to display information to the user by placing a reader in proximity to the item.

[0010] It is yet another object of the invention to use an RFID tag on a product to provide instructions to a recharger.

[0011] It is another object of the invention to provide consumers with information regarding products within the household.

[0012] These and other objects of the invention will become apparent to one of ordinary skill in the art after reviewing the disclosure of the invention.

SUMMARY OF THE INVENTION

[0013] RFID tags attached to a product contain information regarding the product and communicate this information to a reader. This information can include the age of the product, the amount of product left and preparation or care instructions for the product. To record the age of an product, a timer is initiated in the RFID reader once the RFID tag is recognized by the reader. Thereafter, the elapsed time on the timer can be read and displayed by the reader every time the RFID tag is passed in proximity to the reader. For other products, the RFID

tag can have contacts monitoring the level of remaining product. Once the contacts sense that the amount of product is low, this information can be transmitted and communicated by the reader. Preparation and care instructions are prerecorded on the tag or within the reader depending on the type of tag (read only or read-write). Instructions can also be communicated between a product and a base, such as a heater.

[0014] A monitoring system alerts a consumer when a cartridge is near empty or when a device, such as an insect bait/trap, is being effective in controlling pests. An automated triggering and signaling device is applied to the dispenser or bait/trap to signal the consumer when the cartridge is near empty or the trap is being used. Simple electrical or electromechanical mechanisms trigger the signaling device and communicate the status to the consumer via a hand-held PDA or other capable device. When the designated time period of the refill is known, a countdown can be started when the refill is installed, and an automated status of near empty can be signaled after a predetermined time.

[0015] Another use for RFID tags is for initiating instructions within the reader when an item having the RFID tag is brought in proximity to reader. An item needing to be heated or recharged, for instance, has an RFID tag. When the item is placed in the heater or recharger, the reader on the heater or charger senses the proximity of the RFID tag and can initiate the appropriate reheating or recharging cycle, which can be initiated by the RFID tag. Conversely, the RFID tag can contain information on it to communicate to the reader and initiate a series of instructions or commands. The tag can be preprogrammed with specific instructions in the manufacturing process or can be programmable. In this case a read-write RFID tag would be used where instructions or data is written to the tag or previous instructions unwritten.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] **FIGURE 1a** depicts a trigger spray container having a near-empty indicator;

[0017] **FIGURE 1b** depicts a trigger spray container having an alternative near-empty indicator;

[0018] **FIGURE 2** depicts an aerosol can having a functional label incorporating a near-empty indicator;

[0019] **FIGURE 3** depicts containers having near-empty indicators communicating with a central base station;

[0020] **FIGURE 4a** depicts a dispenser having an active refill incorporating a near-empty indicator;

[0021] **FIGURE 4b** shows a dispenser having an alternative refill incorporating a near-empty indicator;

[0022] **FIGURE 5** depicts a bottle having an RFID tag that mates with a holder;

[0023] **FIGURE 5a** depicts a heater and container for flowable products;

[0024] **FIGURE 6** depicts a multiple fragrance dispenser responsive to a key fob controller;

[0025] **FIGURE 7** depicts a fragrance dispenser responsive to a light sequence;

[0026] **FIGURE 8** depicts a reader for an RFID tag recording elapsed time;

[0027] **FIGURE 9** depicts bags incorporating an RFID tag;

[0028] **FIGURE 10** depicts a clip having an RFID tag; and

[0029] **FIGURE 11** depicts an insect trap incorporating an effectiveness indicator.

DETAILED DESCRIPTION OF THE INVENTION

[0030] RFID is a type of automatic identification technology, similar to bar code technology, except that RFID uses radio frequency instead of optical signals. The reader (or reader/writer) produces a low-level radio frequency magnetic field, typically either at 125 KHz or at 13.56 MHz. It must be noted that other frequencies can be used depending on the application. This magnetic field emanates from the reader (or reader/writer) by means of a transmitting antenna, typically in the form of a coil. Meanwhile, an RFID tag, typically including an antenna and an integrated surface, can be placed on any product.

[0031] The RFID system can be either read-only or read/write. Read-only systems, as their name suggests, permit the reader to receive information from the tag, but not vice-versa. Read/write systems, on the other hand, permit two-way communication between the tag and the reader/writer, and each of these components typically include an electronic memory for storing information received from the other component.

[0032] Figure 1a depicts a trigger spray container **10** having a near-empty indicator. The near-empty indicator consists of an RFID (radio frequency identification) tag **12** attached to the interior of the container. The RFID tag **12** has a pair of contacts **14** extending downwardly from the tag. When the contents of the container reach a level below the end of the contacts **14**, an electrical circuit is broken, causing the RFID tag to send a signal to a monitoring unit **20**. Power for the RFID tag to signal the reader is provided by a printed battery. The monitoring unit **20** has a series of LED lights, each LED light designating a particular product being monitored. In response to a signal from the RFID tag **12**, the LED light will illuminate to indicate to the

user or the consumer that the product will soon be in need of replacement. The signal may be audible.

[0033] Figure 1b depicts an alternative near-empty indicator. The trigger spray container **10** has a flexible printed circuit board **16** mounted thereon with a pair of contacts extending downwardly inside of the container. In a manner similar to the embodiment shown in Figure 1a, the reduction in level of product below the terminal ends of the contacts **18** causes the printed circuit board **16** to display a message on a display, such as e-paper attached to the container. Power for the printed circuit board and display is provided by a printed battery **25** adhered to the container exterior.

[0034] Figure 2 depicts the incorporation of a near-empty indicator on an aerosol can **30**. A functional label **32** is attached to the can. The functional label **32** includes a refill sensor **34**. When the contents of the container fall below a certain level, the refill sensor **34** sends a signal to a base monitor **38**. The base monitor **38** is able to display a printed message to the user indicating the need to replace the product in the very near future. The refill sensor is provided power by a printable battery **36** incorporated into the label.

[0035] Figure 3 depicts the ability for a plurality of containers to interact with a single central base station. The trigger spray container **10** has an RFID tag **12**. In this instance, the contacts **114** are molded into the container. The spray can **30** has a near-empty indicator attached to the interior of the can during manufacturing. Both of these containers communicate with a base monitor to alert the consumer that the level of product remaining in either respective container has reached a certain, predetermined low level.

[0036] Figure 4a shows a plug-in appliance for discharging fragrances, insecticides or similar actives. The actives are contained in a replaceable cartridge **42** received by the plug-in appliance **40** and having an RFID tag **44**. Contacts from the RFID tag extend downwardly from the tag and a reduction in the amount of liquid or gel contained in the refill breaks the electrical

circuit when the product falls below a certain level. The signal sent from the RFID tag alerts the consumer of this condition. In this instance, the RFID tag causes indicator light **45** at the top of the plug-in appliance to illuminate. The plug-in appliance can also have an audible message in response to a signal from the RFID tag. An additional embodiment would have the RFID tag signal a timer in the heater **40** to start. When the timer reaches a set time limit a signal is activated indicating that the refill is near empty.

[0037] Figure 4b shows a similar plug-in appliance **46** having a different type of cartridge **48** incorporating an RFID tag **49** having contacts extending downwardly into the container that break an electrical circuit when the product falls below a certain level. In the same manner, after such an event occurs, the RFID tag causes an indicator light **45** to illuminate. An additional embodiment would have the RFID tag signal a timer in the heater **46** to start. When the timer reaches a set time limit a signal is activated indicating that the refill is near empty.

[0038] Some actives and other products are not plugged directly into an outlet but are heated by a base unit, or charging device. Figure 5 shows a charging device comprising a coil **50** for generator a magnetic field, a control device **52** such as a circuit board for controlling the coil to selectively generate the magnetic field, a switch **53** for manually activating the charging device to generate the magnetic field, a heatable element **51** and a detection device **58** such as a reader writer. The heat storage unit has a radio frequency identification device **59** storing information about the heat storage unit. The detection device of the charging device reads the information stored by the RFID tag on the heat storage unit. The charging device is automatically activated to generate the magnetic field when the heat storage unit is placed in proximity to the charging device. With a heat storage unit and charging device, a proximity between tag and reader of 0.1 to six inches is preferred.

[0039] The RFID reader/writer **58** is connected to control device **52**. The heat storage unit has RFID tag **59** including an antenna. Preferably, the RFID tag is affixed to the outside of the heat storage unit or formed integrally with the heat storage unit. The tag signals reader/writer **58** when an appropriate heat storage unit is placed in proximity to the charging device causing control dervice **52** to activate coil **50**. The heatable element **51** generates heat in the presence of the generated magnetic field. Any device not having an RFID tag will not activate the charging device.

[0040] More than signaling the proximity of a container to activate the charger, in a more advanced embodiment, RFID tag **59** can transmit information to reader/writer **58** regarding preferred heating conditions for the particular heat storage unit. This can include both heating durations and peak temperatures. Additionally, the RFID tag can be used to transmit information to the reader/writer **58** regarding the product placed in the charger element. The reader recognizes the unique signature of the tag and accesses a stored regimen corresponding to that signature. Or the tag may store the heating regimen and transmit this information to the reader. In this manner, a single recharger can be used for a variety of different products such as different fragrances, insecticides, sanitizers, odor counteractant, liquid cleaning solution, shaving cream, lotion, or dispensing devices each having a different heating regimen.

[0041] Optionally, the RFID tag could have a writable electronic memory. The electronic memory contains stored information which may be updated by transmissions from the reader/writer **58**, including the heating history of the heat storage unit. The heating history of the bottle can be transmitted to the charge so that the charging device raises the peak temperature each time the charging device cycles on. This incrementally increases the evaporation rate of a fragrance to overcome any possible desensitizing problem. Transmitting the history of the bottle, a signal may be sent to the user to

replace the bottle with a new one based on the known duration of the contents of the bottle.

[0042] A real time clock connected to the control circuit can keep track of how long a particular heat storage unit has been heated and how recently. The control circuit therefore prevents overheating of the heat storage unit in such instances as when the heat storage unit has been recently heated and again plugged into the charging device. The RFID tag may also have a temperature sensor detecting the temperature of the heat storage unit to prevent overheating.

[0043] In addition to heating volatiles, a bottle containing flowable products may be placed in the charging device. The RFID tag on the bottle transmits information to the charging unit that a bottle has been placed in proximity and, optionally, to transmit information regarding the heating regimen of the particular flowable product. A charger and container for heating flowable consumer products is shown in Figure 5a. Similar to the system of Figure 5, the charger has a control device **52**, a detection device, reader/writer **58**, and a magnetic field generator **50**. The charger also has a manual switch **53** and indicator light **54**.

[0044] The container mating with the charger has a housing **140** accommodating a pressurized container **130** having a valve stem **134**. The valve stem leads to the inlet **116** of a reservoir **120**. The reservoir is sized to hold one to five doses of the flowable product dispensed by the pressurized container by an actuator **136**. The reservoir is surrounded by a heatable element **151** generating heat in the presence of the generated magnetic field and a heat retentive body **180**. An RFID tag **59** controls the heating of the heating element. Similar to the embodiment of Figure 5, the tag may simply signal the presence of a suitable container to initiate the magnetic field generator, or initiate a specific heating regimen by accessing a regimen stored in the charger or transmitting the regimen to the charger. As is true with both chargers shown in Figure 5 and 5a, any type of

conventional heating, such as resistive heating, can be used in place of magnetic heating.

[0045] Figure 6 depicts a fragrance dispenser **60** activated by a controller. The controller can be a key fob **62** having a printed circuit board and RFID chip to signal the dispenser. The signals can be controlled by the user by a button to allow the user dispense the fragrance in the dispenser.

[0046] Figure 7 discloses a multi-fragrance dispenser **70** responsive to controls to dispense a particular fragrance. Each fragrance has a corresponding and specific RFID tag. The fragrance to be dispensed in response to specific signals is programmed via a RFID chip. In addition to dispensing a fragrance, the controller causes the RFID chip to illuminate various colored lights, such as LEDs. The dispenser has several LEDs of various colors which illuminate, singly or in combinations. In this manner, visual stimulation is provided to accompany the olfactory stimulation. In addition or place of visual signals, specific audio signals can be generated along with the dispensing of a particular fragrance.

[0047] Figure 8 depicts a reader **60** having a display **62** for visually displaying information transmitted from an RFID tag, such as age and time. In addition, the reader may be provided with a speaker to audibly transmit information. The display has a target area **64** indicating the position of the antenna on the circuit board housed within the reader for receiving information from the RFID tag. A hook **66** may be provided on the reader for allowing the reader to hang from a refrigerator door or other similar device. In place of a hook, other mounting devices, such as magnets, adhesive or Velcro may be used. The reader has a start button **68** used to initialize a timer relating to the RFID tag and reset the timer, if desired.

[0048] RFID tags can be attached to rigid or flexible containers, such as bags. Figure 9 depicts a bag **90** having an RFID tag **92**. The RFID tag **92** is initialized by the depression of a start button **68** on the reader **60**. Once initialized by a particular RFID tag, the timing sequence begins recording elapsed

time since initialization. With a single reader, a plurality of RFID tags on reclosable bags or any other types of containers can be monitored. The tags may be applied by the manufacturer or may be sold separately to be applied by the consumer. If applied by the consumer, the RFID tags may be disposable or reusable with limited number of uses and be attached on multiple bags or containers. In this instance, when the RFID tag is switched from one container to another, it is reinitialized by the reader to again, monitor elapsed time since initialization. A variety of attachment means can be used to attach and remove the reusable version of the tag. In addition to containers, such as bags, RFID tags **92** can be applied to clips **93** used to reclose bags, as seen in Figure 10. After initially opening the bag, the clip **93** is used to reclose or reseal the bag with the RFID tag being initialized. This gives the consumer information about elapsed time since the bag was opened. The clip, being reusable, has an RFID tag reset each time it is applied to a bag for the first time. If the tag is disposable or has a limited number of uses, the clip can have a provision to nest the tag in a pocket or recess.

[0049] The use of RFID tags to monitor elapsed time can be used for a whole host of applications. Any device needing routine maintenance can have an RFID tag to record elapsed time since the last maintenance cycle. Common devices which require routine, timed maintenance include HVAC systems, horticultural items and various items on automobiles.

[0050] Figure 11 depicts an insect trap **94** having an RFID tag **95** measuring insect presence. Activity of insects activates the RFID tag and sends a signal to a monitor **96.** The monitor may have an indicator light **97** or LCD readout **98** to alert the consumer that the trap has been activated by the presence of insects. A reset button **99** adds to the effectiveness of the monitor in assessing the effectiveness of the trap. The insect can trigger a low power electrical trigger to signal the device. Alternatively, pheromone sensors can be used to trigger insect presence.

[0051] Besides elapsed time, prerecorded information can be placed on an RFID tag appropriate for the item to which the tag is attached. For example, such an application is clothes. Clothes may be provided with tags having care instructions. Whether dry cleaning is necessary, the best method for removing stains and the type of wash cycle to allow sorting of laundry into like articles of clothing for washing purposes, can be placed on an RFID tag. As an educational tool, tags may be provided with information allowing children to match clothes together. If the tags are applied by the manufacturer, the tags can be used to store information regarding a sweepstakes or other promotional activity. Also, the tags can be used as a simple means to track inventory of food in a household.

[0052] Other types of information that may be stored on RFID tags is cooking instructions. The packaging of food items may contain RFID tags with cooking instructions. By bringing the package within proximity of a reader, the RFID tag can initiate an audio message providing cooking instructions, or a visual display on a screen.

[0053] Because a reader senses proximity of an RFID tag, tags may be incorporated into items such as keys, pet collars, or any other item that is often lost. Using the portable reader, the user can receive an audio or visual signal through the reader display whenever the reader comes within proximity of an RFID tag. At present, a proximity of two meters is envisioned. However, greater read distances are feasible depending on power requirements. The use of active tags, those having their own power source, enables greater distances. However, one of ordinary skill in the art is able to adjust proximity requirements to suit the particular application.

[0054] The RFID tag may be made small enough that the tag may be added to bait and ingested by rodents or other animals. Once ingested, the tag may be tracked by using the reader to indicate the proximity of the tag.

[0055] Although specific components, materials, configurations, arrangements, etc. have been shown and described

with reference to several preferred embodiments, our invention is not limited to these specific embodiments. One of ordinary skill in the art will realize that various modifications and variations are possible within the spirit and scope of our invention which is intended to be limited in scope only by the accompanying claims.

WHAT IS CLAIMED IS:

1. A system for signaling level of product in a container, comprising:

a container having a sensor affixed to one portion thereof,

contacts extending downwardly from said sensor;

an electrical circuit broken when the level of product in said container falls below said contacts, and

a device for generating a signal from said sensor when said electrical circuit is broken for alerting a user that the level of product is low, and

a remote receiver separate from said container for communicating said signal for alerting the user.

2. The system of claim 1, wherein said sensor comprises an RFID chip.

3. The system of claim 1, wherein said sensor comprises an RFID chip that signals a timer in a primary device, base station or similar device to countdown a present time to refill.

4. The system of claim 2, wherein said sensor comprises an RFID chip that signals a timer in a primary device, base station or similar device to countdown a present time to refill.

5. The unit, comprising:

a base,

a container having an RFID tag, said container fitting in said base, wherein

said RFID tag signals the presence of the container to said base when the container is placed in proximity to said base.

6. The unit of claim 5, wherein said base is a heater.

7. The unit of claim 5, wherein said container contains a flowable product.

8. The unit of claim 5, wherein said container contains a fragrance.

9. The unit of claim 5, wherein said container is a dispensing device.

10. The unit of claim 5, wherein said RFID tag communicates a heating regimen to said base.

11. The unit of claim 5, wherein said RFID tag communicates a heating history for said container to said base.

12. The unit of claim 5, wherein said RFID tag is attached to said container,

Said base having a radio frequency identification reader/writer in operable connection with a microprocessor-based control circuit, said reader/writer transmitting updated information for storage in an electronic memory associated with said RFID tag,

13. A volatile dispensing system, comprising:

at least one container having a volatile,

a holder retaining said at least one container, and

an RFID tag controlling dispensing of said volatile.

14. The system of claim 13, wherein said volatile is a air freshener.

15. The system of claim 13, wherein said volatile is a fragrance.

16. The system of claim 13, wherein said at least one container is a plurality of containers, each container having an RFID tag, and further comprising a controller, said controller controlling which one of said plurality of containers is dispensed.

17. The system of claim 13, wherein said holder is a heater, said RFID tag is connected to said at least one container, and said RFID tag controls dispensing by initiating heating of said container.

18. The system of claim 17, wherein said RFID tag controls dispensing by communicating heating instructions to said heater.

19. A system for monitoring the age of an item, comprising

an RFID tag associated with said item,

a reader having a timer, said reader initializing said timer and displaying elapsed time since initiation when said RFID tag is in proximity to said reader.

20. The system of claim 19, wherein said item is a container, said RFID attached to said container.

21. The system of claim 19, wherein said item is a container, said RFID tag attached to a device designed for closing said container.

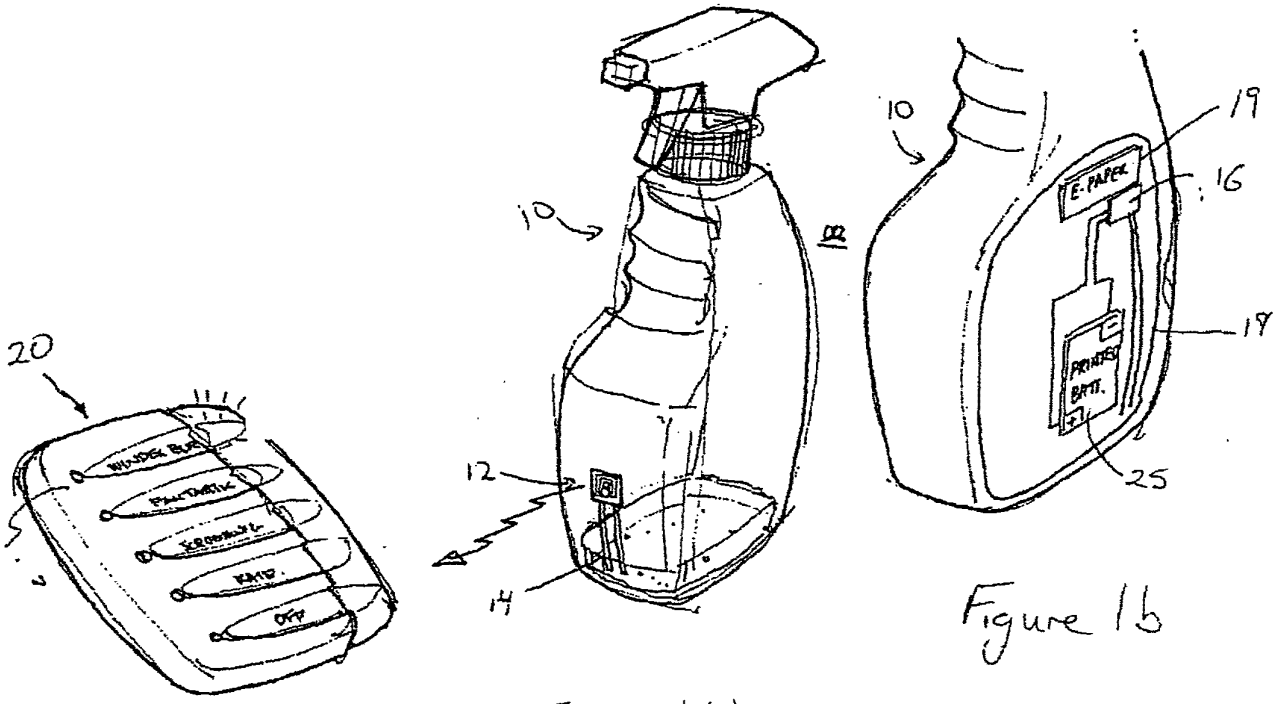


Figure 1(a)

Figure 1b

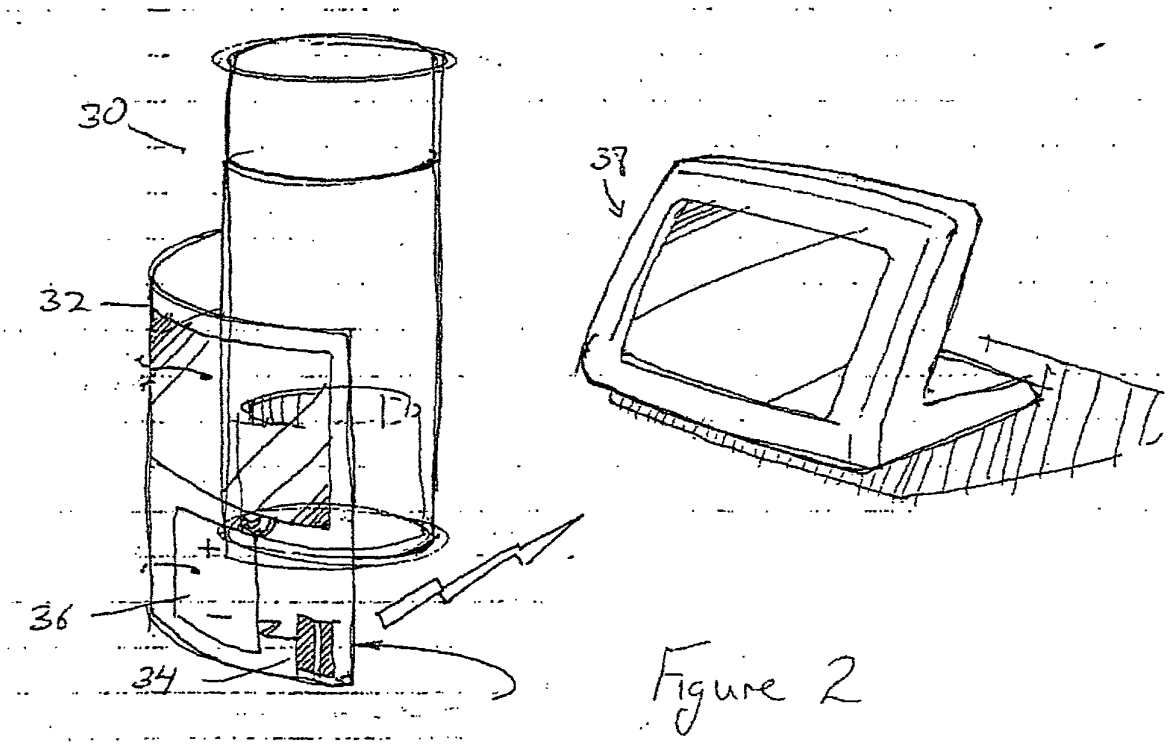


Figure 2

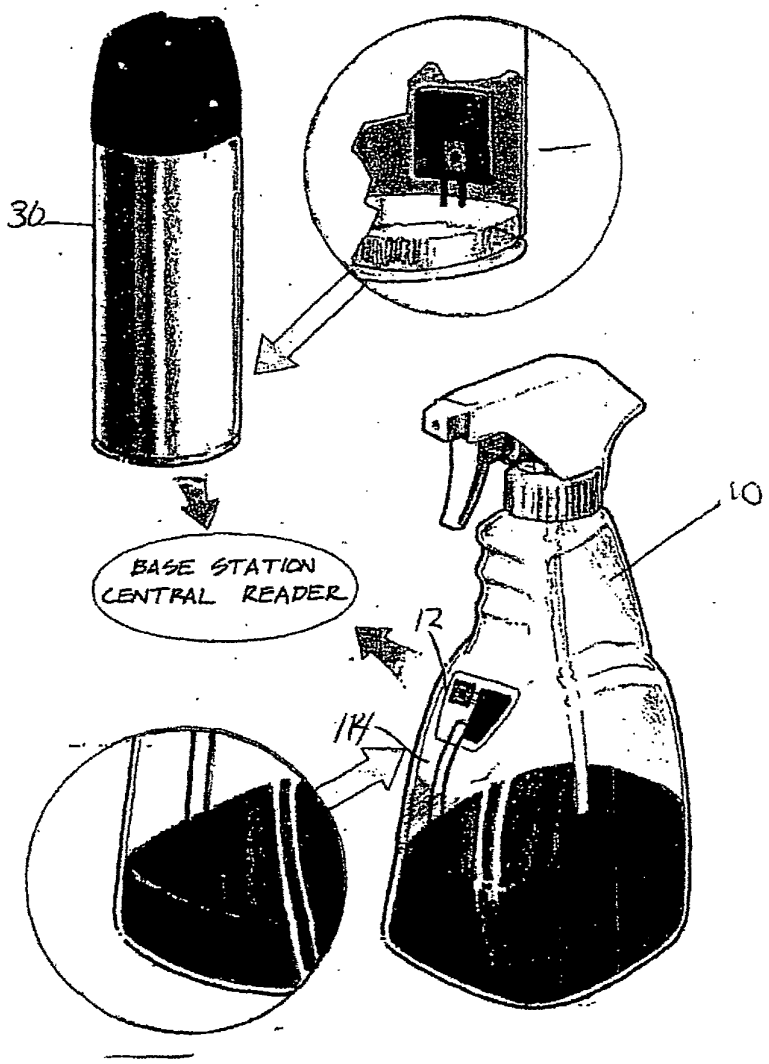


Figure 3

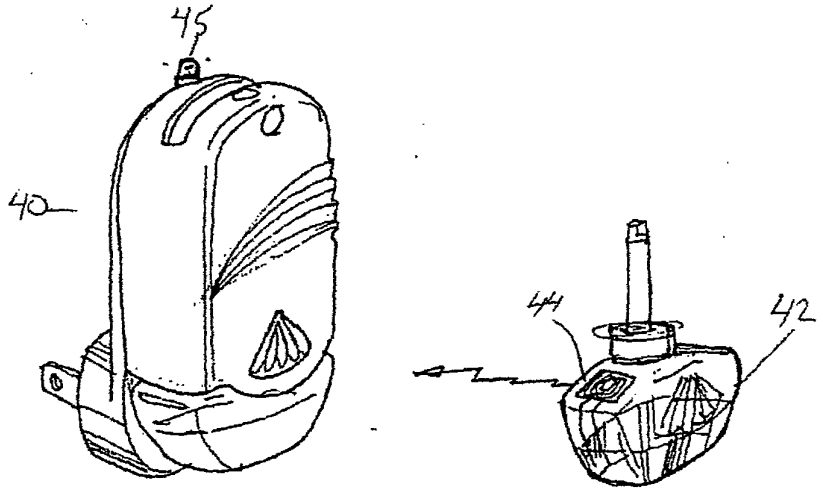


Figure 4a

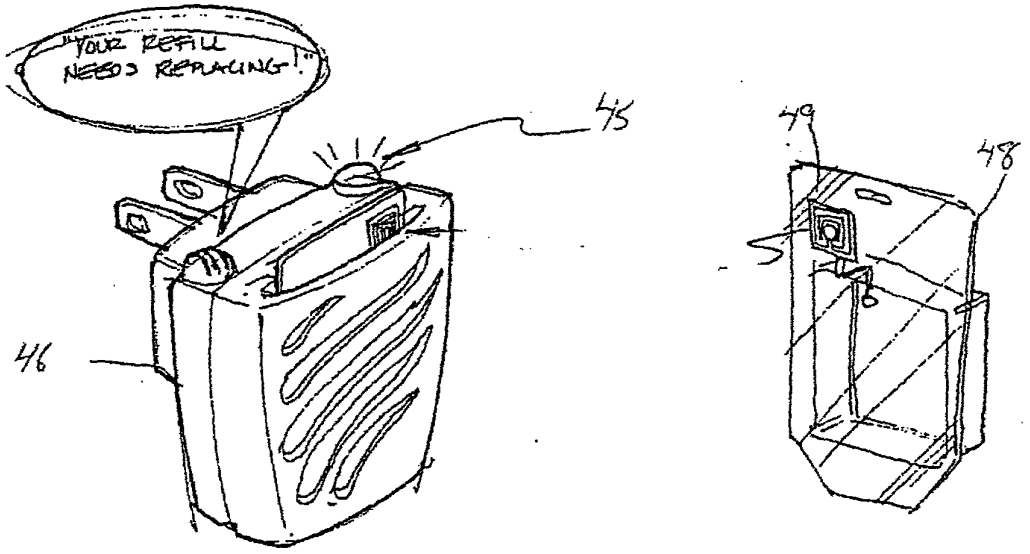


Figure 4b

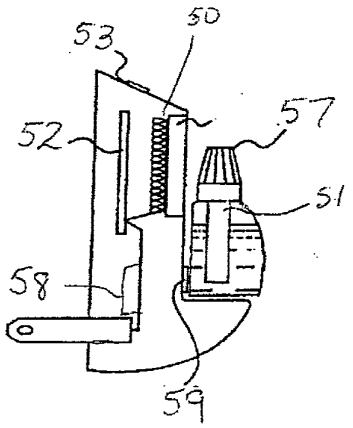


FIG. 5

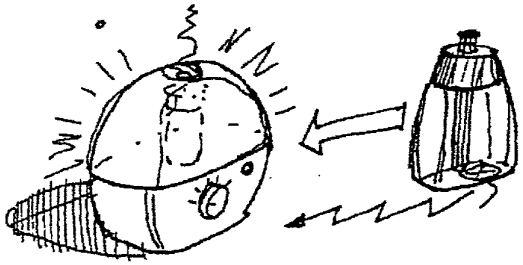


Figure 7

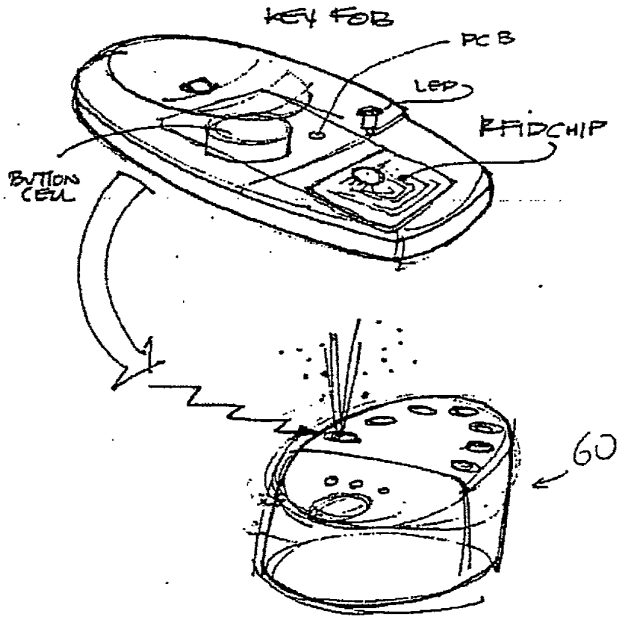


Figure 6

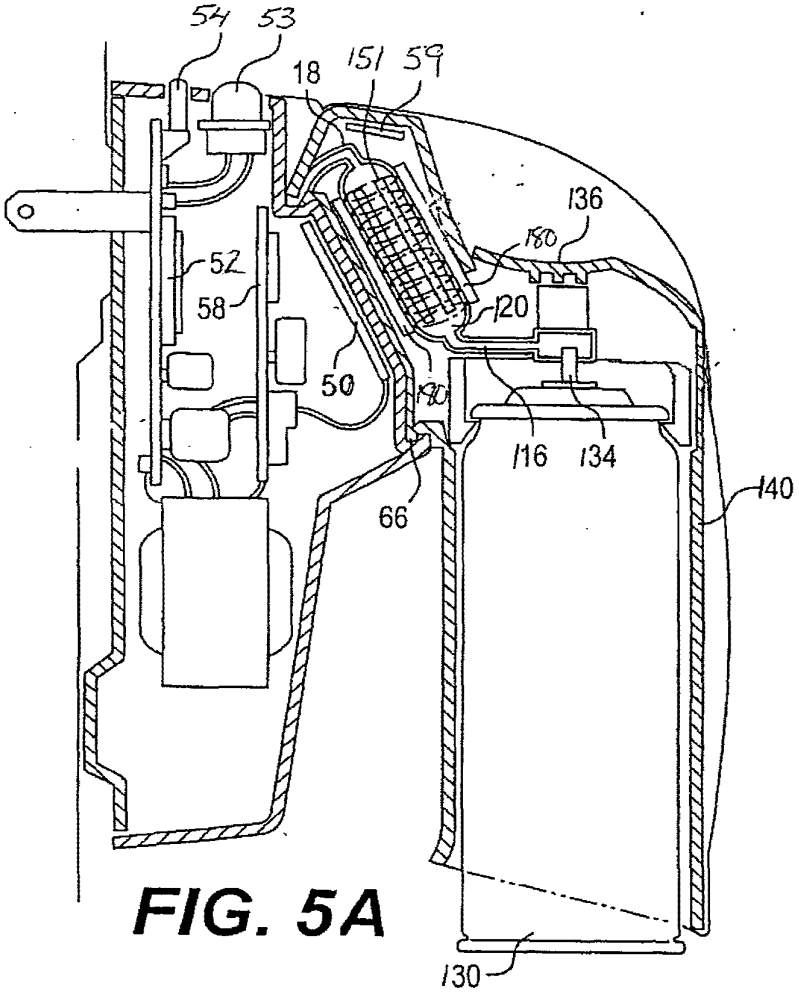


FIG. 5A

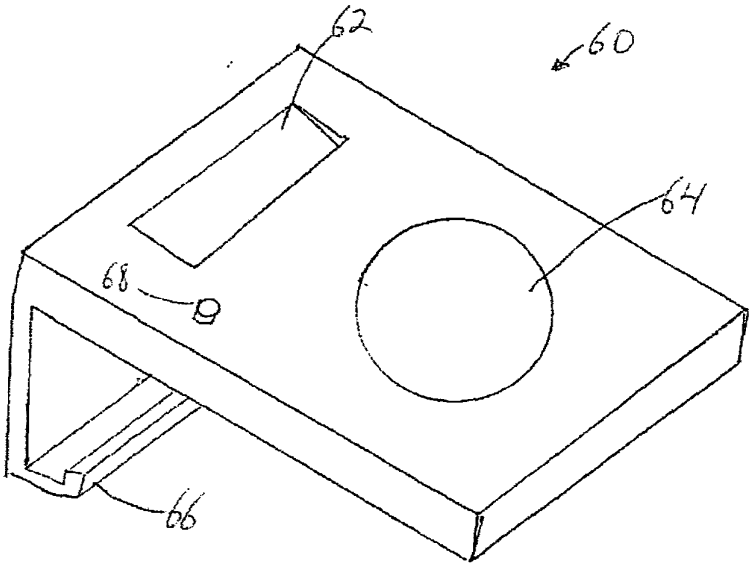


Figure 8

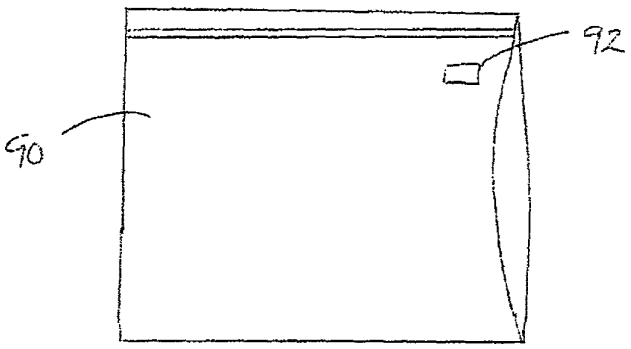


Figure 9

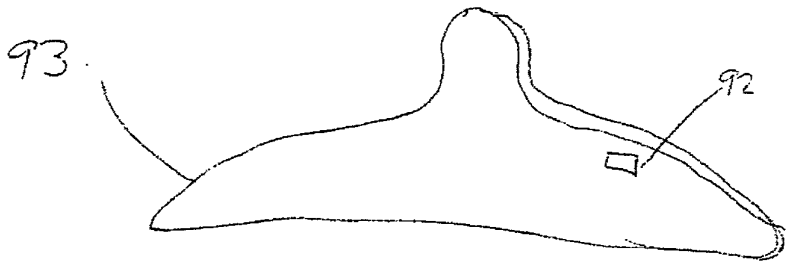


Figure 10

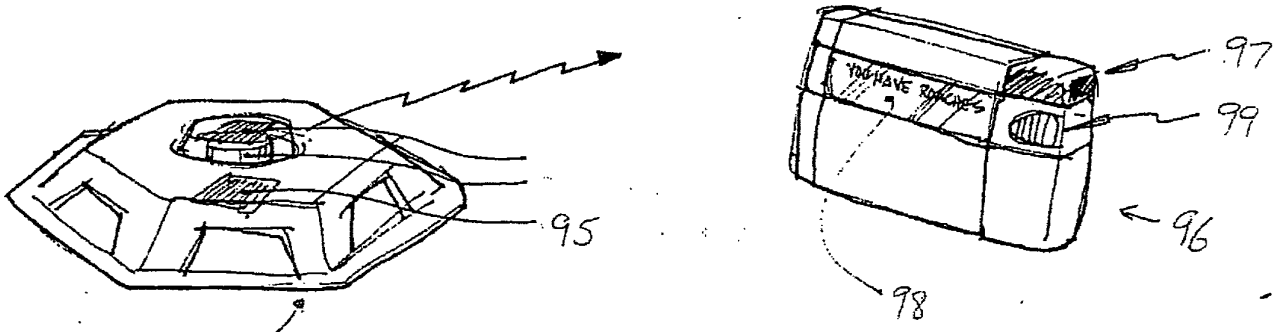


Figure 11

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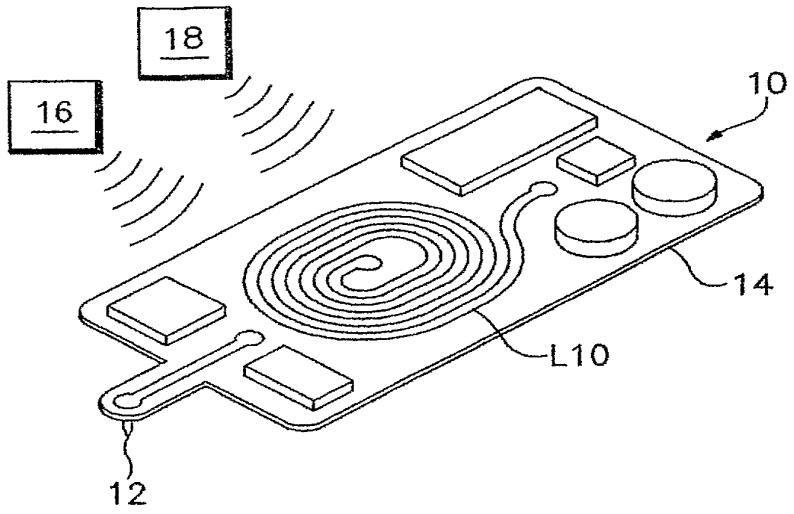
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(54) **Title:** INSERTABLE SENSOR ASSEMBLY HAVING A COUPLED INDUCTOR COMMUNICATIVE SYSTEM



(57) **Abstract:** A sensing system for determining the concentration of an analyte inside an animal body. The system includes an in vivo portion that is adapted to reside inside the animal body and that includes a sensing element that produces a sensing signal. In addition, a wearable ex vivo portion is physically attached to the in vivo portion. The ex vivo portion includes a first inductor that is adapted to receive a varying electro-magnetic signal and that has a pair of terminals. A variable load assembly presents a load across the pair of terminals and varies the load in response to the sensing signal. Also, an electronic monitoring unit is physically separate from the ex vivo portion and includes a second inductor, which is magnetically coupled to the first inductor and is adapted to transmit a varying electro-magnetic signal and to detect changes in load across the terminals of the first inductor.

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INSERTABLE SENSOR ASSEMBLY HAVING A COUPLED INDUCTOR COMMUNICATIVE SYSTEM

FIELD OF THE INVENTION

The invention is generally related to the field of percutaneous analyte sensors.

BACKGROUND ART

Implanted medical devices frequently include a wire coil that is used to receive an electromagnetic wave broadcast from outside the body. Often the transmitted signal is used for information content and to power the embedded device. Referring to FIGS. 1 and 2, which show a system under development that includes a few prior art features that will be discussed here, a system 10 that is currently being developed for the sensing of glucose relies on a very thin "wire" type sensing element 12 that is inserted into the patient's subcutaneous tissue for a few days to a few weeks, depending on the particularities of the implementation. The system 10 also includes an ex vivo portion 14 that is physically attached to the sensing element 12, but resides outside the body and may be adhered to the skin.

Another portion, referred to as the electronics monitoring unit 16 or "EMU," is in wireless communication with the ex vivo portion 14. The EMU 16 is typically quite a bit larger then the ex vivo portion 14 and may be worn by the patient by being suspended from his or her belt, or may be carried by the patient, for instance in a purse. The EMU 16 may be driven by standard AA batteries or by a rechargeable battery pack. It appears to be a commercial reality that smaller batteries have a higher cost per unit

of stored energy than do larger batteries. The EMU 16 would typically be located a little less than a foot away from the ex vivo portion.

A stationary EMU 18 may be made available for nighttime use. The stationary EMU 18 would be approximately the size of a clock radio and would be made to plug into a standard wall electrical outlet. Accordingly, the cost of electric power is inconsequential in the use of EMU 18, which may, consequently be placed as much as about 4 meters (13 feet) away from the ex vivo portion 14.

One problem encountered in the design of the ex vivo portion is the reduction of ex vivo portion size and the amelioration of any hard areas or objects that must be located on the ex vivo portion. In addition, the cost of the ex vivo portion should be as low as possible so that it will be practical to dispose of the ex vivo portion after a few days use. To achieve these goals it is desirable to reduce battery size on the ex vivo portion as much as possible.

Although electromagnetic coupling has been used for communications between an ex vivo device and an implantable device, this has typically been for actuators that communicate with an ex vivo transceiver only occasionally, or for instances in which the ex vivo portion can be retained directly on the other side of the skin from the in vivo portion. For example, U.S. Patent 6,015,386 describes a blood pressure measurement device having an implanted portion and an ex vivo portion that is strapped to the patient's wrist very near to the implanted portion. It appears that the movement of the device, caused by the pressure on the wall of a blood vessel, powers the implanted portion by causing changes in the inductance of

an implanted inductor. This inductor is coupled to an inductor in the ex vivo portion, which detects the changes in inductance.

DISCLOSURE OF THE INVENTION

In a first separate aspect, the present invention is a sensing system for determining the concentration of an analyte inside an animal body. The system includes an in vivo portion that is adapted to reside inside the animal body and that includes a sensing element that produces a sensing signal. In addition, a wearable ex vivo portion is physically attached to the in vivo portion. The ex vivo portion includes a first inductor that is adapted to receive a varying electro-magnetic signal and that has a pair of terminals. A variable load assembly presents a load across the pair of terminals and varies the load in response to the sensing signal. Also, an electronic monitoring unit is physically separate from the ex vivo portion and includes a second inductor, which is magnetically coupled to the first inductor and is adapted to transmit a varying electro-magnetic signal and to detect changes in load across the terminals of the first inductor.

In a second separate aspect, the present invention is an improvement to a biological sensing system that includes an in vivo portion, adapted to reside inside a patient, an ex vivo portion physically attached to the in vivo portion and having an antenna and an electronic monitoring unit that is physically separate from, but in wireless communication with, the ex vivo portion. The improvement is an electronic memory adapted to store memory contents in the ex vivo portion. Also, a transmitter in the electronic monitoring unit is adapted to transmit the

memory signal to the ex vivo portion, directing the ex vivo portion to transmit the memory contents to the electronic monitoring unit.

The foregoing and other objectives, features and advantages of the invention will be more readily understood upon consideration of the following detailed description of the preferred embodiment(s), taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram representation of an analyte sensing assembly, according to the prior art.

FIG. 2 is a side view of an analyte sensing patch that is a part of the assembly of FIG. 1.

FIG. 3 is a simplified schematic diagram of the electronics of an analyte sensing patch according to the present invention.

BEST MODE OF CARRYING OUT THE INVENTION

As described in the Background section, and as shown in FIGS. 1 and 2, in a preferred embodiment a glucose sensing and reporting assembly 10 includes an in vivo glucose sensing element 12 and an ex vivo portion 14, which transmits the data from sensing element 12 to an electronic monitoring unit 16. Together, elements 12 and 14 may be considered a glucose or analyte sensing patch.

In vivo portion 12 may be as described in U.S. Patent 5,165,407. This portion must have a voltage placed across it of 0.65 VDC and produces a sensor current that is generally proportional to the concentration of glucose in body tissue. A typical value for the sensor current is about 5-10 nanoAmps.

In FIG. 3, elements that could be the same as an element in FIGS. 1 or 2, are labeled with the same reference number as in FIGS. 1 or 2, plus 100. Referring to FIG. 3, ex vivo portion includes a 3 VDC battery 111 that drives a power supply U10. The 2.048 VDC output of power supply U10 is fed into a voltage divider 117 having a 0.65 VDC output that drives the noninverting input of an Op Amp U12. The output of Op Amp U12 provides feedback to the inverting input of Op Amp U12, by way of precision 10 MOhm resistor R10. Consequently, the inverting input of Op Amp U12 tracks the noninverting input, which is fixed at a 0.65 VDC reference, thus biasing the sensing element 112. Accordingly, the output of Op Amp U12 equals 0.65 VDC + 0.01*(sensing element current in nano Amps). If, for example, the sensing element current equals 5 nano Amps the output of U12 equals 0.70 VDC.

The op amp U12 output is fed into the input pin of microprocessor U14, which is preferably a Microchip model 16F676. Microprocessor U14 includes an internal analog-to-digital (A/D) converter 119, which converts the voltage at its input pin into a stream of 8 bit digital samples. A clock CL10 determines the rate at which microprocessor U14 operates. In one preferred embodiment, the clock CL10 is set at a rate of 32,768 Hz. The A/D converter 118, however, is operated only every 2 to 4 seconds when an internal counter of the microprocessor U14, which increments with every clock cycle, overflows. This activates an internal oscillator of the microprocessor U14, which then serves as a clock for the A/D, causing it to take one sample. A logic and switching unit 120 of microprocessor U14 averages or otherwise digital filters

the sample into an updated glucose measurement value, before microprocessor U14 returns to an inactive state.

Approximately once per minute, during the brief active period of microprocessor U14, a finished glucose measurement word is sent in serial form into the input pin of an asset identification ID chip U16, which stores the word in a memory subunit 122. A coil interface unit 124, that is part of chip U16, effectively transmits the word in serial form over coil L10, by altering the resistance placed between the terminals of coil L10.

ID chip U16 may be an ATMEL AT24RF08C. This chip includes a dual port 256 word memory and may either send or receive over the pins that are connected with the coil. Chip U16 is controlled by the microprocessor U14 to store data coming from microprocessor U14, so that this data will not be lost if the EMU 116 (or a stationary EMU 118) fails to receive the data. Also, commands from the EMU 116 are stored in chip U16 and are sent into microprocessor U14.

The use of an asset identification ID chip U16 as part of ex vivo portion 14 provides a number of advantages over other methods of providing data to the EMU 116. This type of chip is typically used to tag items in a store in order to prevent theft or to tag an item that is part of a collection of items for easy identification. This type of chip has even been used to tag pets, so that a pet can be easily identified if lost or stolen.

A first advantage of using an asset ID chip is that chip U16 does not require energy from any other part of ex vivo portion 14 to effectively communicate with EMU 116. Rather chip U16 captures enough energy from coil L10 to operate internally, in order to effect the changes in

resistance between the terminals of L10 that effectively transmit data to EMU 116.

Although chip U16 does require a small amount of energy to store data, the ability to store data greatly facilitates the EMU in saving energy, as a low EMU signal can generally be used for reading data from chip U16. The signal strength can be increased if it turns out that the EMU 116 did not provide enough energy to read the data from chip U16. Because the data is stored in chip U16, the data will still be available when the EMU 116 broadcasts with the requisite signal strength to read the data.

In the preferred embodiment, one glucose concentration measurement data word is created every minute. With this embodiment, using an ATMEL AT24RF08C for chip U16, 256 minutes (more than 4 hours) worth of data are stored. Accordingly, data could be stored and made available even in the event of an extended failure of EMU 116.

In one variant of this embodiment, microprocessor U14 is used to implement digital filtering of the data, so that the glucose concentration measurement word created every minute represents data collected over the entire minute interval. In another preferred embodiment, data words are formed more frequently than once per minute.

The Atmel AT24RF08C utilizes a 125 kHz frequency for communicating with the outside world. If this device were to be used for ID chip U16, then coil L10 would preferably be a ferrite-core inductor. If a different chip were to be used for asset ID chip U16, however, this could make possible the use of a higher frequency, making it more practical to implement coil L10 as an air core coil, as is shown in FIG. 1. In this embodiment the air core coil L10

is integrated into the flexible bandage structure that makes up the body of ex vivo portion 14 and is about two inches in diameter.

INDUSTRIAL APPLICABILITY

The invention generally finds industrial applicability in the production and providing of percutaneous analyte sensors.

The terms and expressions that have been employed in the foregoing specification are used as terms of description and not of limitation. There is no intention, in the use of such terms and expressions, of excluding equivalents of the features shown and described or portions thereof, it being recognized that the scope of the invention is defined and limited only by the claims which follow.

CLAIMS

1. A sensing system for determining the concentration of an analyte inside an animal body, said system including:

(a) an in vivo portion, adapted to reside inside said animal body and including a sensing element that produces a sensing signal;

(b) a wearable ex vivo portion physically attached to said in vivo portion, including:

(i) a first inductor adapted to receive a varying electro-magnetic signal and having a pair of terminals; and

(ii) a variable load assembly presenting a load across said pair of terminals and varying said load in response to said sensing signal; and

(c) an electronic monitoring unit that is physically separate from said ex vivo portion and includes a second inductor, which is magnetically coupled to said first inductor and adapted to transmit a varying electro-magnetic signal and to detect changes in load across said terminals of said first inductor.

2. The biological sensing system of claim 1, wherein said ex vivo portion also includes a battery.

3. The biological sensing system of claim 1, wherein said battery biases said sensing element.

4. The biological sensing system of claim 1, wherein said ex vivo portion also includes memory to store measurement values from said in vivo portion.

5. In a biological sensing system that includes an in vivo portion, adapted to reside inside a patient, an ex vivo portion physically attached to the in vivo portion and having an antenna, and an electronic monitoring unit that is physically separate from, but in wireless communication by way of electromagnetic signals with the ex vivo portion, an improvement comprising:

(a) electronic memory adapted to store memory contents in said ex vivo portion; and

(b) a transmitter in said electronic monitoring unit adapted to transmit a said electromagnetic signal to said ex vivo portion, directing said ex vivo portion to transmit at least a portion of said memory contents to said electronic monitoring unit.

6. The biological sensing system of claim 5 wherein said electronic monitoring unit includes a manual actuator adapted to permit a patient to enter a request for data and wherein said transmitter transmits a said electromagnetic signal requesting data to said ex vivo portion in response thereto.

7. The biological sensing system of claim 5 wherein said ex vivo portion is able to effectively transmit to said electronic monitoring unit by sequentially changing impedance across said antenna.

FIG.1

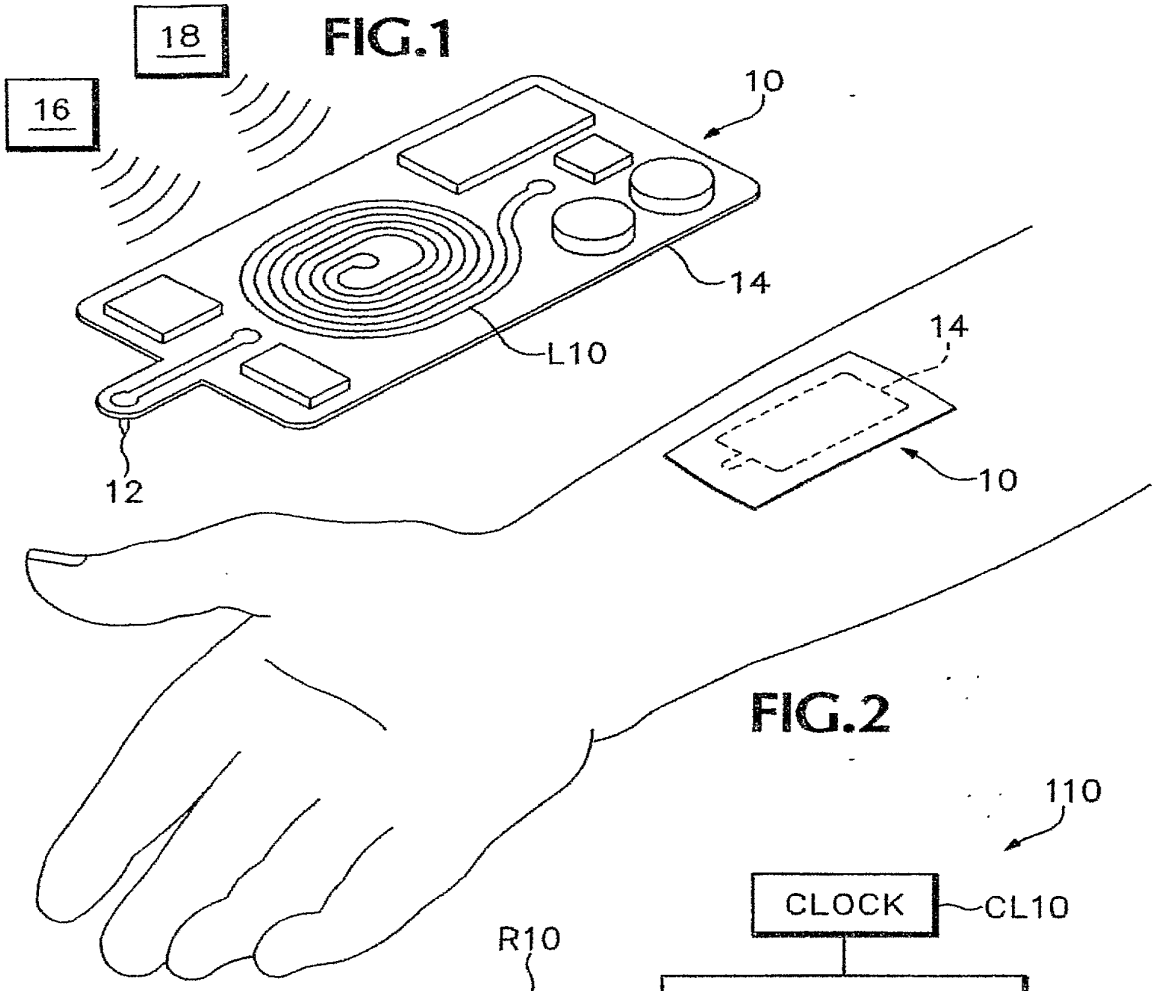


FIG.2

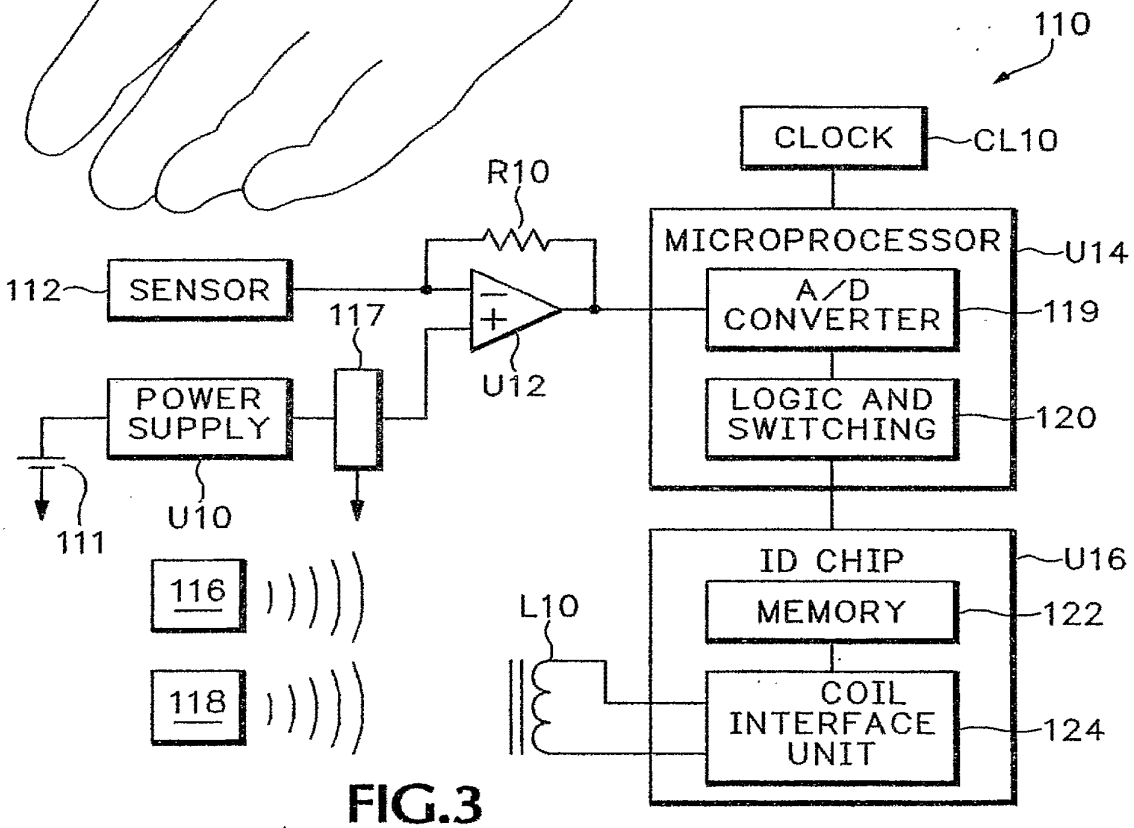


FIG.3

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Erklärungen gemäß Regel 4.17:

— *hinsichtlich der Berechtigung des Anmelders, die Priorität einer früheren Anmeldung zu beanspruchen (Regel 4.17 Ziffer iii)*

— *Erfindererklärung (Regel 4.17 Ziffer iv)*

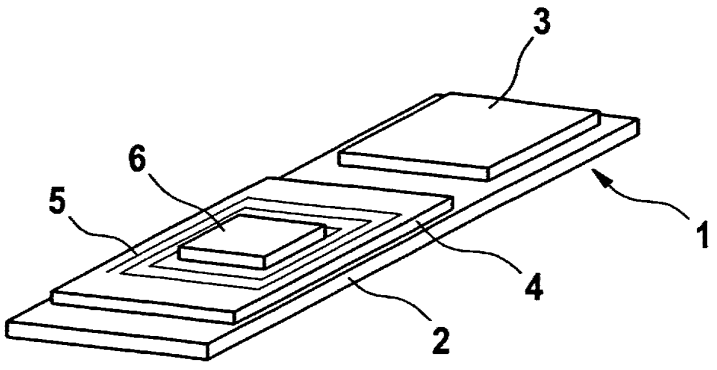
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(54) Title: ANALYTICAL TEST ELEMENT WITH WIRELESS DATA TRANSMISSION

(54) Bezeichnung: ANALYTISCHES TESTELEMENT MIT DRAHTLOSER DATENÜBERTRAGUNG



(57) Abstract: The invention relates to a system for determining the concentration of an analyte in a body fluid, which comprises an analytical test element and an implement which is separate from said test element. At least a part of the electrical components of the system are polymer electronic components. The analytical test element carries an area comprising an analytical chemical for detection of the analyte and a transponder for the wireless transmission of batch-specific data and/or measured values. The implement is provided with a reading module for the wireless transmission of data and power to the test element and an evaluation unit for evaluating the data or measured values received by the transponder.

(57) Zusammenfassung: Die Erfindung betrifft ein System zur Bestimmung der Konzentration eines Analyten aus einer Körperflüssigkeit, das ein analytisches Testelement und davon getrennt ein Instrument beinhaltet, wobei zumindest ein Teil der elektrischen Komponenten des Systems auf der Basis von Polymerelektronik ausgebildet ist. Auf dem analytischen Testelement befindet sich ein Bereich mit Nachweischemie zum Nachweis des Analyten sowie ein Transponder zur drahtlosen Übertragung von chargenspezifischen Daten und/oder Messwerten. Das Instrument weist ein Lesemodul zur drahtlosen Übertragung von Daten und Energie zum Testelement sowie eine Auswerteeinheit zur Auswertung der vom Transponder empfangenen Daten oder Messwerte auf.

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Analytisches Testelement mit drahtloser Datenübertragung

Beschreibung

Die vorliegende Erfindung betrifft ein System zur Bestimmung der Konzentration eines Analyten aus einer Körperflüssigkeit. Weiterhin betrifft die Erfindung ein Verfahren zur Herstellung eines solchen Systems.

Die Untersuchung von Körperflüssigkeiten ermöglicht in der klinischen Diagnostik das frühzeitige und zuverlässige Erkennen von pathologischen Zuständen sowie die gezielte und fundierte Kontrolle von Körperzuständen. Für einzelne Analysen, die gezielt auf einen Parameter gerichtet sind, werden heutzutage oftmals wenige Mikroliter bis hin zu weniger als einem Mikroliter Blut benötigt. Zur Blutgewinnung wird üblicherweise durch die Haut z. B. in die Fingerbeere oder das Ohrläppchen der zu untersuchenden Person mit Hilfe einer sterilen, scharfen Lanzette gestoßen. Diese Methode eignet sich insbesondere, wenn die Analyse der Blutprobe unmittelbar nach der Blutgewinnung durchgeführt werden kann.

Für die chemische und biochemische Analyse von Körperflüssigkeiten haben sich in den dafür spezialisierten Labors, aber insbesondere auch für den Einsatz außerhalb fester Labors trägergebundene Schnelltests etabliert. Basierend auf einer eigens entwickelten Trockenchemie sind solche trägergebundenen Schnelltests, trotz der oftmals komplexen Reaktionen unter Beteiligung empfindlicher Reagenzien, einfach und unkompliziert, selbst von Laien, durchzuführen. Prominentestes Beispiel für trägergebundene Schnelltests sind Teststreifen für die Bestimmung des Blutglukosegehalts bei Diabetikern.

Bei heute verwendeten diagnostischen Testen für den Nachweis eines Analyten (z. B. Blutglukose) in einer Körperflüssigkeit (z. B. Blut) sind die Funktion des Stechens zum Erzeugen einer Hautöffnung und die Nachweisfunktion üblicherweise auf mehrere Bauteile aufgeteilt, z. B. eine Stechhilfe zum Stechen und Erzeugen eines Bluttropfens, und ein analytisches Testelements, z. B. ein Teststreifen, für die Aufnahme des Bluttropfens, die Weiterleitung des Blutes von der Aufnahmestelle zum Nachweisbereich, und den Nachweis eines Analyten, z. B. der Blutglukose.

Vor allem im Bereich des so genannten "Home-Monitoring", also dort, wo medizinische Laien selbst einfache Analysen des Bluts durchführen, und dort insbesondere für die regelmäßige, mehrmals täglich durchzuführende Blutgewinnung durch Diabetiker für die Kontrolle der Blut-

BESTÄTIGUNGSKOPIE

glukosekonzentration, werden Lanzetten und dazu passende Geräte angeboten, die eine möglichst schmerzarme und verlässliche Blutgewinnung ermöglichen. Als Beispiele für Lanzetten und Stechhilfen seien die kommerziell erhältlichen Geräte (Stechhilfen) und Lanzetten Glucolet® der Bayer AG und Softclix® der Roche Diagnostics GmbH genannt. Solche Lanzetten und Geräte sind z. B. Gegenstand von WO 98/48695, EP 0,565,970, US 4,442,836 oder US 5,554,166.

Die eigenhändige Blutzuckerbestimmung ist heute eine weltweit verbreitete Methode in der Diabetes-Kontrolle. Blutzuckergeräte im Stand der Technik wie z. B. Accu-Chek Sensor® (von Roche Diagnostics) bestehen aus einem Messgerät, in das ein Testelement (Teststreifen) eingeführt wird. Der Teststreifen wird beispielsweise mit einem Blutstropfen in Kontakt gebracht, der zuvor mittels einer Stechhilfe aus der Fingerbeere gewonnen wurde. Das Blut wird auf dem Teststreifen in den Bereich transportiert, in dem sich die Nachweischemie befindet. Dort reagiert der gesuchte Analyt mit der Nachweischemie und generiert dabei ein messbares Signal, z. B. einen elektrischen Stromimpuls oder eine Farbänderung. Das Messsignal wird vom Messgerät ausgewertet und auf dem Display des Blutzuckergerätes wird dem Benutzer der aktuelle Blutzuckerwert angezeigt.

Stand der Technik

Für eine konsequente Überwachung des Blutzuckergehaltes ist es erforderlich, die Glukosemessung regelmäßig, beispielsweise mehrmals täglich, durchzuführen. Für jede Messung wird ein neuer Teststreifen benötigt, der in Vorratsdosen zu beispielsweise 50 Stück bereitgestellt wird. Hierbei ist zu beachten, dass die Teststreifen je nach Charge eine unterschiedliche Qualität und unterschiedliche Eigenschaften aufweisen können, die das Messergebnis beeinflussen. Es ist daher erforderlich, das Glukosemessgerät vor dem Einlegen des Messstreifens zu kalibrieren. Der Grund für diese Schwankungen liegt in unvermeidbaren Toleranzen während der Herstellung der Teststreifen sowie in der empfindlichen Nachweischemie. Um dies zu kompensieren, werden von jeder Produktionscharge umfangreiche Stichproben vermessen und daraus chargenspezifische Kalibrationsdaten ermittelt. Diese Daten werden zusammen mit den Teststreifen zum Kunden ausgeliefert, sind für diesen aber nicht sichtbar. Der Datensatz besteht aus einer Chargennummer und Werten die eine Korrekturfunktion beschreiben.

Es ist bekannt, dass der Vorratsbehälter eine aufgedruckte Nummerncodierung enthält, die über eine entsprechende Eingabeeinheit am Glukosemessgerät eingegeben werden muss, um das Glukosemessgerät auf die in dieser Vorratsdose befindlichen Teststreifen einzustellen. Weiterhin

ist bekannt, dass eine Filmfolie jeder Teststreifenpackung beiliegt. Die transparente Filmfolie enthält einen Barcode, der binär codiert die Koeffizienten eines Polynoms n-ter Ordnung enthält. Bei den Glukosemessgeräten Accu-Chek Compact© und Accu-Chek Comfort© von der Roche Diagnostics GmbH beispielsweise wird den Teststreifen ein elektronisches Speichermedium, ein sog. ROM Key, beigelegt, auf dem ein kompletter Satz der Koeffizienten eines Polynoms gespeichert ist (siehe US 5,053,199). Dieser ROM Key wird in das Messgerät eingesteckt, die Daten werden vom Messgerät aus dem Speicherchip gelesen und zur Korrekturrechnung verwendet. US 6,689,320 beschreibt ebenfalls einen elektronischen Datenträger, der allerdings in einem sog. Code Carrier in das Messgerät eingelegt wird; die Daten werden hierbei mit einem Transponder übertragen.

Allen vorgenannten Kalibriermethoden ist gemeinsam, dass der Anwender eine Vielzahl von Schritten durchführen muss, um das Glukosemessgerät auf die Teststreifen-Charge zu kalibrieren. Es besteht die Gefahr, dass bei der manuellen Eingabe Fehler auftreten, oder dass das Einlesen des Speicherchips oder das Einlegen der Filmfolie mit dem Chargen-Code vergessen wird. Insbesondere, wenn der Anwender mehrere Dosen mit Teststreifen verwendet, besteht die Gefahr, dass eine Kalibrierung des Glukosemessgeräts auf die aktuell verwendete Teststreifencharge unterbleibt. Zur Vermeidung dieses Risikos wird heutzutage meist zusätzlich zu dem externen Datenspeicher, der die Kalibrationsdaten enthält, auf die Teststreifen selbst eine Chargenidentifikation in Form eines Barcodes oder Magnetstreifens aufgebracht. Darüber hinaus muss besonders darauf geachtet werden, dass trotz der getrennten Logistik von Teststreifen und Datenträger sicher gestellt ist, dass die richtigen Korrekturwerte den Teststreifen beigelegt werden.

Eine Methode, die erwähnte Verwechslungsgefahr zu vermeiden, besteht darin, die gesamten Kalibrationsdaten direkt mit dem Teststreifen zu verbinden. Der Teststreifen für das Reflochek© von der Roche Diagnostics GmbH beispielsweise hat einen Barcode aufgedruckt, und auf den Reflotron©-Streifen (Roche Diagnostics GmbH) ist ein Magnetstreifen aufgeklebt.

Im Zuge der Entwicklung hin zu immer kleineren Teststreifen und gleichzeitig immer mehr Kalibrationsdaten stößt jedoch die Datenkapazität entsprechend verkleinerter Barcode- oder Magnetstreifen an ihre Grenzen.

DE 102 37 602 beschreibt daher ein System zur Blutglukosemessung, bei der auf dem Teststreifen selbst ein Datenträger mit ausreichender Kapazität vorhanden ist, um alle erforderlichen Daten

darauf zu speichern. Die Kalibriereinheit in diesem Blutglukosemess-System besteht aus einer Empfangseinheit, die mit einer Sendeeinheit auf dem Testträger zusammenwirkt, um drahtlos ein Signal zu übermitteln, das die Qualität und/oder die Eigenschaften des Teststreifens wiedergibt. Durch diese drahtlose und berührungslose Übermittlung der Kalibrationsdaten wird erreicht, dass der Anwender keine zusätzlichen Schritte zur Kalibrierung auf den aktuell verwendeten Teststreifen durchführen muss. Es ist lediglich erforderlich, dass der Testträger in die Nähe des Messgeräts gehalten wird, was z. B. beim Einschieben in das Messgerät der Fall ist. Die Empfangseinheit und die Sendeeinheit bilden hierbei ein sog. Transpondersystem.

R. Puers beschreibt ein Transpondersystem, das in orthopädischen Implantaten eingesetzt wird (Linking sensor systems with telemetry: impact on the system design; Sensors and Actuators (1996) 169-174).

Als ein Beispiel für eine Übertragung analoger Daten beschreibt J. Black et al. einen implementierbaren amperometrischen Glukosesensor mit integrierter Telemetrieeinheit (Integrated sensor-telemetry system for in vivo glucose monitoring; Sensors and Actuators (1996) 147-153).

In WO 031 00942 ist ein Herzschrittmacher beschrieben, der seine Energie über einen Transponder von einer extrakorporalen Batterieeinheit erhält. Im Gegenzug sendet der Herzschrittmacher seinen Ladezustand nach außen.

US 6,217,744 betrifft ein Disposable zur Blutglukosemessung, das seine Messdaten über einen Transponder zum Informationsgerät überträgt, wobei die Blutprobe selbst als Elektrolyt für die Batterie in dem Disposable dient.

Ein Transpondersystem umfasst ein Lesesystem, das hier der Empfangseinheit im Instrument entspricht, und den eigentlichen Transponder, in diesem Fall die Sendeeinheit auf dem Teststreifen. Vom Lesesystem wird die für die Messung notwendige Energie in den Teststreifen eingebracht, d. h. der Teststreifen besitzt keine eigene Stromversorgung. Die Sendeeinheit auf dem Teststreifen sendet im Gegenzug die gespeicherten Kalibrationsdaten sowie die Messsignale der aktuellen Messung an das Messgerät. Die Transponder werden üblicherweise mit Mikroprozessoren in Siliziumtechnologie realisiert. Auch wenn die Produktionskosten für Siliziumchips in den letzten Jahren aufgrund von Miniaturisierung, Integration und Optimierung der Herstellprozesse deutlich gesunken sind, sind sie dennoch immer noch so hoch,

dass sie eine Messung unverhältnismäßig verteuern würden, wenn jeder einzelne Teststreifen, der nach einer einzigen Messung verworfen wird, mit einem solchen Siliziumchip ausgestattet wäre.

Beschreibung der Erfindung

Die Erfindung beschreibt ein System, das sicherstellt, dass bei jeder Messung vertauschungssicher die korrekten Kalibrationsdaten verwendet werden. Darüber hinaus wird die Qualität der Messwerte verbessert, indem die Messwertgenauigkeit durch einen verbesserten Messaufbaus erhöht wird.

Die vertauschungssicheren Kalibrationsdaten werden dadurch gewährleistet, dass auf jedem Teststreifen die Chargenkennung und die Kalibrationsdaten gespeichert sind. Um die erforderliche Datenmenge zu speichern und auf das Messgerät zu übertragen, wird die eingangs erwähnte Transpondertechnologie verwendet. Insbesondere werden hierbei die elektrischen Komponenten auf dem analytischen Testelement zumindest teilweise auf der Basis von Polymerelektronik ausgebildet.

Die Qualität der Messwerte wird erfindungsgemäß dadurch erhöht, indem das elektrochemische Messsystem nach außen galvanisch isoliert wird. Für diese galvanische Trennung wird die eingangs erwähnte Transpondertechnologie verwendet. Insbesondere werden die elektrischen Komponenten auf dem analytischen Testelement zumindest teilweise auf der Basis von Polymerelektronik ausgebildet.

Es wurde gefunden, dass die erfindungsgemäße Anwendung der Transpondertechnologie auf Systeme zur Bestimmung eines Analyten aus einer Körperflüssigkeit unter Nutzung der Polymerelektronik besonders vorteilhaft ist.

Die Polymerelektronik basiert auf der Tatsache, dass bestimmte Polymere (z. B. Pentacen, Polythiophen) halbleitende Eigenschaften besitzen und somit elektronische Schaltkreise realisiert werden können. So kann beispielsweise ein binärer Datenspeicher direkt in das Substrat eines Teststreifens eingebracht werden (Vom organischen Transistor zum Plastik-Chip, Physik Journal 2 (2003) Nr. 2, S. 31-36). Hierbei werden durch punktuelles Anlegen elektrischer Felder je nach Polarität, räumlich diskrete Zonen entweder niederer oder hoher Leitfähigkeit durch das leitfähige Polymersubstrat hindurch, erzeugt. Nach Entfernen der Spannung bleibt der Zustand erhalten. Durch Umpolen der elektrischen Spannung kann der Zustand wieder rückgängig

gemacht werden. Es sind somit Schreib/Lesevorgänge und Speicherung von Informationen wie Chargennummern und Korrekturkurven direkt auf dem Testsubstrat möglich. Die punktuellen Felder werden beispielsweise durch das Anlagen von Spannung an Spalten- und Zeilenleitungen mittels einer Decoderschaltung, vorzugsweise aus halbleitenden Polymeren, gebildet (Polymer Memory, Technology Review September 2002, S. 31). Darüber hinaus können auch weitere Bauteile die zur Realisierung elektrischer Transponderfunktionen notwendig sind (Transistoren, Dioden, Widerstände, Kondensatoren, Spulen, Leitungen, Kontakte) mit leitfähigen Polymeren unmittelbar auf dem Teststreifen realisiert werden (Fast polymer integrated circuits, American Institute of Physics 2002, S. 1735-1737).

Für diese neue Technologie werden Begriffe wie Integrated Plastic Circuits (IPC), organische Elektronik, Polytronik, Electronic Plastic, organische Halbleiter oder Conductive Polymers oft synonym verwendet. Diese Polymere lassen sich beispielsweise durch einfache Drucktechniken, wie Offset-, Tampon-, Siebdruck oder auch Technologien ähnlich dem Laser- oder Tintenstrahldruck, aufbringen, z. B. unter Verwendung von Polymeren in Lösung (sog. elektronischer Tinte). Diese Technik ist insbesondere bei Anwendung auf flache Trägerfolien vorteilhaft, wie sie üblicherweise bei analytischen Testelementen der Fall ist. Da zudem Druck- und Laminiertechniken bereits für die Herstellung analytischer Testelemente routinemäßig eingesetzt werden, lässt sich die Polymerelektronik ohne großen Aufwand in den vorhandenen Produktionsablauf integrieren. Beispielsweise ist in DE 102 53 154 beschrieben, wie die Elektronik für ein komplettes Blutglukose Messsystem im Kreditkartenformat, bestehend aus Messeinheit und Biosensor, in einem einzigen drucktechnischen Prozess in Polymerelektronik aufgebracht wird.

Üblicherweise werden Teststreifen in so genannten Endlos-Prozessen (Rolle-zu-Rolle Prozessen) produziert. Die Rollen werden anschließend zu Teststreifen vereinzelt und in Verpackungseinheiten (Dosen, Magazine) abgefüllt. Gleichzeitig werden von jeder Produktionscharge Stichproben gezogen und validiert. Die ermittelten Abweichungen von den Sollwerten werden über einen Algorithmus in einen Datensatz gewandelt und auf einem Datenträger gespeichert. Die verpackten Teststreifen werden mit den Datenträgern zusammengeführt und konfektioniert ausgeliefert.

Der erfindungsgemäße Einsatz der Transpondertechnologie in Kombination mit der Polymerelektronik ermöglicht das Aufbringen eines Transponders auf das analytische Testelement in einem einfachen und leicht in eine Rolle-zu-Rolle Produktion integrierbaren

Prozessschritt. Darüber hinaus ist ein Transponder aus Polymerelektronik extrem kostengünstig herstellbar, was insbesondere bei Einzelmessstreifen, die nach einmaligem Gebrauch verworfen werden, von großer Bedeutung ist. Die Erfindung ermöglicht es, die analytischen Testelemente während des Rolle-zu-Rolle Prozesses mit einer Chargenidentifikation zu versehen, und den vereinzelten und verpackten Testelementen berührungslos die Kalibrationsdaten aufzuspielen. D. h. das Speichern der Kalibrationsdaten auf einen gesonderten Datenträger und das Sicherstellen des korrekten Konfektionierens der Teststreifen mit dem entsprechenden Datenträger entfallen. Über das Transpondersystem können sowohl Daten auf das analytische Testelement aufgespielt als auch auf dem Testelement gespeicherte bzw. während der Messung generierte Daten abgefragt werden.

So können beispielsweise im Produktionsprozess zunächst die Chargennummern der in einer Verpackungseinheit abgefüllten Testelemente von einer speziellen Leseeinheit abgefragt werden. In der Leseeinheit sind die Kalibrationsdaten zu den dazugehörigen Chargennummern gespeichert. Die Leseeinheit wählt die passenden Kalibrationsdaten aus und überträgt diese auf die Testelemente. Zur Kontrolle ob die Kalibrationsdaten korrekt übertragen wurden, können abschließend die gespeicherten Daten abgefragt werden. Hierbei kann beispielsweise die Anzahl der Antwort-Signale zur Kontrolle dienen, ob die korrekte Teststreifenanzahl verpackt wurde und ob alle Teststreifen den korrekten Datensatz gespeichert haben. Zusätzlich ist es denkbar, die analytischen Testelemente neben der Chargen- auch noch mit einer eindeutigen Identifikationsnummer zu versehen, um so gezielt jeden einzelnen Teststreifen beschreiben und abfragen zu können. Auf diese Weise stellt das erfindungsgemäße Verfahren sicher, dass bei jeder Messung die korrekten Kalibrationsdaten verwendet werden und eine Vertauschung, sowohl während der Konfektionierung in der Produktion als auch in der Anwendung beim Kunden, ausgeschlossen wird.

Bei den chargenspezifischen Kalibrationsdaten kann es sich beispielsweise um eine komplette Kalibrationskurve handeln, oder es werden bestimmte Stützstellen festgelegt, an die ein festgelegter und beispielsweise im Instrument hinterlegter Kurvenverlauf angepasst wird. Darüber hinaus kann die Kalibrationskurve als eine Polynomfunktion dargestellt werden, wobei beispielsweise entweder die gesamte Funktion oder, bevorzugterweise, die Variablen des Polynoms als chargenspezifische Kalibrationsdaten dienen, während die Polynomfunktion im Instrument abgelegt ist. Der Kurvenverlauf bzw. die Polynomfunktion können auch statt direkt im Instrument auf einem ROM Key abgespeichert sein, der dem Instrument beiliegt und vom Kunden in das Instrument eingesteckt wird. Falls zu einem späteren Zeitpunkt der Kurvenverlauf

angepasst werden muss, beispielsweise bei Einführung einer neuen Teststreifengeneration mit leicht verändertem Messverhalten, kann durch einen einfachen Austausch des ROM Key das Instrument daran angepasst werden.

In einer bevorzugten Ausführungsform sind die chargenspezifischen Kalibrationsdaten auf dem analytischen Testelement bzw. auf dessen Verpackung gespeichert und der Kurvenverlauf der Kalibrationskurve ist, beispielsweise in Form einer Polynomfunktion, im Instrument gespeichert. Eine alternative Möglichkeit besteht darin, dass auf einem ROM Key mehrere Kalibrationskurven, beispielsweise unter verschiedenen Kennnummern, gespeichert sind und auf den Teststreifen ist die Kennnummer der zu dieser Charge passenden Kalibrationskurve gespeichert.

Ein weiteres Merkmal der erfindungsgemäßen Kombination von Transpondertechnologie und Polymerelektronik besteht in der Möglichkeit einer Verbesserung der Messtechnik auf dem analytischen Testelement. Das Messen elektrochemischer Größen beruht im Wesentlichen auf elektrolytischen Prozessen oder Elektronenbeweglichkeiten in flüssigen Phasen. Werden in einem gemeinsamen Flüssigkeitskreis mehrere elektrochemische Sensorsysteme verwendet, werden diese zwangsläufig durch gemeinsame elektrische Schaltkreise wie Spannungsversorgung und Masseleitungen, oder parasitäre Leitungsmechanismen elektrolytisch oder elektrisch undefiniert verbunden. In der Regel handelt es sich bei elektrochemischen Messungen um Gleichstrom- oder niederfrequente Prozesse, d. h. es sind im Wesentlichen galvanische, also stromleitende, Mechanismen. die zu Fehlerströmen führen, die einerseits die Messwerte, und andererseits die chemische Reaktion selbst verfälschen können. Um diese Problematik zu umgehen, bedient man sich heutzutage oft aufwendiger Trennverstärker. Hierbei werden die elektrochemischen Messsysteme soweit getrennt, dass nur die Verbindung über den unvermeidlichen flüssigen, elektrochemischen Pfad selbst besteht. Durch diese "Einfachverbindung" ist kein überlagerter Stromkreis vorhanden, über den parasitärer elektrischer Strom fließen kann. Heutzutage übliche transformatorische Trennverstärker sind meist teuer, da kleine Gleichgrößen (Strom, Spannung) aufwendig in Wechselgrößen überführt werden müssen. Für ein solches analytisches Testelement müsste eine zum restlichen System galvanisch getrennte zusätzliche Stromquelle bereitgestellt werden. Dies sind meist Batterien oder transformatorisch getrennte Netzteile, die eine relativ große Baugröße aufweisen. Alternativ zu elektrischen Trennverstärkersystemen gibt es auch optische Trennsysteme. Hierbei werden nach dem opto-elektrischen Prinzip die als elektrische Gleichgrößen gewonnenen Messwerte mit Lichtschranken übertragen. Bei optischen

Trennsystemen kann jedoch die Versorgungsenergie nur in Grenzen und mit relativ schlechtem Wirkungsgrad übertragen werden.

Es wurde gefunden, dass anstelle von Trennverstärker insbesondere auch Transponder geeignet sind, um elektrische Systeme galvanisch zu trennen. Die erfindungsgemäße Kombination von Transpondertechnologie und Polymerelektronik ermöglicht die Bereitstellung eines kostengünstig in großer Stückzahl herstellbaren analytischen Testelements, bei dem durch galvanische Entkopplung parasitäre Kriechströme vermieden werden. Insbesondere die geforderte Übertragung kleiner Messwerte bei hohen Potentialunterschieden ist mit Transpondern ohne Potentialverschleppungen möglich. Hierbei wird die Energie in Form einer Wechselspannung transformatorisch nach dem Induktionsprinzip von dem im Instrument befindlichen Lesemodul drahtlos und berührungslos zum auf dem analytischen Testelement befindlichen Sendemodul übertragen. Besonders die flachen, auf Folien aufgebrachten Aufbaustrukturen der Polymerelektronik ermöglichen eine gute, lineare magnetische Übertragung der Signale über die Transformatorspulen. Die Energie setzt die Messung auf dem analytischen Testelement in Gang. Das elektrische Messsignal wird zunächst als Gleichgröße (Strom oder Spannung) gewonnen, anschließend in eine Wechselgröße gewandelt und dann induktiv zum Instrument übertragen, beispielsweise durch magnetische Feldkopplung im Nahfeld, indem das Signal auf eine Trägerfrequenz aufmoduliert wird. Das erfindungsgemäße System ermöglicht daher eine kontaktlose, bidirektionale Datenübertragung.

Mit Polymerelektronik aufgebrachte Übertragungsspulen können extrem nah neben- bzw. übereinander liegen, etwa in einem Abstand von 0,1 mm. Dies ermöglicht den Einsatz kleiner Spulenabmessungen, was insbesondere im Zuge der Miniaturisierung der analytischen Testelemente von Vorteil ist. Mit der Technologie der Polymerelektronik können nicht nur planare Strukturen, sondern durch den Einsatz mehrere Layer dreidimensionale Strukturen wie die eines Feldeffekttransistors aufgebracht werden (Organic field-effect transistors – the breakthrough at last, Chemphyschem 2001, 2, 163-165).

Die Erfindung betrifft ein System zur Bestimmung der Konzentration eines Analyten in einer Körperflüssigkeit, das ein analytisches Testelement und davon getrennt ein Instrument beinhaltet, wobei zumindest ein Teil der elektrischen Komponenten des analytischen Testelements auf der Basis von Polymerelektronik ausgebildet ist. Auf dem analytischen Testelement befindet sich ein Bereich mit Nachweischemie zum Nachweis des Analyten und das Instrument weist eine Auswerteeinheit zur Auswertung von Daten auf.

Eine bevorzugte Ausführungsform der Erfindung betrifft ein oben beschriebenes System, wobei sich auf dem analytischen Testelement ein Sendemodul zur drahtlosen Übertragung von Daten befindet und das Instrument ein Lesemodul zur drahtlosen Übertragung von Daten aufweist. Sendemodul und Lesemodul arbeiten nach der eingangs beschriebenen Transpondertechnologie.

Das erfindungsgemäße System umfasst die Komponenten, die zur Bestimmung der Konzentration eines Analyten in einer Körperflüssigkeit notwendig sind. Minimal beinhaltet das System ein analytisches Testelement mit Nachweischemie und ein Instrument mit Auswerteeinheit. Insbesondere kann das System darüber hinaus beispielsweise eine Stechhilfe und eine Anzeigeeinheit umfassen, wobei diese beiden Komponenten sowohl in Testelement bzw. Instrument integriert als auch eigenständige Einheiten sein können.

Mit Analyt ist ein Bestandteil der Körperflüssigkeit gemeint, der im Nachweisbereich mit der Nachweischemie reagiert, so dass – ab einer gewissen Menge des Analyten – die Reaktion in einer Messanordnung gemessen werden kann. Eine bevorzugte Ausführungsform besteht darin, Blut als Probenflüssigkeit zu verwenden und Blutglukose als Analyt im Nachweisbereich nachzuweisen und daraus die Konzentration der Blutglukose zu ermitteln.

Neben Blut sind auch interstitielle Flüssigkeit und andere körpereigene Flüssigkeiten als Körperflüssigkeiten möglich. Ebenfalls ist es möglich, nicht nur einen Analyten, z. B. Blutglukose, sondern auch mehrere Analyten, z. B. HbA1C, nachzuweisen, und dies sowohl aus einer Körperflüssigkeit, z. B. Blut, als auch aus einem Gemisch mehrerer Körperflüssigkeiten, z. B. Blut plus interstitielle Flüssigkeit, durchzuführen.

Unter einem analytischen Testelement ist jede Form von trägergebundenen Schnelltests für die Diagnostik zu verstehen, insbesondere Schnelltests in Streifenform, sog. Teststreifen, hierbei insbesondere zur Bestimmung des Blutglukosegehalts bei Diabetikern.

Das Instrument bezeichnet den Teil des Systems, der die Messsignale, die im analytischen Testelement erzeugt werden, empfängt und in der Auswerteeinheit auswertet. Das Instrument kann außerdem eine Halterung enthalten, in der ein analytisches Testelement oder eine Verpackung für ein oder mehrere Testelemente, z. B. ein Container oder ein Magazin, positioniert wird. Darüber hinaus kann auch eine Anzeigeeinheit, z. B. ein LCD Display, in das

Instrument integriert sein. Üblicherweise stellt das Instrument ein batteriebetriebenes Handgerät dar.

Heutzutage werden häufig die elektrischen Leitungen und Kontakte auf dem analytischen Testelement in Gold oder ähnlich inerten Metallen ausgeführt und z. B. durch Laserablation strukturiert abgetragen. Erfindungsgemäß können die Leiterbahnen und Kontakte anstelle von Metall auch in Polymerelektronik ausgeführt werden. So kann beispielsweise ein heute auf dem Markt verfügbarer Teststreifen mit Goldkontakten und einem Datenträger (z. B. einem Magnetstreifen bzw. Barcode) zur Streifenidentifikation durch ein analytisches Testelement ersetzt werden, bei dem die elektrischen Leitungen und Kontakte durch Polymerelektronik-Leiterbahnen und -Kontakte ausgebildet sind. Bevorzugter Weise ist die Streifenidentifikation in einem Polymerelektronikspeicher abgelegt. In besonders bevorzugter Weise befindet sich auf dem analytischen Testelement auch ein Polymerelektronik-Transponder zum Beschreiben und Auslesen des Speichers. Selbstverständlich ist es auch möglich, nur die Goldkontakte oder nur den Datenträger durch Polymerelektronik zu ersetzen.

Erfindungsgemäß kann die Polymerelektronik sowohl auf dem Testelement als auch im Instrument verwendet werden. In einer bevorzugten Ausführungsform sind ein Teil oder auch alle elektrischen Komponenten auf dem analytischen Testelement auf der Basis von Polymerelektronik ausgebildet und im Instrument ist die Elektronik in konventioneller Technologie realisiert.

Das Sendemodul auf dem analytischen Testelement dient als Transponder, auf dem während der Produktion Daten gespeichert werden, wie zum Beispiel Identifikationsdaten (Chargennummer, Streifentyp, ggf. Seriennummer), Verfallsdatum sowie chargenspezifische Kalibrationsdaten. Es ist auch möglich, nach der Produktion zusätzlich Daten zu speichern, beispielsweise aktuelle Kundenhinweise, Logistikdaten, Informationen des Einzelhandels, z. B. der Apotheke, oder anderes. Sobald der Teststreifen in das Instrument eingelegt ist, werden dem Instrument beispielsweise die Identifikationsdaten zur Kontrolle übermittelt, beispielsweise ob der für das Instrument passende Teststreifen eingelegt und ob das Verfallsdatum abgelaufen ist. Gegebenenfalls können auch Hinweise oder Informationen für den Kunden, die vorab auf dem analytischen Testelement abgespeichert wurden, angezeigt werden. Anschließend können die Messsignale, die während der Messung der Konzentration des gesuchten Analyten erzeugt werden, vom Teststreifen zum Instrument übertragen werden.

Das Lesemodul wandelt die vom Sendemodul empfangenen Signale um und leitet sie weiter an die Auswerteeinheit, in der sie ausgewertet werden. Das Ergebnis, beispielsweise die Konzentration der Blutglukose, wird in der Anzeigeeinheit, z. B. einem LCD Display, dem Anwender angezeigt. Üblicherweise ist die Anzeigeeinheit in das Instrument integriert, es ist jedoch auch möglich, dass die Anzeige in einer eigenständigen Einheit realisiert ist. Beispielsweise kann das Testelement als Implantat oder Teilimplantat ausgebildet sein, das Instrument mit dem Lesemodul wird entsprechend über dem Testelement direkt auf der Haut oder über der Kleidung getragen, und die Anzeigeeinheit kann eine Art Armbanduhr sein, die am Handgelenk befestigt wird. Die Übertragung der Daten von Auswerteeinheit zur Anzeigeeinheit ist ebenfalls mit einem Transpondersystem realisiert. Darüber hinaus können auf diese Art natürlich auch noch weitere Module, insbesondere eine Insulinpumpe oder ein elektronisches Diabetik-Tagebuch, angesteuert werden.

Beispielsweise nutzt das erfindungsgemäße Transpondersystem zur drahtlosen Übertragung von einem implantatierten Testelement zu einem extra-korporalem Lesemodul Frequenzen im Bereich von 125 kHz mit einer Reichweite im Körper von cirka 10 bis 20 cm, wie sie z. B. bei Implantaten zur Tieridentifikation verwendet werden. Für die Übertragung von einem Lesemodul zu einer eigenständigen Anzeigeeinheit oder anderen externen Systemkomponenten, z B. einer Insulinpumpe oder einem Datenmanagementsystem wie einem elektronischen Tagebuch, werden beispielsweise Frequenzen im Bereich von 13,56 MHz benutzt, mit denen in Luft ungefähr bis zu 1m Distanz überbrückt werden kann. Sollen darüber hinaus Daten über weitere Strecken übertragen werden, z. B. zu weiterführenden externen Geräten, beispielsweise einem PC zur Datenverwaltung, so können mit Frequenzen im Bereich von 800 bis 2.000 MHz (UHF Bereich) Entfernungen bis zu ungefähr 4 m überbrückt werden.

Die Messwerte, die während der Messung der Konzentration der gesuchten Analyten erzeugt werden, werden drahtlos und berührungslos vom Messmodul zum Sendmodul übertragen. Unter drahtlos und berührungslos soll hier nur die Signalübertragung und gegebenenfalls die Energieübertragung als solche verstanden werden. Selbstverständlich sind die elektrischen Komponenten auf dem analytischen Testelement bzw. im Messgerät mit elektrischen Schaltungen "verdrahtet" und natürlich ist es möglich, dass das analytische Testelement das Instrument berührt, insbesondere wenn das Testelement in das Instrument eingeschoben wird. Die drahtlose und berührungslose Datenübertragung bietet mehrere Vorteile gegenüber kontaktgebundener Übertragung: so ist, abhängig von der Dimensionierung der Transponderspulen, die Lagetoleranz des analytischen Testelements relativ zum Messgerät

deutlich größer. Zudem ist der Übertragungswiderstand von elektrischen Kontakten bei hochohmigen niederstromigen Signalen, wie sie für die vorliegende Anwendung typisch sind, sehr kritisch. Es wird zwar versucht, die Kontakte möglichst zuverlässig zu gestalten, z. B. indem inerte Materialien wie Gold verwendet werden und indem die Gegenkontakte spitz ausgeformt sind und sich auf den flachen Kontaktflächen eingraben, um eventuell vorhandene Ablagerungen zu beseitigen. Dennoch kommt es vor, dass beispielsweise während der Handhabung des Testelements durch Handschweiß eine isolierende Schicht oder ein Kurzschluss bzw. Leckstrom zwischen den eng nebeneinander liegenden Kontakten entsteht, durch Kratzer ein Kontakt unterbrochen wird oder ein Leckstrom zu einem benachbarten Kontakt auftritt.

Diese Kontaktproblematik wird durch das erfindungsgemäße Transpondersystem gelöst. In einer Ausführungsform werden beispielsweise zumindest die sensiblen Messdaten drahtlos übertragen, beispielsweise wenn die Energie zum Betreiben der Messung auf dem Testelement weiterhin über elektrische Kontakte zur Verfügung gestellt wird oder wenn das Testelement eine eigene Energiequelle aufweist. In einer weiteren, bevorzugten Ausführungsform werden sowohl die Messdaten als auch die zur Messung notwendige Energie mit dem Transpondersystem kontaktlos übertragen. In einer dritten Ausführungsform sind die Kontakte in Polymerelektronik ausgebildet. Polymere sind auch gegenüber aggressivem Schweiß unempfindlich. Durch Erzeugen einer Spannungsspitze an den Kontaktflächen ist es zudem möglich, die Kontakte zwischen Testelement und Messgerät punktuell zu verschweißen und dadurch reproduzierbar einen sehr geringen Übergangswiderstand zu generieren.

Eine weitere bevorzugte Ausführungsform der Erfindung betrifft ein System zur Bestimmung der Konzentration eines Analyten aus einer Körperflüssigkeit das ein analytisches Testelement beinhaltet, das einen Bereich mit Nachweischemie zum Nachweis des Analyten aus einer Körperflüssigkeit sowie einen Speicher zur Speicherung elektronischer Daten aufweist. Außerdem beinhaltet das System ein Instrument, das eine Auswerteeinheit zur Auswertung der Daten und eine Anzeigeeinheit aufweist. Das System ist dadurch gekennzeichnet, dass die elektrischen Komponenten des Systems zumindest teilweise auf der Basis von Polymerelektronik ausgebildet sind.

Die elektronischen Daten, die auf dem analytischen Testelement gespeichert werden, können eine Teststreifen-Identifikation, chargenspezifische Kalibrationsdaten und die bei der Konzentrationsmessung erzeugten Messwerte umfassen. Die Identifikation, z. B. Chargennummer, Streifentyp sowie eventuell zusätzlich das Verfallsdatum, werden bevorzugt

bereits während der Herstellung des Teststreifens auf dem Testelement gespeichert und anschließend nicht mehr geändert. Daher könnte dies auch durch eine feste Verdrahtung realisiert werden. Ansonsten werden hierfür auch ein- oder mehrfach beschreibbare Software-Speicher, z. B. EPROM oder EEPROM, verwendet. Erfindungsgemäß ist hierzu insbesondere ein wieder beschreibbarer Polymerelektronik-Speicher bevorzugt.

Um die Kalibrationsdaten auf den bereits verpackten analytischen Testelementen zu speichern, ist ein über ein Transpondersystem beschreibbarer Speicher notwendig. Darüber hinaus kann es sinnvoll sein, die während der Konzentrationsmessung erhaltenen Messsignale auf dem analytischen Testelement zu speichern, bevor die Daten zum Messgerät übertragen werden. Auf diese Weise können die Messwerte bei Bedarf mehrfach gesendet werden, z. B. wenn bei der Übertragung zum Messgerät ein Fehler auftritt.

Darüber hinaus ist es auch möglich, dass das Sendemodul vom Lesemodul übermittelte Energie empfängt, z. B. sobald das analytische Testelement in das Instrument eingeschoben wird, insbesondere falls das analytische Testelement keine eigene Energieversorgung besitzt. Bei einem passiven Transpondersystem besitzt der Transponder keine eigene Energieversorgung und ist daher nur aktiv, solange er in Verbindung mit der Leseeinheit steht. In der Regel arbeiten die Transponder über magnetische Feldkopplung im Nahfeld, d.h. der Transponder muss nahe genug an die Leseeinheit gebracht werden. Beim Beschreiben des Transponders werden die Daten in elektrisch beschreibbare Speicher, z. B. einem EPROM oder einem EEPROM, abgelegt und sind nach Wegnahme der Energie dauerhaft gespeichert.

In einer bevorzugten Ausführungsform der Erfindung weist das analytische Testelement keine eigene Energiequelle auf. In diesem Fall wird die zur Messung und eventuell auch zur Speicherung notwendige elektrische Energie drahtlos über das Transpondersystem vom Instrument zum Testelement übertragen. Diese Ausführungsform ist insbesondere bei Implantaten vorteilhaft, da dann die Verweildauer des Implantats nicht durch die Lebensdauer der Stromquelle, z. B. einer Batterie, limitiert wird. Insbesondere bei analytischen Testelementen, die als Disposable für die In-vitro Einmalmessung verwendet werden (so genannte Einmal-Teststreifen), kann es aus Kostengründen vorteilhaft sein, wenn das Testelement keine eigene Energieversorgung benötigt.

Zusätzlich ist es möglich, einen temporären Energiespeicher in das Testelement zu integrieren, beispielsweise eine Kapazität oder ein Akkumulator. Hierdurch kann beispielsweise die

Kontaktzeit flexibler gehandhabt werden, so kann z. B. ein kontinuierlich messendes System mit einem solchen Energiepuffer über längere Zeit weiter messen, unabhängig davon, ob sich das Instrument permanent in der Nähe des Testelements befindet.

In einer weiteren erfindungsgemäßen Ausführungsform weist das analytische Testelement eine eigene Energieversorgung auf. Ein solcher so genannter aktiver Transponder kann insbesondere dann sinnvoll sein, wenn das Testelement mehrere Messungen durchführen kann. So könnte beispielsweise ein solches, z. B. (teil-)-implantiertes, Testelement über 24 Stunden die erforderlichen bzw. eingestellten Messungen durchführen und der Anwender braucht nur einmal am Tag die Messdaten vom Testelement zum Instrument zu übertragen. Besitzt das Testelement eine wiederaufladbare Energieversorgung (Akkumulator, Kapazität), so kann während der Datenübertragung im Bedarfsfall der Energiespeicher aufgeladen werden.

In einer weiteren Ausführungsform beinhaltet das analytische Testelement des erfindungsgemäßen Systems mehrere Elektroden, insbesondere mehr als zwei Elektroden, die in Kontakt mit der Nachweischemie stehen. Die Elektroden sind zu einem bzw. mehreren elektronischen Schaltkreisen verschaltet, wobei die elektronischen Schaltkreise galvanisch getrennt sind. D. h. die Schaltkreise weisen keine gemeinsame Energiequelle oder gemeinsame Masse auf und sind soweit nach außen galvanisch isoliert, dass nur die Verbindung über den unvermeidlichen flüssigen Pfad der Nachweischemie selbst besteht. Da der elektrische Kontakt nur an einer Stelle besteht, kann sich kein parasitärer Kriechstrompfad aufbauen, der den Messwert verfälschen könnte. Um die galvanische Trennung zu realisieren, müsste beispielsweise jeder Schaltkreis eine eigene Stromversorgung aufweisen, was sehr kostspielig wäre. Erfindungsgemäß wird die galvanische Entkopplung durch das Transpondersystem gelöst. Alle Schaltkreise auf dem analytischen Testelement besitzen einen Transponder und sind gegeneinander galvanisch getrennt. Ein gemeinsames Lesemodul oder auch für jeden Transponder ein eigenes Lesemodul überträgt die Energie auf die Schaltkreise. Hierbei kann sich das Lesemodul im Instrument oder aber auch auf dem analytischen Testelement befinden. Im letztgenannten Fall kann die Übertragung der Energie vom Lesemodul, das sich auf dem Teststreifen befindet, zum Instrument entweder über elektrische Kontakte oder über ein weiteres Transpondersystem, bestehend aus einem gemeinsamen Transponder oder wieder aus mehreren Transpondern, vonstatten gehen.

Einfache elektrochemische Systeme bestehen meist aus zwei bis drei Elektroden. Häufig kommen sog. Potentiostaten mit 3 Elektroden (Arbeits-, Gegen- und Referenzelektrode) zur Anwendung.

Insbesondere ist hierbei ein parasitärer Widerstand von der Gegenelektrode zum Ausgang des Potentiostaten kritisch, da dieser direkt in die Signalverstärkung einfließt. Es ist daher von Vorteil, wenn der gesamte Potentiostat, bis auf die Elektroden, hermetisch mit einer Isolierschicht versiegelt ist. In dieser Ausführungsform verarbeitet und speichert der Transponder beispielsweise keine digitalen Informationen, sondern verarbeitet den analogen Signalstrom und überträgt diesen zum Lesemodul. Die für den Messprozess notwendigen Funktionen sind dabei im Transponder integriert, wie z. B. die permanente Versorgung der Arbeitselektrode mit einem Potenzial (typischerweise einige 100 mV, vorzugsweise -350 mV). Dabei ist das Transpondersystem so ausgelegt, dass die benötigte Energie in geeigneten Refresh-Intervallen vom Instrument zur Verfügung gestellt und zwischen gespeichert wird.

Insbesondere bei einem Potentiostat, der als Implantat oder Teilimplantat ausgeführt ist, z. B. zur kontinuierlichen Messung eines Analyten, ist es von besonderer Bedeutung, dass sich durch die erfindungsgemäße Verwendung der Transpondertechnologie das elektrische System hermetisch kapseln lässt und dennoch Information und Energie übertragen werden kann.

Eine bevorzugte erfindungsgemäße Ausführungsform betrifft implantierte analytische Testelemente. Der Einsatz der Transpondertechnologie ermöglicht es, ein Testelement in den Körper zu implantieren und ohne transkutane Verbindungen durch die Haut von außen zu betreiben. Durchführungen durch die Haut vermindern den Tragekomfort, z. B. beim Duschen, und bergen inhärent das Risiko einer Infektion. So kann beispielsweise ein analytisches Testelement zur kontinuierlichen Messung der Blutglukose in das Unterhautfettgewebe in der Bauchgegend eingesetzt werden und außen auf der Haut wird das Instrument gehalten, entweder nur temporär, um eine Messung durchzuführen, oder permanent, z. B. von einem Gürtel oder einem Pflaster, insbesondere bei kontinuierlichen Messungen des Analyten im Minutenbereich. In beiden Fällen kann zumindest kurzzeitig das Instrument entfernt werden, z. B. zum Duschen. Auch bei teilimplantierten analytischen Testelementen, die beispielsweise an ihrem einen Ende in ein Pflaster integriert sind, während das andere, meist lanzettenförmige Ende in die Bauchdecke gestochen wird, kann das relativ große und schwere Instrument für die Messungen in der Nähe des Testelements platziert und wenn nötig einfach entfernt werden. Da das Teilimplantat keine offenen elektrischen Kontakte hat, ist auch hier die Empfindlichkeit gegen Umwelteinflüsse deutlich geringer. Darüber hinaus kann das Instrument, insbesondere wenn es auch die Anzeigeeinheit beinhaltet, auch über der Kleidung getragen werden. Das Instrument kann unabhängig davon, ob es mit oder ohne Anzeigeeinheit ausgestattet ist, die empfangenen Daten in größerem Umfang, beispielsweise mehrere Hundert Messwerte, speichern.

Eine bevorzugte Methode, mit dem erfindungsgemäßen Transpondersystem Daten zu übertragen, besteht darin, die Signale, typischerweise Gleichstrom- oder Gleichspannungssignale, in eine Frequenz zu wandeln und einer Trägerfrequenz, die beispielsweise der Energieübertragung dient, aufzumodulieren.

Eine Variante der Erfindung beschreibt die Verwendung unterschiedlicher Trägerfrequenzen. Dies kann zur Unterscheidung der Transpondersysteme genutzt werden. Insbesondere wenn mehrere Transponder gleichzeitig angesprochen werden, beispielsweise bei mehreren parallelen Transpondern auf einem analytischen Testelement oder beim Beschreiben mehrerer Teststreifen, die sich in einer Verpackung befinden, kann es vorteilhaft sein, jeden Transponder einzeln anzusprechen. Durch die Verwendung schmalbandiger Filter kann beispielsweise jede Trägerfrequenz einzeln behandelt und Übersprechen vermieden werden.

Ein weiteres Merkmal der Erfindung besteht darin, dass die mit dem Transpondersystem übertragenen Signale nicht nur digitale Daten, z. B. die Kalibrationsdaten, sondern darüber hinaus auch analoge Signale, insbesondere die bei der Messung der Analytkonzentration erhaltenen Messwerte, enthalten können. Die heute üblichen Transpondersysteme werden zumeist nur zur Übertragung digitaler Daten verwendet. DE 103 22 167 beschreibt beispielsweise den Einsatz von Transpondern für die logistische Rückverfolgung von wieder verwendbaren Lastträgern; US 6,579,498 offenbart eine Transponder-gestützte Übertragung von digitalen Daten bei einem implantierten Blutglukosesensor. In der eingangs erwähnten Publikation von J. Black ist beispielsweise die Machbarkeit einer drahtlosen Übertragung von analogen Daten zur Glukosemessung gezeigt.

Üblicherweise liegen die Kalibrations- und Identifikationsdaten des analytischen Testelements als digitale Daten und die bei der Konzentrationsmessung eines Analyten erhaltenen Messsignale in Form von analogen Daten vor. Bei der erfindungsgemäßen Anwendung der Transpondertechnologie werden die digitalen Daten beispielsweise gemäß der oben erwähnten Amplitudenmodulation übertragen. Die analogen Daten werden entweder vor dem Senden digitalisiert oder als Analogsignale, z. B. ebenfalls mit Amplitudenmodulation, übermittelt.

Die Kalibrations- und Identifikationsdaten, die auf dem analytischen Testelement gespeichert sind, sind entweder in einem elektronischen Speicher, z. B. aus Polymerelektronik, abgelegt oder sie sind in einem Magnetstreifen bzw. Barcode, der sich auf dem Teststreifen befindet, codiert.

Die Messsignale werden entweder auf einem elektronischen Datenspeicher gespeichert, bevor sie an das Instrument, z. B. per Transpondersystem, weitergegeben werden, oder sie werden direkt ohne Zwischenspeicherung an das Instrument weitergegeben. Der elektronische Speicher auf dem analytischen Testelement ist bevorzugterweise ein nicht-flüchtiger Speicher, insbesondere der Speicher bzw. Speicherbereich, in dem die Kalibrations- und Identifikationsdaten gespeichert sind.

In einer bevorzugten Variante der Erfindung beinhaltet das analytische Testelement einen Speicher zur Speicherung elektronischer Daten, wobei dieser Speicher auch beschreibbar ist, wenn sich das analytische Testelement in einer Verpackung befindet. Beispielsweise werden die Teststreifen in einen Container (Einzeltest-Magazin oder Band-Magazin) verpackt und anschließend werden die Kalibrationsdaten von einem außen befindlichen Lesemodul durch die Verpackung zu dem auf dem Testelement befindlichen Transponder gesendet und dort gespeichert. Die Verpackung ist hierbei so gestaltet, dass eine drahtlose Übertragung der Daten möglich ist, insbesondere besteht das Verpackungsmaterial vorzugsweise aus Kunststoff oder Pappe, was für die eingesetzte Übertragungsstrahlung nahezu vollständig durchlässig ist.

In einer weiteren erfindungsgemäßen Ausführungsform weist das analytische Testelement keine elektrischen Kontakte zum Instrument auf, über die Daten oder elektrische Energie zwischen dem Testelement und dem Instrument übertragen werden, beispielsweise weil sämtliche Daten und gegebenenfalls die Energie über ein Transpondersystem übermittelt werden.

Beispielsweise besteht die elektrische Schaltung auf dem analytischen Testelement, beispielsweise die Transponderantenne oder die Leiterbahnen und Kontakte, zumindest teilweise aus Polymerelektronik, der Transponder selbst ist jedoch als Siliziumchip ausgebildet. Die höheren Herstellkosten des Siliziumchips können bei komplexen analytischen Testelementen, die beispielsweise mehrere Messungen durchführen können, akzeptabel sein. Insbesondere kann diese Ausführungsform günstig sein, wenn sich der Transponder nicht direkt auf dem analytischen Testelement, sondern auf einer Verpackung für ein oder mehrere Testelemente befindet. In dieser alternativen Ausführungsform beinhaltet das System zusätzlich eine derartige Verpackung, die insbesondere ein Container oder ein Magazin für mehrere Testelemente, z. B. eine Trommel, sein kann. Zusätzlich ist es möglich, auf der Verpackung einen sog. Testzähler zu implementieren, der in dem Speicher auf dem Container die Anzahl der mit diesem Container durchgeführten bzw. noch durchführbaren Tests ablegt. Auf diese Wiese kann jederzeit vom Instrument abgefragt werden, wie viele unbenutzte Testelemente sich noch in der Verpackung

befinden. Ist diese Information nur im Instrument angelegt, könnte es zu Fehlfunktionen kommen, beispielsweise wenn ein angebrochener Container aus dem Instrument herausgenommen und durch einen anderen angebrochenen oder neuen ersetzt wird. Selbstverständlich kann auch auf dem Testelement selbst ein Indikator gespeichert werden, der anzeigt, ob das Testelement bereits benutzt wurde oder nicht.

Eine weitere bevorzugte Ausführungsform der Erfindung betrifft ein System, das ein analytisches Testelement, das einen Bereich mit Nachweischemie zum Nachweis des Analyten aufweist, wobei die elektrischen Komponenten auf dem Testelement zumindest teilweise auf der Basis von Polymerelektronik ausgebildet sind, sowie eine Verpackung, in der ein oder mehrere analytische Testelemente verpackt sind, wobei die Verpackung einen Speicher zur Speicherung elektronischer Daten und ein Sendemodul zur drahtlosen Übertragung von Daten aufweist. Darüber hinaus beinhaltet das System ein Instrument, das eine Auswerteeinheit zur Auswertung der Daten sowie ein Lesemodul zur drahtlosen Übertragung von Daten aufweist.

Beispielsweise werden die Teststreifen in einen Container (Trommel, Magazin) verpackt. Die Kalibrations- und Identifikationsdaten sind hierbei auf dem Container gespeichert und nicht auf den Testelementen. Der Container, z. B. eine Trommel mit analytischen Testelementen ähnlich der, wie sie beim Accu-Chek Compact© verwendet wird, wird in das Instrument eingesetzt und der Transponder auf dem Container sendet die Daten an das Lesemodul im Instrument. Der Vorteil dieser Variante liegt darin, dass beispielsweise für mehrere Teststreifen nur ein Sendemodul notwendig ist, insbesondere wenn die Verarbeitung der Messsignale ohne Transponder arbeitet (z. B. bei foto-optischen Testelementen).

Gemäß einer weiteren erfindungsgemäßen Ausführungsform, insbesondere für Einmalteststreifen, weist das analytische Testelement keine eigene Energieversorgung auf. Auf dem Testelement sind z. B. Chargennummer, Streifentyp, Verfallsdatum und Kalibrationsdaten gespeichert. Das Testelement wird vom Anwender oder automatisch vom Instrument aus der Verpackung entnommen und beispielsweise in eine Halterung im Instrument gebracht. Die Positionierung des Testelements in der Halterung gewährleistet eine korrekte Position von Sende- und Lesemodul. Insbesondere gewährleistet die Halterung das Einbringen des analytischen Testelements in den Sende- und Empfangsbereich des Lesemoduls. Der Sende- und Empfangsbereich beschreibt den Bereich, innerhalb dessen elektronische Daten drahtlos zwischen Lesemodul und Sendemodul ausgetauscht werden können. Die Ausdehnung dieses Bereichs wird insbesondere durch die Abmessungen der Transponderspulen, der Energie und

Frequenz der übertragenen elektromagnetischen Wellen sowie eventueller Abschirmungen, z. B. durch Metallteile, definiert. Beispielsweise kann die Halterung so gestaltet sein, dass die Transpondermodule sehr nahe, typischerweise auf einen Abstand von 0,1 bis 3 mm, zusammen kommen. Aufgrund der geringen Distanz, die überbrückt werden muss, können die Transponderspulen sehr klein sein und es wird nur wenig Energie zur drahtlosen Übertragung benötigt, beispielsweise im Bereich von 0,1 bis 10 mJ. Ein geringer Energiebedarf ist insbesondere bei batteriebetriebenen Instrumenten von Vorteil. Außerdem kann der Sende- und Empfangsbereich räumlich stark eingegrenzt werden, um sicher zu stellen, dass nur das eingebrachte Testelement angesprochen wird und nicht zusätzlich in der Nähe befindliche weitere Testelemente. Alternativ kann der Sende- und Empfangsbereich auch so gestaltet sein, dass das analytische Testelement zur drahtlosen Datenübertragung, mit oder ohne eine Halterung, beispielsweise dicht neben oder auf dem Instrument positioniert werden kann. Darüber hinaus kann sich die Halterung zum Einbringen des analytischen Testelements in den Sende- und Empfangsbereich in einer Verpackung für mehrere Testelemente befinden und die Verpackung wird entsprechend zum Instrument positioniert, beispielsweise durch eine Halterung für die Verpackung am Instrument bzw. durch eine Halterung für das Instrument an der Verpackung.

In einer weiteren bevorzugten Ausführungsform befindet sich das Sendemodul nicht auf dem Testelement, sondern auf einer Verpackung, die ein oder mehrere Testelemente beinhaltet, und eine Halterung positioniert die Verpackung im Instrument so, dass Sende- und Lesemodul sehr nahe zusammen kommen, so dass sich das Sendemodul der Verpackung im Sende- und Empfangsbereich des Lesemoduls befindet.

Eine weitere bevorzugte Ausführungsform der Erfindung betrifft ein analytisches Testelement, das einen Bereich mit Nachweischemie zum Nachweis eines Analyten aufweist, wobei sich auf dem analytischen Testelement ein Sendemodul und ein Lesemodul befinden und zwischen diesen beiden Modulen drahtlos Daten innerhalb des Teststreifens übertragen werden. Darüber hinaus kann neben den Daten auch elektrische Energie übertragen werden. Die elektrischen Komponenten auf einem solchen analytischen Testelement sind bevorzugterweise zumindest teilweise auf der Basis von Polymerelektronik ausgebildet. Ein derartiges analytisches Testelement kann darüber hinaus auch zum Instrument Daten bzw. Daten und Energie drahtlos übertragen, z. B. mittels eines zweiten Transpondersystems mit einem Sendemodul auf einem Teststreifen und einem Lesemodul im Instrument. Selbstverständlich kann es sich bei den Daten, die mit einem Transpondersystem innerhalb des Teststreifens übertragen werden, sowohl um digitale als

auch um analoge Daten handeln. Beispielsweise kann ein solches Teststreifen-internes Transpondersystem dazu genutzt werden, die elektrischen Stromkreise auf einem elektro-chemischen Teststreifen galvanisch zu entkoppeln, wobei die Energie vom Instrument zum Nachweisbereich übertragen wird, und die Messsignale, z. B. als analoge Spannungs- oder Stromwerte, werden im Gegenzug vom Nachweisbereich zum Instrument gesendet.

Bei dem erfindungsgemäßen System kann sowohl ein elektro-chemisches als auch ein foto-optisches Messverfahren zur analytischen Bestimmung verwendet werden, insbesondere wenn sich beispielsweise bei einem foto-optischen Teststreifen die Messeinheit auf dem Teststreifen befindet und somit wie bei einem elektro-chemischen Teststreifen die elektrischen Messsignale auf dem Teststreifen zu generieren und auf das Instrument zu übertragen sind.

Beispielsweise kann ein Lichtstrahl vom Instrument auf den Nachweisbereich gelenkt werden und ein auf dem Teststreifen befindliches Fotoelement, z. B. eine Solarzelle aus Polymerelektronik, empfängt das optische Messsignal und wandelt es in ein elektrisches Signal um. Dieses Signal kann dann mit dem Transpondersystem berührungslos zum Instrument übertragen werden.

Zur sensorischen Erfassung des Analyten, insbesondere von Blutglukose, werden die im Stand der Technik bekannten Verfahren eingesetzt. Hierbei werden foto-optische bzw. elektrochemische Verfahren bevorzugt. Foto-optische Messverfahren sind beispielsweise Reflexionsphotometrie, Absorptionsmessung oder Fluoreszenzmessung, elektro-chemische Verfahren sind zum Beispiel Potentiometrie, Amperometrie, Voltametrie, Coulometrie.

Ein weiterer Gegenstand der Erfindung ist ein Verfahren zur Herstellung eines analytischen Testelements, das einen Bereich mit Nachweischemie zum Nachweis eines Analyten in einer Körperflüssigkeit, einen Speicher zur Speicherung elektronischer Daten und ein Sendemodul zur drahtlosen Übertragung von Daten aufweist, wobei die Herstellung die Schritte Speichern einer Chargenidentifikation auf dem analytischen Testelement; Verpacken des analytischen Testelements; und Speichern von Kalibrationsdaten auf dem verpackten analytischen Testelement beinhaltet.

Ein weiterer Gegenstand der Erfindung ist ein Verfahren zur Herstellung eines analytischen Testelements, das einen Bereich mit Nachweischemie zum Nachweis eines Analyten in einer Körperflüssigkeit aufweist, wobei die Herstellung die Schritte Speichern einer

Chargenidentifikation auf einer Verpackung, die einen Speicher zur Speicherung elektronischer Daten und ein Sendemodul zur drahtlosen Übertragung von Daten aufweist; Verpacken des analytischen Testelements in der Verpackung; und Speichern von Kalibrationsdaten auf der Verpackung beinhaltet.

Ein weiterer Gegenstand der Erfindung ist ein Verfahren zur Bestimmung der Konzentration eines Analyten in einer Körperflüssigkeit, das die Schritte Einlegen eines analytischen Testelements, das einen Bereich mit Nachweischemie zum Nachweis eines Analyten in einer Körperflüssigkeit, einen Speicher zur Speicherung elektronischer Daten und ein Sendemodul zur drahtlosen Übertragung der Daten aufweist, in ein Instrument, das eine Auswerteeinheit zur Auswertung der Daten und ein Lesemodul zur drahtlosen Übertragung der Daten aufweist; Auftragen der Körperflüssigkeit auf das analytische Testelement; drahtlose Übertragung der Daten vom analytischen Testelement zum Instrument; und Auswerten der Daten in der Auswerteeinheit des Instruments beinhaltet.

Ein weiterer Gegenstand der Erfindung ist ein Verfahren zur Bestimmung der Konzentration eines Analyten in einer Körperflüssigkeit, das die Schritte Einlegen einer Verpackung, in der ein oder mehrere analytische Testelemente mit Nachweischemie zum Nachweis eines Analyten in einer Körperflüssigkeit verpackt sind, und die Verpackung einen Speicher zur Speicherung elektronischer Daten sowie ein Sendemodul zur drahtlosen Übertragung der Daten aufweist; Bereitstellen eines analytischen Testelements aus der Verpackung; Auftragen der Körperflüssigkeit auf das analytische Testelement; drahtlose Übertragung der Daten von der Verpackung zu einem Instrument , das eine Auswerteeinheit zur Auswertung von Daten und ein Lesemodul zur drahtlosen Übertragung der Daten aufweist; und Auswerten der Daten in der Auswerteeinheit des Instruments beinhaltet.

Beispielsweise sind auf dem Teststreifen die chargenspezifischen Kalibrationsdaten gespeichert. Der Teststreifen wird vom Benutzer in die entsprechende Halterung im Instrument eingelegt, beispielsweise von Hand oder der Teststreifenvoratsbehälter besitzt eine Entnahmevorrichtung, die den Teststreifen aus den Voratsbehälter in das Instrument transportiert. Bevorzugterweise schaltet sich das Instrument automatisch ein, sobald der Teststreifen eingelegt wird und ist nach einem kurzen Selbsttest messbereit. Anschließend gibt der Benutzer die zu messende Probe mit Körperflüssigkeit auf. Die Probe reagiert mit der Nachweischemie auf dem Teststreifen und generiert dabei ein Messsignal. Bei foto-optischen Systemen kann dies beispielsweise ein Farbumschlag sein, bei elektro-chemischen Systemen wird beispielsweise ein Stromsignal erzeugt.

Der Farbumschlag wird von der Messoptik in ein elektrisches Signal umgewandelt. Die Optik ist üblicherweise in das Instrument integriert, sie kann sich jedoch auch auf dem Teststreifen befinden, insbesondere wenn die Optik zumindest teilweise in Polymerelektronik realisiert ist. Mit Hilfe des Transpondersystems werden die Kalibrationsdaten vom Teststreifen zum Instrument drahtlos übertragen bzw., falls die Optik auf dem Teststreifen ist, wird zusätzlich zunächst die Energie zum Betreiben der Optik vom Instrument zum Testsreifen übertragen und nach der Messung die Messsignale vom Teststreifen zum Instrument. Unter Einbeziehen der chargenspezifischen Kalibrationsdaten werden die Messsignale in der Auswerteeinheit im Instrument ausgewertet. Bevorzugtermaßen weist das Instrument eine Anzeigeeinheit, z. B. ein LCD Display, auf, die dem Benutzer den Messwert anzeigt.

In einer alternativen Ausführungsform befinden sich ein oder bevorzugt mehrere Teststreifen in einer Verpackung, z. B. einem Container. Auf der Verpackung sind die chargenspezifischen Kalibrationsdaten gespeichert und der Transponder befindet sich ebenfalls in der Verpackung. Die Verpackung wird vom Benutzer in das Instrument eingelegt. zur Benutzung wird das Instrument eingeschaltet, wobei es bevorzugterweise automatisch einen Teststreifen in eine Position transportiert, in der der Benutzer die Probe auftragen kann. Anschließend erfolgt Probenauftrag und foto-optischer bzw. elektro-chemischer Messung wie oben beschrieben. Bevorzugtermaßen handelt es sich um foto-optische Teststreifen und die Messoptik befindet sich im Instrument. Die Kalibrationsdaten werden vor oder nach der Messung vom Transponder auf der Verpackung drahtlos zum Instrument übertragen, während die optischen Messsignale von der Optik im Instrument empfangen und unter Einbeziehen der Kalibrationsdaten in der Auswerteeinheit ausgewertet und bevorzugterweise in einer Anzeigeeinheit angezeigt werden. Bei einem elektro-chemischen Teststreifen werden ebenfalls die Kalibrationsdaten vom Transponder auf der Verpackung drahtlos zum Instrument übertragen und beispielsweise werden die elektrischen Messsignale über elektrische Kontakte vom Teststreifen zum Instrument übertragen, über die auch die benötigte Energie zur Erzeugung des Messsignals eingespeist wird.

Beschreibung der Figuren

Die Erfindung wird durch die nachfolgenden Figuren näher erläutert: Die Figuren 1 bis 23 zeigen schematisch Prinzipskizzen für konkrete Ausführungsformen der Erfindung.

Figur 1 zeigt ein analytisches Testelement mit einem Transpondersystem.

Figur 2 zeigt ein erfindungsgemäßes analytisches Testelement eingelegt in ein Instrument.

Figur 3 zeigt die Verwendung eines leitfähigen Polymersubstrats als Datenspeicher.
Figur 4 zeigt die Übermittlung von Daten auf mehrere analytische Testelemente mit dem erfindungsgemäßen Transpondersystem.
Figur 5 zeigt eine Skizze eines Systems mit mehreren galvanisch getrennten Schaltkreisen.
Figur 6 zeigt ein schematisches Blockschaltbild eines Systems mit mehreren galvanisch getrennten Schaltkreisen.
Figur 7 zeigt ein Mehrelektrodensystem mit Transponder.
Figur 8 zeigt ein teilimplantiertes analytisches Testelement.
Figur 9 zeigt ein implantiertes analytisches Testelement.
Figur 10 zeigt eine Prinzipschaltung eines Potentiostat-Transponders.
Figur 11 zeigt einen elektro-chemischen Teststreifen mit Transponder aus Polymerelektronik.
Figur 12 zeigt eine Schnittdarstellung des Teststreifens aus Figur 11 eingelegt in ein Instrument.
Figur 13 zeigt einen foto-optischen Teststreifen mit Transponder aus Polymerelektronik.
Figur 14 zeigt eine Schnittdarstellung des Teststreifens aus Figur 13 eingelegt in ein Instrument.
Figur 15 zeigt ein Testelement mit mehreren Potentiostat-Sensor Systemen.
Figur 16 zeigt das Testelement aus Figur 15 eingesetzt in ein Instrument.
Figuren 17 und 18 zeigen ein teilimplantierbares analytisches Testelement.
Figuren 19-21 zeigen Beispiele für Datenübertragung auf verpackte Teststreifen.
Figuren 22 und 23 zeigen einen Schreib-Lese-Speicher aus Polymerelektronik.

In Figur 1 ist ein analytisches Testelement 1 gezeigt, bestehend aus einem Substrat 2, auf dem sich ein Nachweisbereich 3 zum Nachweis eines Analyten aus einer Körperflüssigkeit sowie ein Sendemodul, das das Transpondersubstrat 4 beinhaltet, in bzw. auf dem sich die Transponderantenne 5 und die Transponderelektronik 6 befinden, die als Polymerelektronik hergestellt sind.

Figur 2 zeigt eine Prinzipskizze eines analytischen Testelementes 1, das in ein Instrument 7 eingelegt ist. Die Identifikations- und Kalibrationsdaten des Teststreifens sind in der Transponderelektronik 6 gespeichert und werden über die Transponderantenne 5 zum Lesemodul 8, das sich ebenfalls im Instrument 7 befindet, übertragen. Die drahtlose Datenübertragung wird mit dem Pfeil 9 angedeutet. Die im Nachweisbereich 3 ermittelten Messsignale werden über die elektrischen Kontakte 15 zum Instrument 7 weitergeleitet. Der hier dargestellte Teststreifen kann für eine elektro-chemische und für eine foto-optische Messung geeignet sein. Bei einem foto-optischen Testelement entfallen entweder die Kontakte 15 und die Auswerteoptik ist im Instrument 7, oder die Auswerteoptik ist zumindest teilweise auf dem

Teststreifen integriert, so dass die optischen Messsignale auf dem Testelement in elektrische Größen umgewandelt und die elektrischen Signale über die Kontakte 15 an das Instrument weitergegeben werden.

Die Verwendung eines leitfähigen Polymersubstrats 14 als binärer Speicher für elektronische Daten ist in Figur 3 schematisch dargestellt. Die Steuerelektronik 10 steuert die Elektrodenmatrix 11 so an, dass punktuell zunächst hochohmige Zonen 12 zu niederohmigen Zonen 13 werden.

Figur 4 zeigt die drahtlose Übermittlung von Daten 9 zwischen einem Lesemodul 8 und mehreren analytischen Testelementen 1. Die Sendemodule auf dem Testelement sind hier durch das Transpondersubstrat 4 und die Transponderelektronik 6 dargestellt. Diese Anwendung kann zum Beispiel in der Produktion verwendet werden. Hierbei sind die Teststreifen 1 in einer Verpackung, z. B. einem Container der das elektromagnetische Feld nicht behindert, verpackt und ein spezielles Lesemodul 8 in der Produktion fragt zunächst die Teststreifen-Identifikation von den Testelementen ab, um die Chargennummern abzufragen, überträgt dann die chargenspezifischen Kalibrationsdaten und kontrolliert abschließend durch erneute Abfrage, ob die Datenübertragung korrekt war. In einer zweiten Verwendung des hier dargestellten Aufbaus befinden sich die Testelemente 1 in einem Container im Instrument oder dicht neben dem Instrument und das Lesemodul 8, das sich im Instrument befindet, liest die Daten vom Testelement aus. Hierbei handelt es sich beispielsweise um Streifentyp, Verfallsdatum und Kalibrationsdaten. Darüber hinaus ist es auch möglich, dass benutzte Testelemente nach der Messung wieder in den Container zurückgelegt werden. Die Benutzung wird beispielsweise auf dem Testelement gespeichert, z. B. zusammen mit den Messwerten, und an das Lesemodul gemeldet, oder direkt an das Lesemodul gesendet und dort, beispielsweise zusammen mit den Messwerten, gespeichert, oder ein Testelement, zu dem ein Messwert auf dem Testelement bzw. im Instrument gespeichert ist, wird automatisch als benutzt angesehen.

Figur 5 zeigt anhand einer Prinzipskizze ein System mit galvanisch getrennten Schaltkreisen. Auf dem Transpondersubstrat 4 befinden sich mehrere gegeneinander isolierte elektrische Schaltkreise bestehend aus Transponderantenne 5, Transponderelektronik 6, sowie in den elektro-chemischen Nachweisbereich 3 hineinragende Messelektroden 16. Die Messsignale werden von ebenso vielen parallel angeordneten Antennen 17 im Lesemodul 8 empfangen.

Figur 6 zeigt ein vereinfachtes Blockschaltbild des in Figur 5 dargestellten Beispiels, wobei auch noch von weiteren Modulen 30, z. B. ein elektrochemisch arbeitender Durchflusssensor, Signale gesendet und/oder empfangen werden können.

Figur 7 zeigt ein komplexes Mehrelektrodensystem als Potentiostat-Transponder für die elektrochemische Messung beispielsweise von Blutglukose und Blutgerinnung mit elektrischen Zuleitungen 18, die von der Transponderelektronik und –antenne 6 bzw. 5 zu den Messelektroden 16 im Nachweisbereich 3 reichen. Eine Deckschicht 19 gewährleistet eine hermetische Trennung des Transpondersystems.

Figur 8 zeigt ein teilimplantierbares lanzettenartiges Testelement 1 mit Potentiostat-Transponder, das bevorzugt für eine kontinuierliche Glukosemessung eingesetzt wird. Hierbei wird regelmäßig die Glukosekonzentration bestimmt, die Daten im Transponder abgespeichert, und immer wenn das Lesemodul 8 in der Nähe ist, werden die Signale an das Instrument übertragen. So kann der Anwender das Instrument problemlos kurzzeitig, z. B. zum Umziehen oder Duschen, abnehmen. Das Testelement 1 besteht aus einem an einem Ende spitzen und relativ steifen Substrat 2, an dessen Spitze sich die Messelektroden 16 befinden. Elektrische Leiterbahnen 18 führen von den Elektroden 16 zum anderen, außerhalb des Körpers befindlichen, Sendemodul bestehend aus Transponderelektronik und –antenne, 6 bzw. 5. Das ganze Testelement 1 ist mit einer Deckschicht 19 wasserdicht verkapselt, lediglich die Messelektroden 16 haben, gezwungenermaßen, nach außen offene Kontakte. Über dem Testelement 1 kann sich beispielsweise ein Pflaster 22 befinden, bzw. das Lesemodul 8 kann bequem über einer Kleidung 22 getragen werden.

Figur 9 zeigt ein Potentiostat-Testelement 1 ähnlich dem in Figur 8 gezeigten Beispiel als (voll-) implantierte Version. Die gesamte Elektronik, bis auf die Messelektroden 16, ist hermetisch in einer Glas- oder Polymerkapsel 23 verkapselt. Um höhere Eindringtiefen in die Gewebeschichten zu erreichen verwendet man bevorzugt Niederfrequenztransponder im Bereich von 125 kHz. Um dafür geeignete, kleine Antennenspulen zu erreichen, werden diese mit Stabferritkernen 24 ausgestattet.

Figur 10 beschreibt eine Prinzipschaltung eines Potentiostat-Transponders. Die Transponderelektronik beinhaltet u. a. einen Lastmodulator 25, einen Energiespeicher 26, z. B. in Form einer Kapazität, und einen Spannungs-/Frequenzwandler 27. Das Ruhepotential 28 liegt permanent an der Arbeitselektrode 29 an. 30 und 31 bezeichnen Referenz- bzw. Gegenelektrode. Das Lesemodul weist unter anderem Bandpassfilter 32, Energiesender und Schreibeinheit 33, Leseeinheit 34, Speicher 35 sowie Steuerungseinheit 36 auf.

Figur 11 zeigt ein analytisches Testelement 1 mit einem Transponder aus Polymerelektronik, das nach einem elektro-chemischen Messverfahren arbeitet. Auf dem Substrat 2 befindet sich eine Abstandsfolie 51, die zwischen Substrat 2 und Deckfolie 52 eine Blutkapillare 50 bildet, in die die Messelektroden 16 für die elektro-chemische Messung hineinragen. In bzw. auf die Transponderfolie 4 sind die Transponderantenne 5, die Transponderelektronik 6 und

Transponderspeicher 54 in Polymerelektronik realisiert. Der Transponder dient hierbei zur Übertragung von Teststreifen-Identifikations- und Kalibrationsdaten. Die Messsignale werden über die Sensorkontakte 15 übertragen.

Durch das Einlegen des Teststreifens 1 aus Figur 11 in ein Instrument wird das Sendemodul 37 und insbesondere Transponderantenne 5 nah zum Lesemodul 55 und insbesondere zur Lesemodul-Antenne 17 positioniert (siehe Figur 12). Das Lesemodul 55 befindet sich hier mit auf der Elektronikleiterplatine 56 des Instruments 7, ebenso wie die Instrumentkontakte 70, die die Sensorkontakte 15 auf dem Teststreifen 1 kontaktieren.

Bei dem Testelement 1 in Figur 13 befindet sich der Nachweisbereich 3, der über die Blutkapillare 50 befüllt wird, unter dem Transpondermodul aus Polymerelektronik, bestehend aus Transpondersubstrat 4, -antenne 5, -elektronik 6 und –speicher 54. Die Blutkapillare 50 wird durch die Abstandsfolie 51 zwischen Substrat 2 und Deckfolie 52 gebildet.

Ist das Testelement 1 aus Figur 13 in ein Instrument 7 eingesetzt, liegen Transponderantenne 5 und Lesemodul-Antenne 17 sehr nah übereinander und gewähren so eine leichte Datenübertragung über kurze Distanz (siehe Figur 14). Das Transpondermodul 37 befindet sich auf der Oberseite des Teststreifens, der fotometrische Nachweisbereich 3 wird von der Unterseite von der Beleuchtung 58 beleuchtet und dem optischen Leser 59 ausgelesen. Eine oben- und eine untenliegende Leiterplatte 56 sind mit dem Lesemodul 55 bzw. den Optikmodulen 58 und 59 bestückt.

Das Testelement 1 in Figur 15 weist einen Nachweisbereich 3 in Form eines Flüssigkeitskanals auf, durch den die Probe vom Einlass 60 zum Auslass 61, z. B. für kontinuierliche Blutglukosemessung, fließt. Drei Messelektroden 16 eines Potentiostats ragen in den Flüssigkeitskanal hinein. Auf dem Transpondersubstrat 4 befinden sich eine Polymerelektronik-Transponderantenne 5 und die Transponderelektronik 6, die aus Polymerelektronik oder (zumindest teilweise) mit Siliziumchips aufgebaut ist. Parallel zu dem ersten Potentiostat-Sensor-System befindet sich noch ein baugleiches paralleles System, wobei beide Systeme galvanisch voneinander getrennt sind.

Eingelegt in ein Instrument 7, korrespondieren die parallelen Transponderantennen 5 auf dem Testelement 1 mit den entsprechenden Lesemodul-Antennen 17, die die Daten an die Lesemodul-Elektronik 55 weiterleiten, für eine drahtlose Datenübertragung 9 (siehe Figur 16).

Ein weiteres Beispiel eines kontinuierlich messenden analytischen Testelements 1 ist in Figur 17 und 18 dargestellt. Das Substrat 2 weist ein nadelförmiges Ende auf, das durch die Haut 20 in das Gewebe 21 gestochen wird, so dass die Messelektroden 16 direkt im Gewebe 21 messen können. Auf dem flächigen extrakorporalen Teil des Substrats 2 befinden sich die Potentiostatelektronik und das Transpondermodul 37 als Polymerelektronik oder Siliziumchip. Eine Deckschicht 19 kapselt die Elektronik bis auf die Messelektroden ein. Ein Pflaster 62 fixiert das Testelement 1 auf der Haut.

Figur 19 bis 21 zeigen Beispiele für eine Datenprogrammierung in Produktion und Logistik. In Figur 19 und 20 schreibt ein Lesemodul 8 während der Produktion die chargenspezifischen Kalibrationsdaten auf Teststreifen 1, die bereits fertig verpackt in einer Trommel 63 bzw. einem Magazin 64 vorliegen. In Figur 21 sind mehrere Teststreifendosen 63 in einem Karton 65 zu einem Gebinde zusammengefasst und werden dann von einem Lesemodul 8 in der Produktion oder in der Logistikkette beschrieben. Es ist auch möglich, Daten (z. B. Chargen- oder Seriennummern der Teststreifen) bei der Herstellung des Polymerelektronik-Transponders fest zu verdrahten. Die Daten müssen dann nicht extra aufgespielt werden, sind aber auch nachträglich nicht mehr zu ändern.

Figur 22 und 23 zeigen einen Schreib-Lese-Speicher aus Polymerelektronik, wie er beispielsweise für einen Transponderspeicher 54 verwendet wird. Das Polymersubstrat 4, z. B. aus PDOT (Polyethylenedioxythiophene), besitzt an der Oberseite Zeilenleitungen 66 und an der Unterseite Spaltenleitungen 67. Durch Anlegen einer Spannung an eine bestimmte Zeilen- 66 und einer bestimmten Spaltenleitung 67 ändert das Polymer 4 am Kreuzungspunkt seine elektrische Leitfähigkeit von hochohmig 12 zu niedrigohmig 13. Durch Umpolen der Spannung ist der Effekt umkehrbar, bei Wegnahme der Spannung bleibt der letzte Widerstandswert erhalten. Auf diese Weise erhält man einen binären Datenspeicher. Für die Speicherung der Kalibrationsdaten eines Blutglukoseteststreifens sind beispielsweise 10 Zeilen und 10 Spalten ausreichend. Durch messen der Widerstände zwischen definierten Spalten- und Zeilenleitungen werden die Daten wieder ausgelesen.

Patentansprüche

1. Ein System zur Bestimmung der Konzentration eines Analyten in einer Körperflüssigkeit beinhaltend
- ein analytisches Testelement, das einen Bereich mit Nachweischemie zum Nachweis des Analyten in einer Körperflüssigkeit aufweist, und davon getrennt
- ein Instrument, das eine Auswerteeinheit zur Auswertung von Daten aufweist,
dadurch gekennzeichnet, dass zumindest ein Teil der elektrischen Komponenten des analytischen Testelements auf der Basis von Polymerelektronik ausgebildet ist.

2. Ein System gemäß Anspruch 1, wobei
- das analytische Testelement ein Sendemodul zur drahtlosen Übertragung von Daten aufweist, und
- das Instrument ein Lesemodul zur drahtlosen Übertragung von Daten aufweist.

3. Ein System gemäß einem der Ansprüche 1 oder 2, wobei
- das analytische Testelement einen Speicher zur Speicherung von Daten aufweist.

4. Ein System gemäß einem der Ansprüche 1 bis 3 , wobei das analytische Testelement ein Sendemodul zur drahtlosen Übertragung von Daten und Energie sowie das Instrument ein Lesemodul zur drahtlosen Übertragung von Daten und Energie beinhalten.

5. Ein System gemäß einem der Ansprüche 1 bis 4, wobei die elektronische Schaltung auf dem analytischen Testelement mehrere Elektroden, die in Kontakt mit der Nachweischemie stehen, und mehrere galvanisch getrennte elektronische Schaltkreise beinhaltet, und zur drahtlosen Übertragung von Daten bzw. Daten und Energie das analytische Testelement mehrere parallele Sendemodule und das Instrument mehrere parallele Lesemodule aufweisen.

6. Ein System gemäß einem der Ansprüche 1 bis 5, wobei die Daten, die drahtlos zwischen dem Sendemodul auf dem analytischen Testelement und dem Lesemodul auf dem Instrument übertragen werden, zumindest teilweise analoge Daten beinhalten.

7. Ein System gemäß einem der Ansprüche 1 bis 6, wobei das analytische Testelement einen Speicher zur Speicherung von Daten beinhaltet und der Speicher auch beschreibbar ist, wenn sich das analytische Testelement in einer Verpackung befindet.

8. Ein System gemäß einem der Ansprüche 1 bis 7, wobei sich auf dem analytischen Testelement ein Sendemodul und ein Lesemodul befinden und zwischen diesen beiden Modulen drahtlos Daten bzw. Daten und Energie innerhalb des analytischen Testelementes übertragen werden.

9. Ein System gemäß einem der Ansprüche 1 bis 8, wobei das Instrument eine Halterung zur Positionierung des analytischen Testelements beinhaltet.

10. Ein System zur Bestimmung der Konzentration eines Analyten in einer Körperflüssigkeit beinhaltend
- ein oder mehrere analytische Testelemente, die einen Bereich mit Nachweischemie zum Nachweis des Analyten in einer Körperflüssigkeit aufweisen, davon getrennt
- ein Instrument, das eine Auswerteeinheit zur Auswertung von Daten sowie ein Lesemodul zur drahtlosen Übertragung von Daten aufweist, und
- eine Verpackung, in der die ein oder mehreren analytischen Testelemente verpackt sind, und die Verpackung einen Speicher zur Speicherung von Daten sowie ein Sendemodul zur drahtlosen Übertragung von Daten aufweist,

dadurch gekennzeichnet, dass zumindest ein Teil der elektrischen Komponenten der Verpackung auf der Basis von Polymerelektronik ausgebildet ist.

11. Ein System gemäß Anspruch 10, wobei das Instrument eine Halterung zur Positionierung der Verpackung beinhaltet.

12. Ein analytisches Testelement zur Bestimmung der Konzentration eines Analyten in einer Körperflüssigkeit, das einen Bereich mit Nachweischemie zum Nachweis des Analyten in einer Körperflüssigkeit aufweist, dadurch gekennzeichnet, dass zumindest ein Teil der elektrischen Komponenten des analytischen Testelements auf der Basis von Polymerelektronik ausgebildet ist.

13. Ein analytisches Testelement gemäß Anspruch 12 dadurch gekennzeichnet, dass das analytische Testelement ein Sendemodul zur drahtlosen Übertragung von Daten aufweist.

14. Eine Verpackung, in der ein oder mehrere analytische Testelemente verpackt sind, dadurch gekennzeichnet, dass die Verpackung einen Speicher zur Speicherung von Daten sowie ein Sendemodul zur drahtlosen Übertragung von Daten aufweist.

15. Ein Verfahren zur Herstellung eines analytischen Testelements, das einen Bereich mit Nachweischemie zum Nachweis eines Analyten in einer Körperflüssigkeit, einen Speicher zur Speicherung von Daten und ein Sendemodul zur drahtlosen Übertragung von Daten aufweist, wobei die Herstellung die Schritte beinhaltet:
- Verpacken des analytischen Testelements, sowie
- Speichern von Kalibrationsdaten auf dem verpackten analytischen Testelement.

16. Ein Verfahren zur Herstellung eines analytischen Testelements gemäß Anspruch 15 dadurch gekennzeichnet, dass das Verfahren vor den Schritten
- Verpacken des analytischen Testelements, sowie
- Speichern von Kalibrationsdaten auf dem verpackten analytischen Testelement
den Schritt
- Speichern einer Chargenidentifikation auf dem analytischen Testelement
beinhaltet.

17. Ein Verfahren zur Herstellung eines analytischen Testelements, das einen Bereich mit Nachweischemie zum Nachweis eines Analyten in einer Körperflüssigkeit aufweist, wobei die Herstellung die Schritte beinhaltet:
- Verpacken des analytischen Testelements in der Verpackung, sowie
- Speichern von Kalibrationsdaten auf der Verpackung.

18. Ein Verfahren zur Herstellung eines analytischen Testelements gemäß Anspruch 17 dadurch gekennzeichnet, dass das Verfahren vor den Schritten
- Verpacken des analytischen Testelements in der Verpackung, sowie
- Speichern von Kalibrationsdaten auf der Verpackung
den Schritt
- Speichern einer Chargenidentifikation auf einer Verpackung, die einen Speicher zur Speicherung von Daten und ein Sendemodul zur drahtlosen Übertragung von Daten aufweist,
beinhaltet.

19. Ein Verfahren zur Bestimmung der Konzentration eines Analyten in einer Körperflüssigkeit, das die Schritte beinhaltet:
- Einbringen eines Sendemoduls eines analytischen Testelements in einen Sende- und Empfangsbereich eines Lesemoduls eines Instruments, wobei
  das analytische Testelement einen Bereich mit Nachweischemie zum Nachweis eines Analyten in einer Körperflüssigkeit, einen Speicher zur Speicherung von Daten und das Sendemodul zur drahtlosen Übertragung der Daten aufweist, und das Instrument eine Auswerteeinheit zur Auswertung der Daten und das Lesemodul zur drahtlosen Übertragung der Daten aufweist,
- Auftragen der Körperflüssigkeit auf das analytische Testelement,
- drahtlose Übertragung der Daten vom analytischen Testelement zum Instrument, sowie
- Auswerten der Daten in der Auswerteeinheit des Instruments.

20. Ein Verfahren gemäß Anspruch 19 dadurch gekennzeichnet, dass das analytische Testelement in das Instrument eingelegt oder eingeschoben wird und dadurch das Sendemodul des analytischen Testelements in den Sende- und Empfangsbereich des Lesemoduls des Instruments eingebracht wird.

21. Ein Verfahren zur Bestimmung der Konzentration eines Analyten in einer Körperflüssigkeit, das die Schritte beinhaltet:
- Einbringen eines Sendemoduls einer Verpackung, in der ein oder mehrere analytische Testelemente mit Nachweischemie zum Nachweis eines Analyten in einer Körperflüssigkeit verpackt sind, in einen Sende- und Empfangsbereich eines Lesemoduls eines Instruments, wobei
  die Verpackung einen Speicher zur Speicherung von Daten sowie das Sendemodul zur drahtlosen Übertragung der Daten aufweist, und
  das Instrument eine Auswerteeinheit zur Auswertung der Daten und das Lesemodul zur drahtlosen Übertragung der Daten aufweist,
- Bereitstellen eines analytischen Testelements aus der Verpackung,
- Auftragen der Körperflüssigkeit auf das analytische Testelement,
- drahtlose Übertragung der Daten von der Verpackung zum Instrument, sowie
- Auswerten der Daten in der Auswerteeinheit des Instruments.

22. Ein Verfahren gemäß Anspruch 21 dadurch gekennzeichnet, dass die Verpackung in das Instrument eingelegt oder eingeschoben wird und dadurch das Sendemodul der

Verpackung in den Sende- und Empfangsbereich des Lesemoduls des Instruments eingebracht wird.

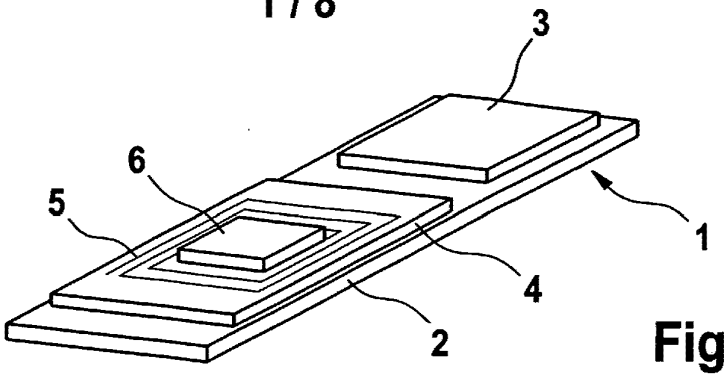


Fig. 1

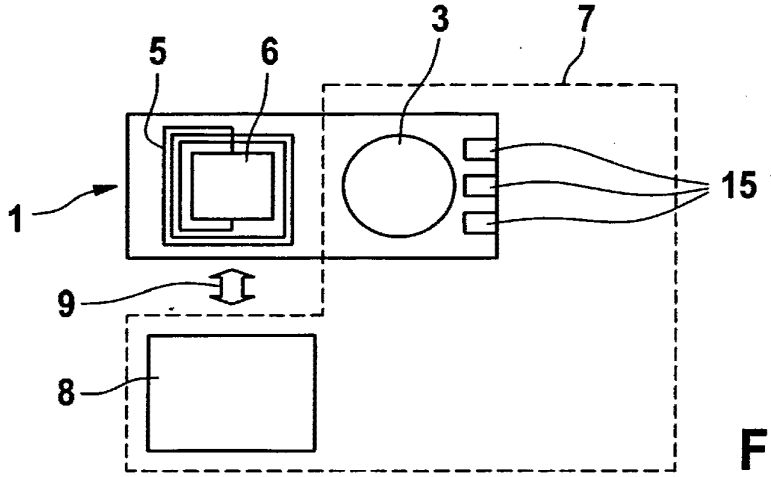


Fig. 2

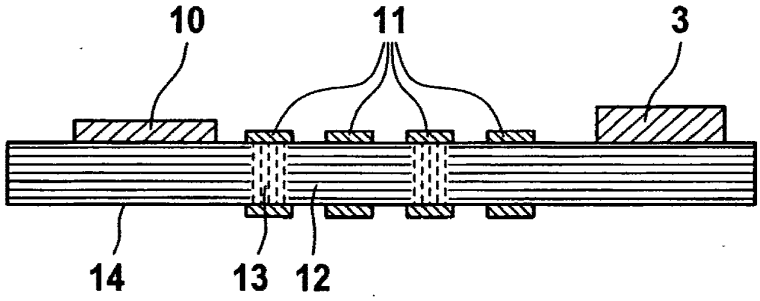


Fig. 3

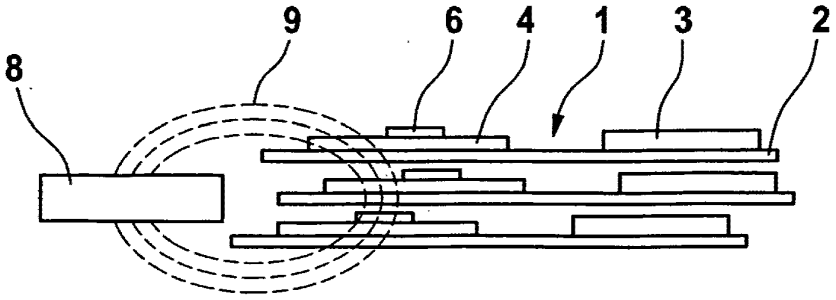


Fig. 4

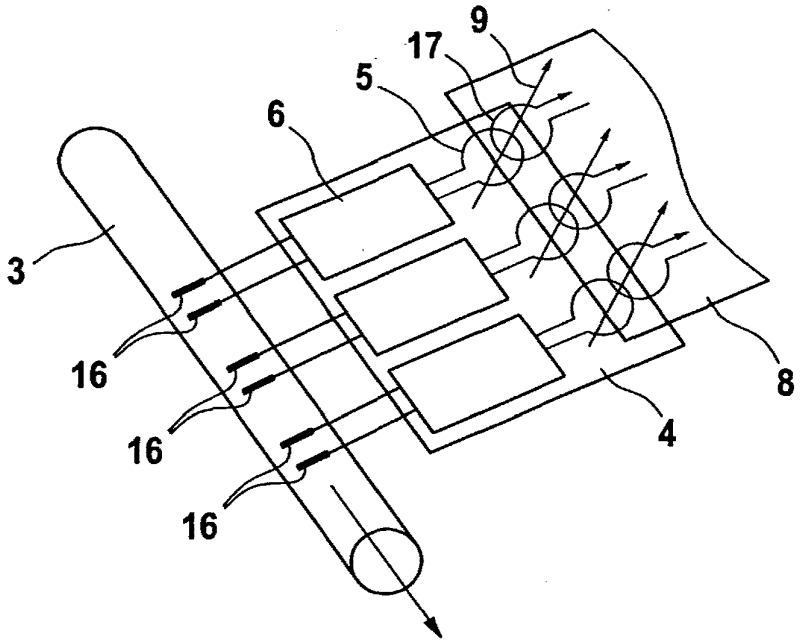


Fig. 5

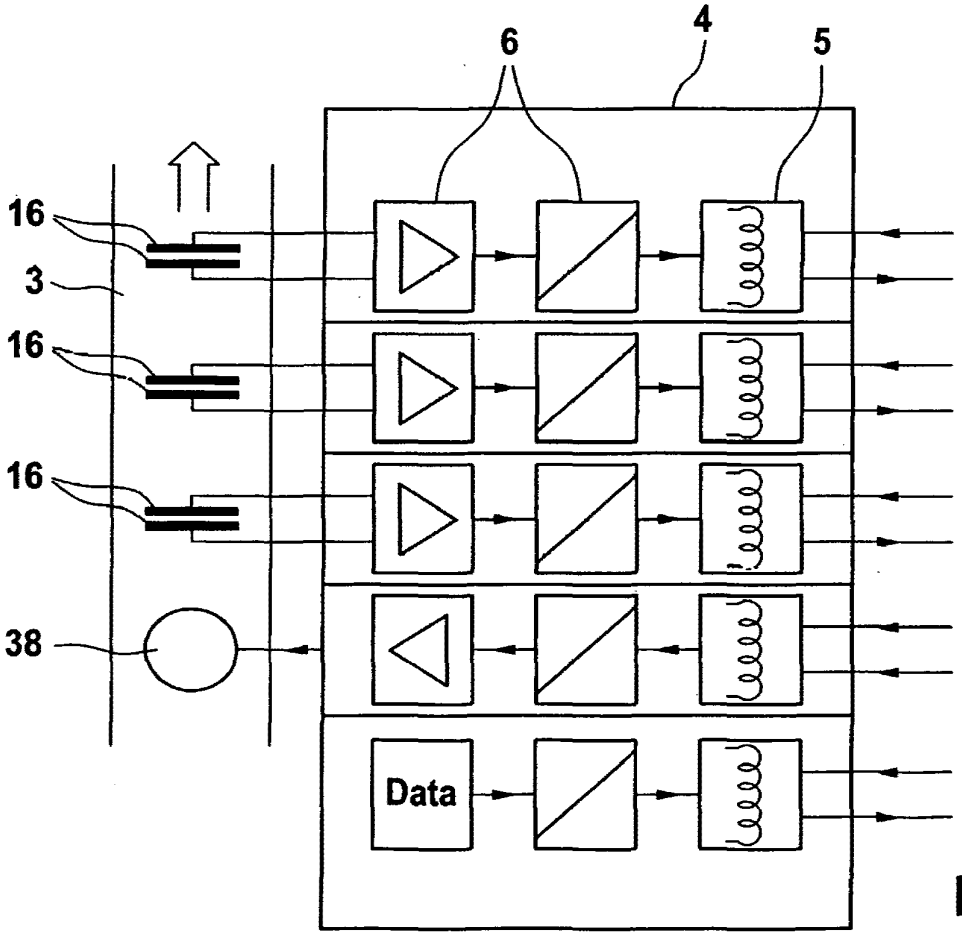


Fig. 6

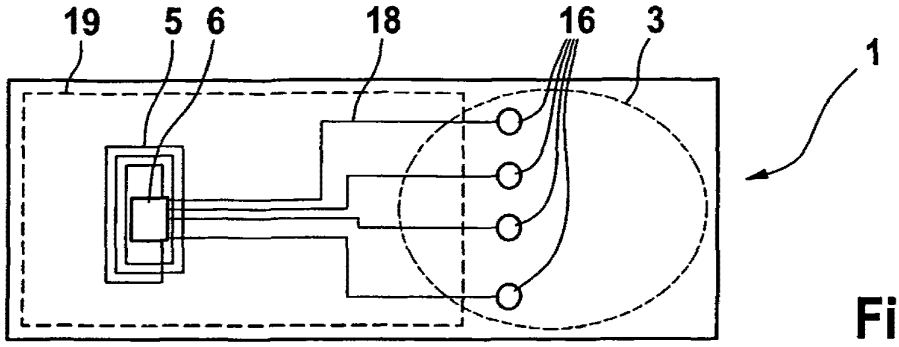


Fig. 7

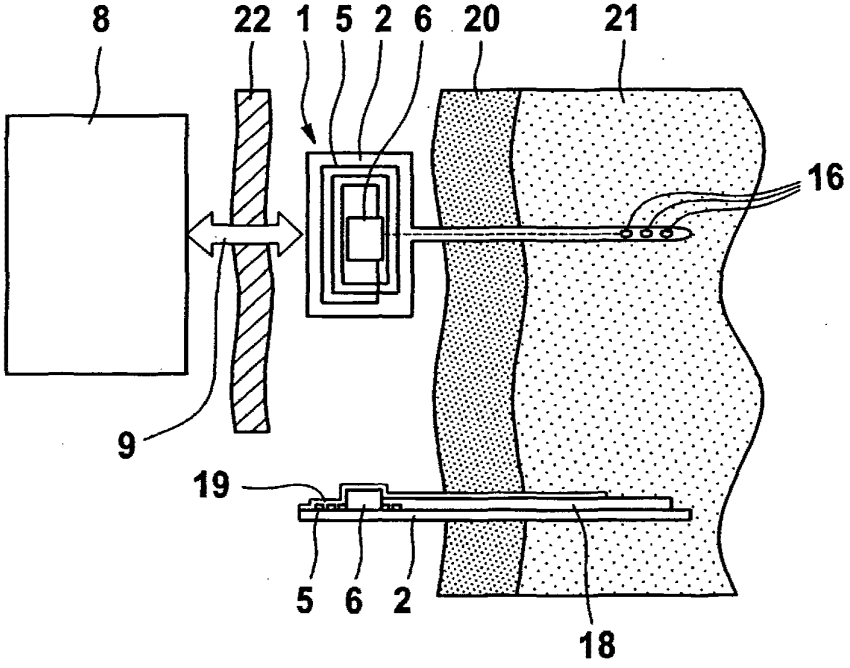


Fig. 8

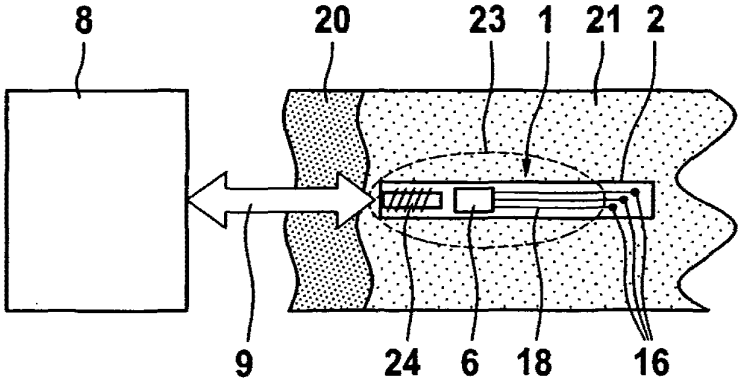


Fig. 9

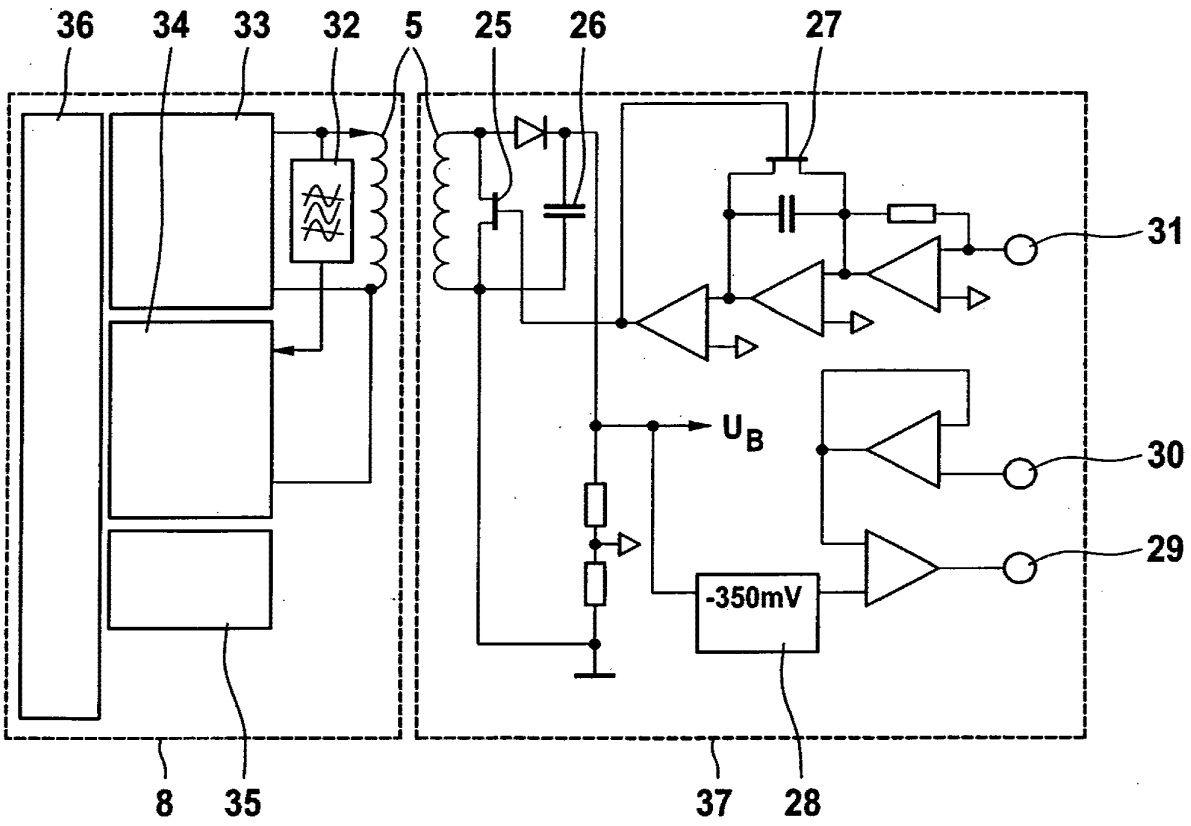


Fig. 10

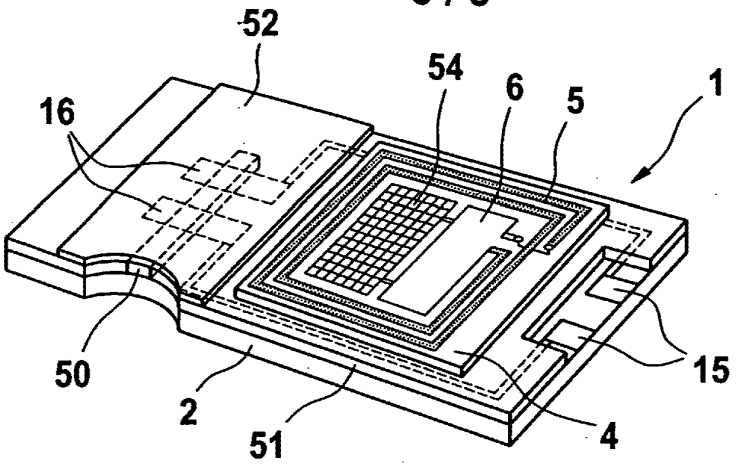


Fig. 11

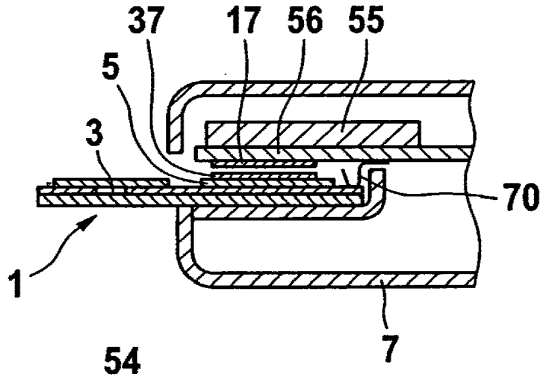


Fig. 12

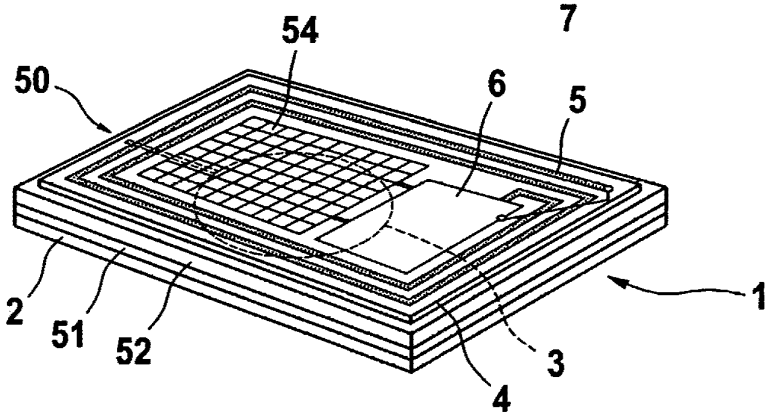


Fig. 13

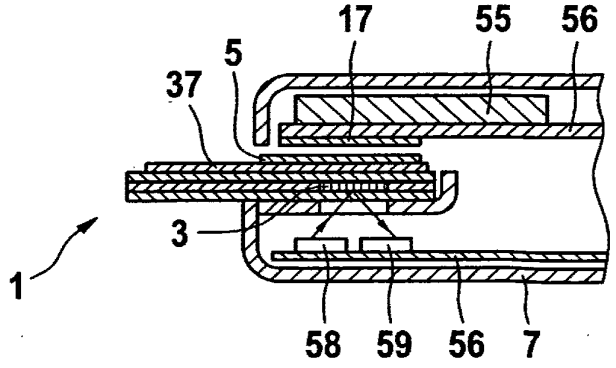


Fig. 14

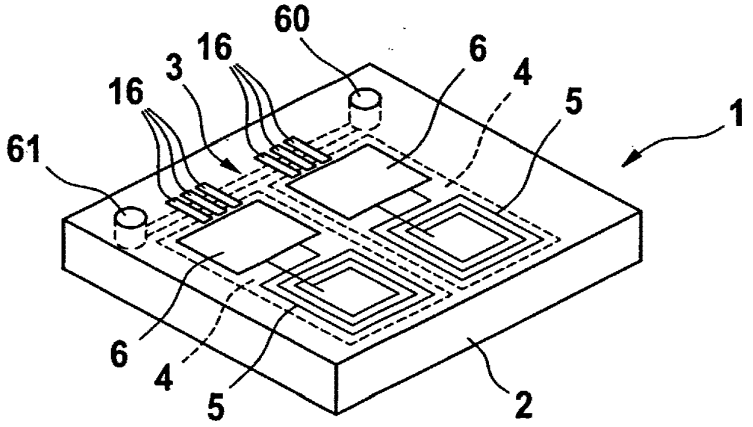


Fig. 15

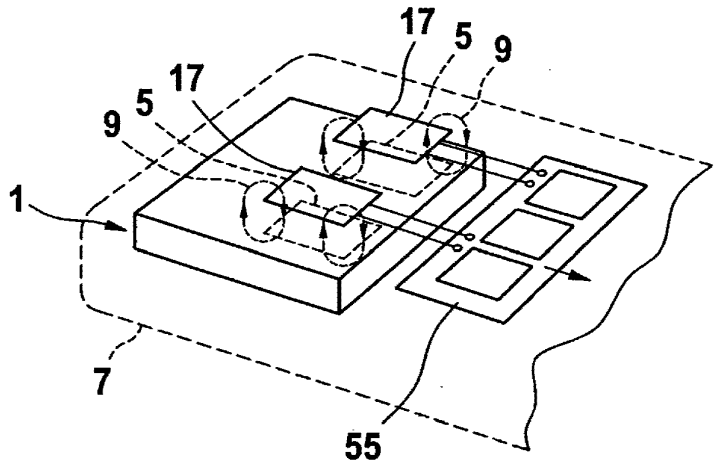


Fig. 16

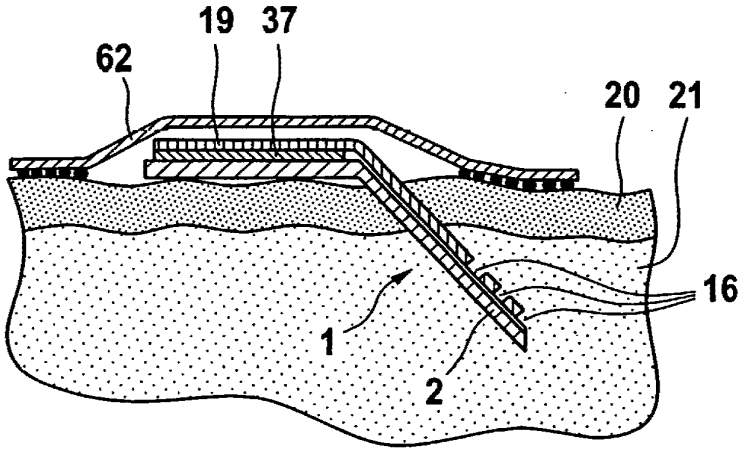


Fig. 17

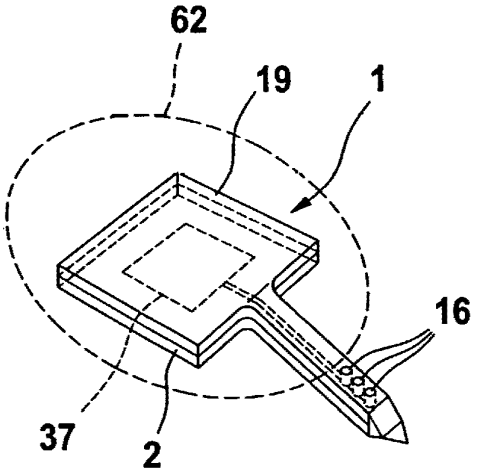


Fig. 18

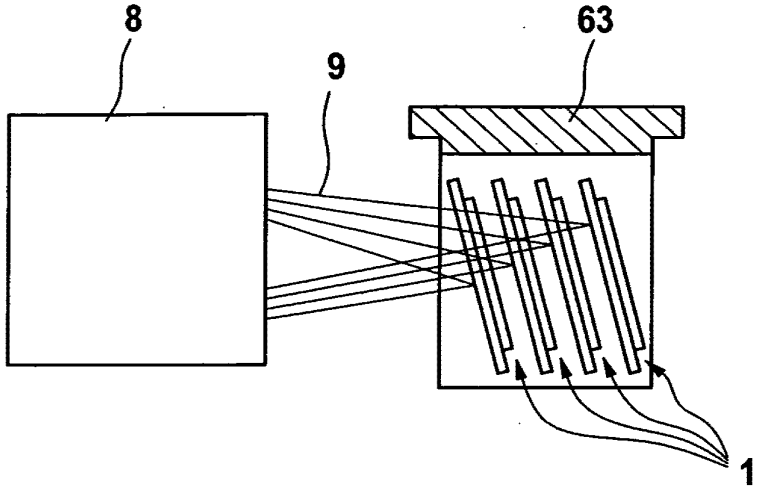


Fig. 19

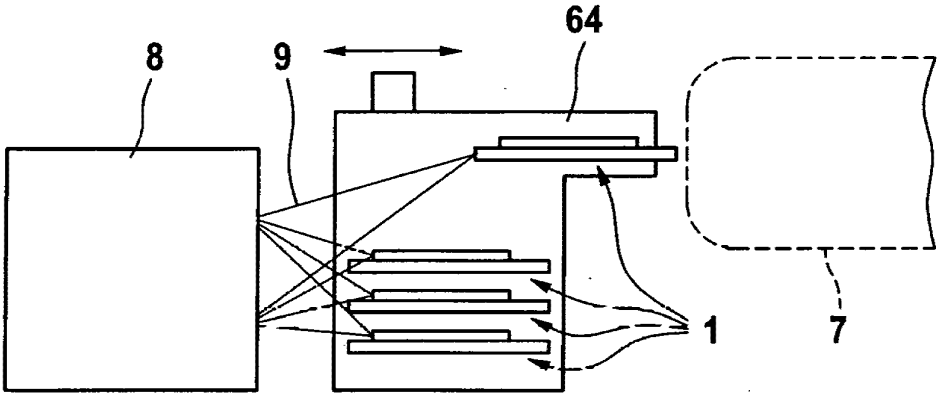


Fig. 20

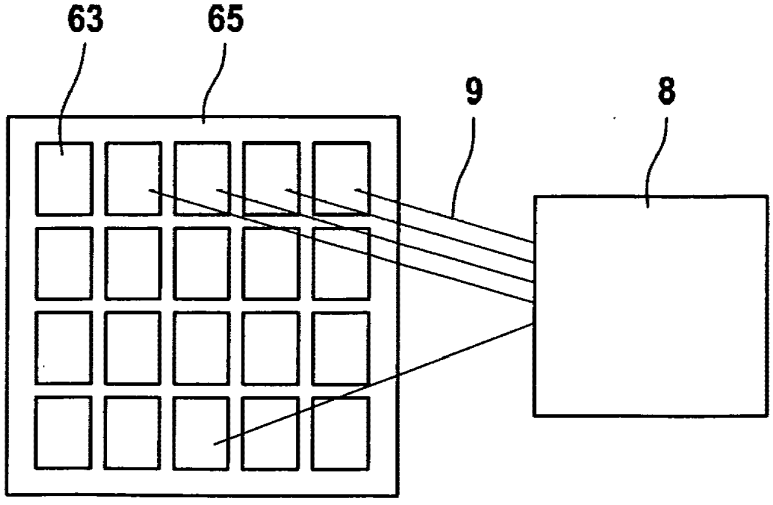


Fig. 21

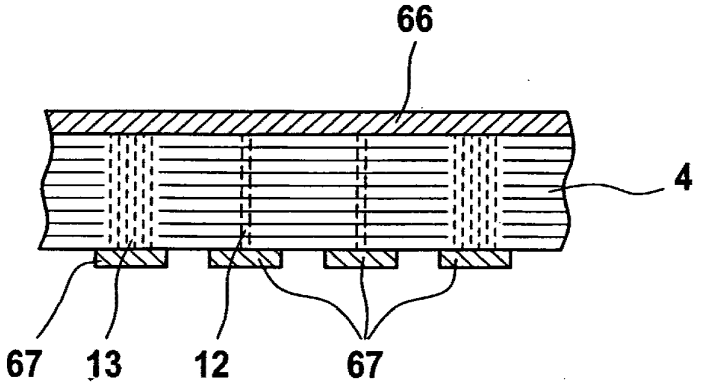


Fig. 22

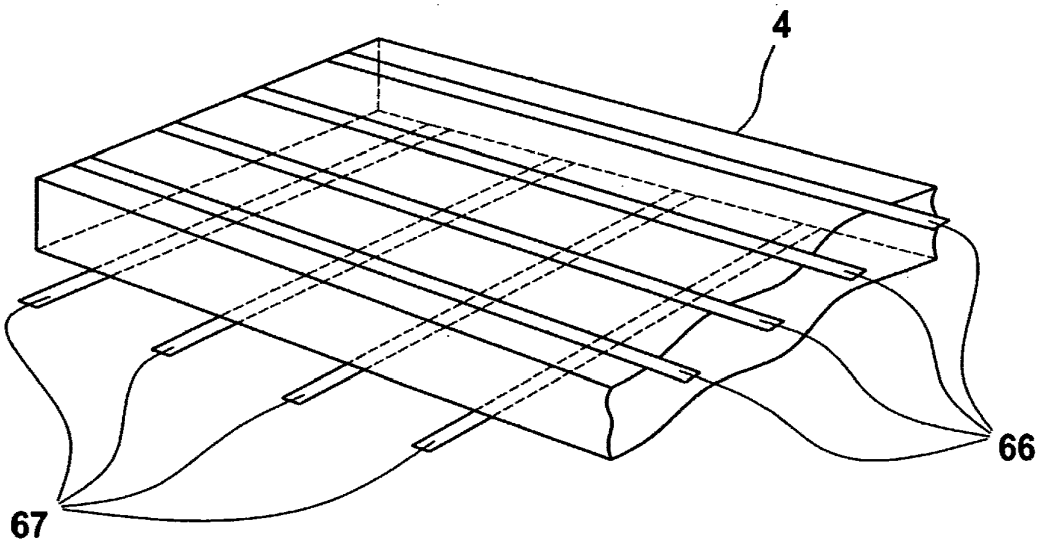


Fig. 23

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP2005/010806

A. CLASSIFICATION OF SUBJECT MATTER
G01N33/487 A61B5/00

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)
G01N A61B

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, WPI Data, PAJ, INSPEC, BIOSIS, EMBASE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 217 744 B1 (CROSBY PETER) 17 April 2001 (2001-04-17) cited in the application the whole document	2-9
Y	DE 102 37 602 A1 (I.E.M. INDUSTRIELLE ENTWICKLUNG MEDIZINTECHNIK UND VERTRIEBSGESELLSCHA) 18 March 2004 (2004-03-18) cited in the application the whole document	2-9
Y	DE 102 53 154 A1 (SIEMENS AG; ROCHE DIAGNOSTICS GMBH) 27 May 2004 (2004-05-27) cited in the application the whole document	2-9

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

[X] Patent family members are listed in annex.

° Special categories of cited documents :

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"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 when the document is taken alone

"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

Date of the actual completion of the international search	Date of mailing of the international search report
22 December 2005	10/01/2006

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Komenda, P

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Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP2005/010806

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	"Polytronic: Chips von der Rolle" FRAUNHOFER MAGAZIN, FRAUNHOFER GESELLSCHAFT, MUENCHEN, DE, no. 4, 2001, pages 8-13, XP002257822 ISSN: 1434-7113 the whole document	2-9
A	US 5 580 794 A (ALLEN ET AL) 3 December 1996 (1996-12-03) column 9, line 12 - line 28; figures 1,2	2-9
P,A	WO 2005/024375 A (POLYIC GMBH & CO. KG; CLEMENS, WOLFGANG; GERLT, AXEL; HAHN, ALEXANDER;) 17 March 2005 (2005-03-17) page 4, line 6 - line 26	2

1

Form PCT/ISA/210 (continuation of second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

mation on patent family members

International Application No
PCT/EP2005/010806

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6217744 B1	17-04-2001	NONE	
DE 10237602 A1	18-03-2004	NONE	
DE 10253154 A1	27-05-2004	AU 2003294625 A1	03-06-2004
		CA 2516490 A1	27-05-2004
		WO 2004044571 A1	27-05-2004
		DE 10394075 D2	06-10-2005
		EP 1563288 A1	17-08-2005
US 5580794 A	03-12-1996	AU 7563294 A	21-03-1995
		CA 2170402 A1	02-03-1995
		EP 0722563 A1	24-07-1996
		JP 9503581 T	08-04-1997
		WO 9506240 A1	02-03-1995
WO 2005024375 A	17-03-2005	DE 10341093 A1	14-04-2005

INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2005/010806

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
G01N33/487 A61B5/00

Nach der Internationalen Patentklassifikation (IPK) oder nach der nationalen Klassifikation und der IPK

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
G01N A61B

Recherchierte aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)
EPO-Internal, WPI Data, PAJ, INSPEC, BIOSIS, EMBASE

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	US 6 217 744 B1 (CROSBY PETER) 17. April 2001 (2001-04-17) in der Anmeldung erwähnt das ganze Dokument -----	2-9
Y	DE 102 37 602 A1 (I.E.M. INDUSTRIELLE ENTWICKLUNG MEDIZINTECHNIK UND VERTRIEBSGESELLSCHA) 18. März 2004 (2004-03-18) in der Anmeldung erwähnt das ganze Dokument -----	2-9
Y	DE 102 53 154 A1 (SIEMENS AG; ROCHE DIAGNOSTICS GMBH) 27. Mai 2004 (2004-05-27) in der Anmeldung erwähnt das ganze Dokument -----	2-9
	-/--	

[X] Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen

[X] Siehe Anhang Patentfamilie

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"&" Veröffentlichung, die Mitglied derselben Patentfamilie ist

Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
22. Dezember 2005	10/01/2006

Name und Postanschrift der Internationalen Recherchenbehörde	Bevollmächtigter Bediensteter
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Komenda, P

1

Formblatt PCT/ISA/210 (Blatt 2) (Januar 2004)

C.(Fortsetzung) ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie°	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
A	"Polytronic: Chips von der Rolle" FRAUNHOFER MAGAZIN, FRAUNHOFER GESELLSCHAFT, MUENCHEN, DE, Nr. 4, 2001, Seiten 8-13, XP002257822 ISSN: 1434-7113 das ganze Dokument	2-9
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(54) Title: A THREE-DIMENSIONAL ADHESIVE DEVICE HAVING A MICROELECTRONIC SYSTEM EMBEDDED THEREIN

(57) Abstract: Accordingly, the present invention relates to a three-dimensional adhesive device to be attached to the body surface of a mammal comprising a microelectronic sensing system 5 characterized by (a) a three-dimensional adhesive body made of a pressure sensitive adhesive having an upper surface and a bottom surface; (b) a microelectronic system embedded in the body of the pressure sensitive adhesive; 10 (c) one or more cover layer(s) attached to the upper surface; and (d) optionally a release liner releasable attached to the bottom surface of the adhesive device. Suitably the microelectronic system is a microelectronic sensing system capable of 15 sensing physical input such as pressure, vibration, sound, electrical activity (e.g. from muscle activity), tension, blood-flow, moisture, temperature, enzyme activity, bacteria, pH, blood sugar, conductivity, resistance, capacitance, inductance or other chemical, biochemical, biological, mechanical or electrical properties. 1

A three-dimensional adhesive device having a microelectronic system embedded therein

Field of invention

The invention relates to micro electronic systems predominantly for monitoring physiological or neurological conditions. More particular the invention relates to invasive and non-invasive microelectronic systems embedded in a three-dimensional adhesive device, which may be attached to the surface, suitably the skin, of a mammal. The microelectronic systems suitably utilises wireless communication and are useful for measuring ECG (Electro CardioGraphy), EMG (Electro MyoGraphy), EEG (Electro EncephaloGraphy), blood glucose, pulse, blood pressure, pH, and oxygen.

Background

The attachment of sensing systems to the skin by means of pressure sensitive adhesives is well established. Thus, AMBU A/S, DK has a number of products for measuring ECG, which is attached to the skin by foam adhesives, micro-porous adhesives or hydrogel adhesives. These sensors are in general connected with wires to a monitoring device.

In WO 03/065926 A2 Ozgus et al disclose a wearable biomonitor with a flexible and thin integrated circuit. The patent application addresses a way to achieve high comfort of wear by using a thin layer adhesive or pads of adhesive for fixation to the skin. However, the adhesives used are occluding. The application further describes a sensor module for wireless data collection having a thin sheet of silicon comprising the circuit and a flexible power source being build into the sensor module as layers.

In US 5,054,488 Mus et al disclose an opto-electronic sensor for producing electrical signals representative of a physiological condition. The sensors may be attached to the body by a double-sided pressure sensitive adhesive on a polyester lining.

In US 5,458,124 Stanko et al disclose electro-cardiographic-electrodes being attached to the body by double-sided pressure sensitive adhesive.

In US 6,372,951 Ter-Ovanesyan et al disclose a sensor operatively connected to a disposable article, fitted to the wearer by an adhesive patch. A wide variety of body adhering compositions may be used.

In US 6,385,473 Haines et al disclose a laminated sensor device attached to mammalian subject with two strips of hydrocolloid adhesive. The laminated structure consists also of hydrogel in contact with hydrocolloid adhesive. The lifetime of the device is specified to 24 hrs.

In WO 99/59465 Feierbach et al disclose an apparatus for monitoring the physiological condition of a patient. The apparatus includes a patch having a distal side for being fixed to the patient. Also the apparatus may include an electronics housing that may be coupled with said patch. In one embodiment the surface of the apparatus may be pre-formed to the contours of a body part. The patch carrying the electronic housing may be soft and provide a natural feel and may be produced from latex, silicon or another rubberised fabric. The upper surface of the patch with the electronic housing may have a smooth convex shape as illustrated in figure 2B and figure 8 of the patent. The patch is coupled to the skin of the the patient by an adhesive. Such adhesive may be a hydrocolloid skin protective adhesive manufactured by 3M. Hence the patent application teaches the use of a hydrocolloid adhesive liner for fixation of a sensor having a smooth and soft backing optionally in a pre-formed shape to fit a contour of the body.

In US application 2003/0009097 A1 Sheraton et al disclose a sensor having a hydrogel electric conducting central skin contacting part and a hydrocolloid adhesive part surrounding this central part for adhesion of the sensor and on said combined disc a conductive terminal connected to a wire. This construct is further protected by laminate film layers adhered to the terminal and the outer rim of adhesive. The patent application teaches the use of hydrocolloid adhesives for fixation of sensors to the skin and emphasizes the aspect of making very thin and flexible electrodes. The patent application is peculiar in the sense that it combines the use of hydrocolloid adhesives and hydrogels. For any practical purpose the disclosed constructs will be useless as the moisture from the hydrogel will migrate into the hydrocolloid adhesive and disrupt this over time.

Recent developments in devices for monitoring physiological conditions are wire-less types. Apart from being able to monitor a physiological condition invasively or non-

invasively and potentially compare to a reference, they are be able to process data and transmit them to a portable device. In fact the attachable device may also function as an alarm itself, e.g. by use of e.g. light emission, audio alarm or another warning signal.

When monitoring physiological or neurological conditions of the human body it is important that the attached microelectronic system is as comfortable to wear as possible, especially when the person carrying the device is not bedridden and shows normal physical activity or even excess physical activity like in sport or in sports medicine. The user should preferably not feel the attached microelectronic system and the monitoring should preferably be kept in private. However, in this respect the known microelectronic systems suffer from several major drawbacks as described below.

Attachment to the skin by means of occlusive pressure sensitive adhesives often leads to skin irritation due to the occlusion of moisture and due to irritants, such as monomers from the pressure sensitive adhesive polymer system, e.g. from for instance acrylic adhesives. Irritation may be the in form of itching and erythema and may especially develop when the adhesive device is attached for a prolonged period of time. Occlusion may also increase the risk of creating allergy to the adhesive composition. One often used way to solve the negative effects of occlusion is to use micro porous tapes, but such tapes are essentially two-dimensional and thin and does not protect the microelectronic system from shear forces due to friction against clothes and the like.

In the above references, the devices are attached to the skin by thin planar adhesive layers carrying the microelectronic system as a bulky part leading to discomfort of the patient or person carrying the device due to stiffness or friction against clothing and increasing the risk of involuntarily detachment from the skin. When such a device is to be used for a prolonged period of time, it is important to reduce any type of discomfort due to skin irritation or inconvenience of carrying a bulky device. Furthermore it is crucial for the signal detection that the adhesive device is kept fixed to the skin until it is deliberately removed.

Proper adhesion of the device requires a fairly thick layer of the planar adhesive. However, a fairly thick layer may show a tendency of adhering at the edge to clothing or linen and by doing so a tendency to roll and detach is created.

Many sensors are connected to the monitoring systems with wires. The disadvantage of such a system is that the patient does not have freedom to move since the wires are attached to the sensors on the body and connected to a monitoring system. Whenever the patient wants to move he must be careful not to dislodge any of the wires attached to the sensors, and he must further pick up the monitoring system and carry it along.

None of the above mentioned references describes a body sensor device consisting of an optionally hydrocolloid containing thermoplastic pressure sensitive adhesive and/or chemically curing pressure sensitive adhesive, moulded or cast into a three-dimensional adhesive body having a micro electronic system embedded therein as according to the present invention.

The known sensors overcoming some of the above-mentioned disadvantages are not as simple and inexpensive to manufacture with respect to the adhesive part of the device as the adhesive devices of the invention.

The adhesive devices of the invention having a microelectronic system embedded therein may be produced relatively easily and besides a cover layer and optionally a release layer, without the need of any other layers in the device and is therefore commercially attractive.

With an embedment of the micro electronic components an improved protection against mechanical damage and penetration of moisture from the surrounding environment is also achieved.

Furthermore, today many types of electronics are temporarily attached to different surfaces. Especially within medical care different types of medical devices such as probes and sensors are attached to different areas of the skin in order to, for example, detect different biomedical signals or retrieve samples from a patient. Often these medical devices are only attached for a limited period of time until a disease is diagnosed or a patient's health has improved. However, some chronic diseases may require periodical monitoring, for example while the patient is sleeping, or in some cases constant monitoring is desired day and night. The medical device, which is attached to the skin of the patient, may be adapted to detect many types of signals, it could for example be a sensor for detecting one or more signals such as electromyographic (EMG) signals, electrocardiographic (ECG) signals and electroencephalography (EEG) signals.

Such medical devices may be broken up into at least three general elements, a microelectronic element for measuring a desired value, such as for example a biosignal; an adhesive for attaching the microelectronic element to a surface; and a power source for powering at least a part of the microelectronic circuit.

The different elements have different lifespan, however, since the elements are typically assembled in one inseparable unit they are all disposed after use. When looking at the elements individually it may however be understood that they have different lifespan. Thus, the adhesive element typically has a one-time use only. The power source may in some cases be reused a few times depending on the application and the size of the battery. However, the microelectronic element may be reused a large number of times thereby making it an expensive element to dispose after one use only.

Thus in order to improve the cost effectiveness of the medical device there exists a need to be able to reuse the element(s), which are still operable after use.

US 2002/0180605 discloses a method of monitoring a physiological characteristic. The method disclosed can include subsequent steps of removing adhesive pads from a sensor module and heating the senor module in an autoclave for sterilization after data has been transferred from the sensor module to the receiver module.

Summary of the Invention

Accordingly, the present invention relates to a three-dimensional adhesive device comprising an microelectronic sensing system characterized by

(a) a three-dimensional adhesive body made of a pressure sensitive adhesive having an upper surface and a bottom surface;
(b) a microelectronic system embedded in the body of the pressure sensitive adhesive;
(c) one or more cover layer(s) attached to the upper surface; and
(d) optionally a release liner releasable attached to the bottom surface of the adhesive device.

Suitably, the microelectronic system is a microelectronic sensing system. The microelectronic sensing system is suitably capable of sensing physical input such as pressure, vibration, sound, electrical activity (e.g. from muscle activity), tension, blood-flow, moisture, temperature, enzyme activity, bacteria, pH, blood sugar, conductivity, resistance, capacitance, inductance or other chemical, biochemical, biological, mechanical or electrical input.

Brief description of the Drawings

Figure 1 shows a die section of the shape of a typical representative of the adhesive device according to the invention. CT is the maximal thickness of the device and PT is the thickness in the periphery of the device.

Figure 2 illustrates a microelectronic system embedded/integrated in a three-dimensional (3D) adhesive. The zoom-box indicates the part of the adhesive device illustrated in figure 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12.

Figure 3 illustrates a microelectronic system (hatched box) that is completely integrated within the adhesive body.

Figure 4 illustrates that parts of the microelectronic system may be positioned in different locations integrated within the adhesive device with proper mechanical or electrical interconnection between the parts.

Figure 5 illustrates a microelectronic system, which is applied into a recess in the adhesive body. The recess is distal to skin fixation area. The microelectronic system may optionally be exchangeable, or reusable.

Figure 6 illustrates the microelectronic system in which the upper part may be exchangeable or reusable and the lower part be permanently integrated in the adhesive body.

Figure 7 illustrates that parts of the microelectronic system may be situated in different locations within the adhesive device with proper mechanical or electrical interconnection between the parts.

Figure 8 illustrates a microelectronic system, which is embedded/applied into a recess on the adhesive side of the adhesive body.

Figure 9 illustrates a device with a microelectronic system in which the lower part may be exchangeable or reusable and the upper part be permanently integrated in the adhesive body.

Figure 10 illustrates a system with some microelectronic components integrated within the adhesive body during production (small hatched box) and some microelectronic components applied later thereby establishing the necessary mechanical/electrical connections.

Figure 11 illustrates a microelectronic system embedded in the adhesive which system is applicable and accessable both from the distal side and the skin fixation side of the adhesive body.

Figure 12 illustrates a system where the microelectronic system is assembled from two parts one of which, or each of which may be exchangeable or reusable.

In all the above constructs of the invention the upper surface remains smooth irrespective the presence of components of the microelectronic system at the upper surface. This may be achieved by proper construction of the microelectronic components, encapsulation etc.

The constructions shown in figures 8, 9, 10, 11 and 12 are particularly suitable for microelectronic systems including an element, e.g. an electrode which should have skin contact.

Figures 13 -18 illustrates an embodiment of the invention where an antenna, a Central Processing Unit, a battery and electrodes are embedded in an adhesive device. Figure 13 illustrates the two-dimensional shape of the device indicating a cross-section by A-A. In Figure 15 the third dimension is shown as the cross-section A-A. The circle B from the rim of the device is further magnified in figure 16 and the circle C of the centre is like wise magnified in figure 17. Figure 14 illustrates the position of the antenna placed in the outer part of the adhesive device and being connected to the central part of the microelectronic

system. Figure 16 shows more in detail the building of the antenna lying embedded in the adhesive. Figure 17 shows the position of the central part of the microelectronic system with a battery, a CPU and an electrode protruding the adhesive. The battery and the CPU are enveloped in a transparent silicone rubber. Finally figure 18 illustrates the adhesive device in a three-dimensional mode.

Fig. 19 shows one embodiment of a sensor assembly according to the invention seen in a exploded perspective view.

Fig. 20 shows the embodiment of a sensor assembly in a sectional view along line XX – XX in Fig. 19.

Fig.21 shows the embodiment of a sensor assembly seen from the bottom.

Fig. 22a and 22b shows another embodiment of a device according to the invention wherein Fig. 22b shows a portion of Fig. 22a in an enlarged view.

Fig. 23 shows yet another embodiment of a device according to the invention seen in a perspective view.

Fig. 24 shows the embodiment of a device according to the invention in a sectional view along line XXIV – XXIV in Fig. 23.

Detailed description of the Invention

The present invention relates to adhesive devices having a microelectronic system embedded in an adhesive body made from a pressure sensitive adhesive.

In the following the term "three-dimensional" used when defining an element e.g. an adhesive body or device, refers to an element having a considerable varying contour when seen in cross section. Thus, for example a three-dimensional adhesive body will have a maximum thickness and a minimal thickness. According to the invention the maximum thickness will be at least twice the thickness of the minimal thickness. In a preferred

embodiment the outer rim or the peripheral edge of the adhesive device has a thickness which is less than half of the thickest part of the sensor, normally the central part.

In contrast to the term "three-dimensional" the term "two-dimensional" used when defining an element refers to an element, which has a generally planar surface. Thus, the maximum thickness of a two-dimensional adhesive body is below two times the minimal thickness of the adhesive body.

As used herein in relation to the micro electronic system or components thereof, the term "embedded", means that the pressure sensitive adhesive of the adhesive body is surrounding all or some of components of the micro electronic system, either partly or fully. Thus, the term embedded covers the situation where all sides of the system or component(s) is covered by the adhesive of the adhesive body and also the cases where not all sides of the embedded item is covered with the adhesive of the adhesive body, e.g. when the item is placed in a recess or cavity in the adhesive body and is accessible from the outside.

As "embedded" is the general term used for the description of the way the micro electronic system is positioned in the adhesive body the term "integrated" means that the micro electronic system or specific components thereof are covered by adhesive on all sides and the term "applied" is used when the micro electronic system only is partly covered.

Integrated and covered on all sides also covers the situation where the integrated component is connected, e.g. electrically or otherwise to another component embedded in the adhesive body.

As used herein, a microelectronic "sensing" system means a microelectronic system comprising a transducer having an element capable of detecting a physiological or neurological condition.

As used herein through hole means a hole through the adhesive body having opening(s) at the upper surface of the adhesive body and opening(s) at the bottom surface of the adhesive body. Preferably the through hole has one opening at the upper surface and one at the bottom surface of the adhesive body. The through hole may have any suitable shape.

By the "thickness" of the adhesive device is meant the length of the shortest line which may be drawn between a specific point on the upper surface to a point on the bottom surface, or the shortest line which may be drawn between a specific point on the bottom surface to a point on the upper surface.

For the purpose of the present invention the expression "skin" is used to designate the outer surface of mammals.

As mentioned above, it has surprisingly been found that a wire-less microelectronic systems in which the micro electronic parts are embedded in a three-dimensionally shaped pressure sensitive adhesive body solve the problems of the known sensor devices.

Due to the properties of the three-dimensional pressure sensitive adhesives, an optimal protection of the micro electronic system is created. The adhesive provide sealing towards the skin surface and the adhesive device is protected from exterior liquids due to the polymeric cover layer(s) on top of the adhesive device. Furthermore the adhesive protects the embedded micro electronic parts from mechanical damage.

The adhesive bodies according to the invention are made from pressure sensitive adhesives that are shaped three-dimensionally, having a varying thickness from the centre to the peripheral edge of the adhesive body and having the micro electronic sensing system embedded within the adhesive body, suitably where the adhesive body is thickest.

A device with such a shape and suitably with bevelled edges provides a smooth interface with the skin. The adhesive device will give a gentle feel and will not tend to give friction to clothes and linen. A special advantage will be that the adhesive device will less easily involuntarily fall off due to bulkiness and adhesiveness at the edge. This is very important to the very function of the device.

Moreover, the construction of the adhesive device is simple and convenient as the adhesive body have a triple function as the means for fixation of the device to the skin, the means for protection of the microelectronic system and the means for shaping the device into a convenient shape. The construction require less components and process

steps in the assembly of the three-dimensional device and is therefore less expensive and easier to manufacture.

According to one embodiment of the invention, the three-dimensional adhesive body has an essentially planar bottom surface adapted to adhere to the body surface of a mammal and an smooth upper surface. The adhesive device is suitably thickest at the central part of the body and thinnest at the periphery of the body.

Preferably, the upper surface has a smooth convex surface, but it may in principle take any form.

The outer rim or the peripheral edge of the adhesive device must be shaped to a thickness less than half of the thickest part of the sensor, normally the central part.

Thus, in a further embodiment of the invention, the thickness of the adhesive device at the periphery is less than 50 % of the thickness of the adhesive device where it is thickest, suitably the thickness at the periphery is less than 25 % of the thickness of the adhesive device where it is thickest, preferred the thickness at the periphery is less than 10 % of the thickness of the adhesive device where it is thickest, and most preferred the thickness at the periphery is less than 5 % of the thickness of the adhesive device where it is thickest.

The thickness at the periphery of the adhesive device is typically under 0.4 mm. In one embodiment the thickness may be between 0.01 and 0.4 mm. Suitably, the thickness at the periphery of the adhesive device is above 0.05 mm, preferably between 0.05-0.4 mm.

Typically the adhesive device is between 0.5 and 15 mm, more suitably between 1 – 5 mm where it is thickest, typically but not necessarily, at the centre of the adhesive body.

Suitably, the angle between the bottom surface of the adhesive device and a line drawn from any point of the circumference of the bottom surface and the point at the upper surface where the adhesive body is thickest is below 60 degrees, preferably below 45 degrees and most preferably below 30 degrees.

The outer rim of the adhesive body may suitably be shaped circular or oval, with or without flaps and lobes, or it may be shaped rectangular or triangular to obtain as convenient and safe a device as possible.

Normally the outer rim of the adhesive body will consist of the adhesive of the adhesive body. However, there may be embodiments where the microelectronic system or component(s) thereof, is placed in/or at the outer rim, whereby the outer rim does not solely consists of the adhesive of the adhesive body.

The pressure sensitive adhesive making up the three-dimensional adhesive body is suitably a mouldable thermoplastic or chemically curing pressure sensitive adhesive having a flexibility enabling the adhesive device to conform to the curvature of body parts while retaining its adhesive properties even under movements.

Suitable, pressure sensitive adhesives making up the adhesive body is an adhesive based on polymers selected from block-copolymers such as styrene-block-copolymers, and hydrogenated styrene-block-copolymers, amorphous poly-alpha-olefins (APAO), polyacrylics, polyvinylethers, polyurethanes, polyelhylenevinylacetate, silicone or from the group of hydrogel pressure sensitive adhesives.

Pressure sensitive adhesives based on these polymers are known and the skilled person knows how to prepare adhesives based on these polymers.

The block-copolymers, such as styrene-block-copolymers, and hydrogenated styrene-block-copolymers, may suitable be selected from Styrene/ethylene-Butylene/Styrene (SEBS), Styrene/Isoprene/Styrene (SIS), and Styrene/Ethylene-Propylene/Styrene (SEPS).

The adhesive may also be based on PDMS (polydimethylsiloxane), and may suitably be a PDMS gel.

Hydrogel adhesives may also be based on or comprise amfifilic polymers, polyvinylpyrrolidone, polyvinyl alcohol, polyethyleneoxide, gelatins, natural gums and cellulose derivatives or any combinations thereof.

The pressure sensitive adhesive may be formulated according to the principles and based on the polymers listed and disclosed in the handbook of Donatas Satas: Handbook of pressure sensitive adhesive technology, Third edition.

In one particular embodiment of the invention, the pressure sensitive adhesive making up the adhesive body comprises hydrocolloids. The pressure sensitive adhesive comprising the hydrocolloids may be any of the above-mentioned types of pressure sensitive adhesive or any other pressure sensitive adhesive known in the art.

Thus, U.S. Patent No. 3,339,549 discloses a blend of a rubbery elastomer such as polyisobutylene and one or more water-soluble or water swellable hydrocolloids such as a powdery mixture of pectin, gelatine and carboxymethylcellulose. The adhesive mass has a water-insoluble film applied to one surface. A composition of this type is available commercially from E.R. Squibb & Sons Inc. under the trademark "Stomahesive" and is used as a skin barrier around stomas to prevent skin breakdown by the corrosive fluids discharged by the stoma.

In adhesive compositions of this type, the polyisobutylene is responsible for provision of the adhesive properties and the dispersed hydrocolloid powders absorb fluid and render the adhesive agent capable of also adhering to moist skin (wet tack). These compositions are also gaining increasing acceptance as wound dressings for dermal ulcers, burns and other exuding wounds.

In a number of embodiments, styrene copolymers have been incorporated which are disclosed in a number of patent references.

Thus, US Patent No. 4,231,369 Sorensen et al. disclose an ostomy skin barrier consisting of a styrene copolymer having dispersed therein a water-soluble hydrocolloid gum and a tackifier.

In US Patent No. 4,367,732 Poulsen et al. disclose an ostomy skin barrier consisting of a water soluble hydrocolloid dispersed in a continuous phase consisting of a styrene copolymer, a hydrocarbon tackifier, and a plasticizer, an antioxidant, and an oily extender.

US Patent No. 4,551,490 (Doyle et al.) discloses medical grade pressure sensitive adhesive compositions comprising a homogeneous mixture of 5-30% of one or more polyisobutylenes, 3-20% of one or more styrene radial or block type copolymers having a content of diblock copolymer below 20%, mineral oil, one or more water soluble hydrocolloid gums, and a tackifier. One or more water swellable cohesive strengthening agents, an antioxidant, and various other optional ingredients also may be included within the adhesive composition.

US patent No. 5,492,943 discloses a pressure sensitive adhesive composition including a blend of two viscoelastic adhesive elastomers, specifically, high molecular weight polyisobutylene and a styrene block copolymer, which along with a plasticizer (preferably petrolatum) and a suitable tackifier and antioxidant, form a continuous phase in which hydrocolloids such as sodium carboxymethylcellulose and pectin are dispersed.

In US patent 4,867,748 Samuelsen disclose geometries of sealing pads from hydrocolloid adhesives combined with backing films and the processing of such.

The adhesive compositions disclosed in US patent No. 5,492,943 are stated to be used for wafers for adhering ostomy appliances to the skin and differ from known compositions by comprising styrene block-copolymers having a higher content of diblock copolymer, completely avoiding the use of low molecular weight polyisobutylene and furthermore by preferably not including gelatine.

Pressure sensitive adhesives containing hydrocolloids is a particularly suitable group of adhesives being characterized by having a particulate phase of hydrocolloids dispersed in the adhesive phase. An adhesive containing hydrocolloids may absorb moisture from the skin avoid occlusion of the skin, while maintaining its adhesive properties to skin. Moreover, and adhesive body containing hydrocolloids may have any thickness and still having the non-occlusive properties. A hydrocolloid adhesive may be processed as a hot melt and is easily moulded into specific shapes.

This means that the hot melt property combined with the easy moulding enables graduation of the thickness of the adhesive body from the edge of the adhesive device comprising the microelectronic system to the central parts giving a smooth non-abrupt projecting profile.

Recipes for making pressure sensitive adhesives useful for an adhesive body according to the invention are described in more detail below.

Thus, a typical pressure sensitive adhesive composition comprises a substantially homogeneous mixture of 10-60 weight percent of one or more rubbery elastomeric components, 5-60% of one or more absorbent particles, 0-50% tackifier resin, 0-10% of a plasticiser and 0-60 % of a non-polar oily extender, based on the total weight of the composition.

The rubbery elastomeric base could be selected from the group consisting of physically cross-linked elastomers (suitably block copolymers containing polystyrene blocks), a chemically cross-linked natural or synthetic rubbery elastomer, or a rubbery homopolymer.

A physically cross-linked elastomer selected from block-copolymers of styrene, and one or more butadienes may be a styrene-butadiene-styrene block copolymer, a styrene-isoprene copolymer and is preferably a mixture of styrene-isoprene-styrene and styrene-isoprene block copolymers.

A chemically cross-linked rubbery elastomer may be e.g. butyl rubber or natural rubber.

A rubbery homopolymer may be a polymer of a lower alkene such as low density polyethylene or propylene, preferably atactic polypropylene (APP) or polyisobutylene.

A tackifying resin optionally used in accordance with the invention is preferably a hydrogenated tackifier resin and is more preferred selected from a group comprising polymers and copolymers of cyclopentadiene, dicyclopentadiene, alpha-pinene or beta-pinene.

When the physically cross-linked elastomer is a styrene-butadiene-styrene block copolymer or a styrene-isoprene-styrene block copolymer, the adhesive suitably comprise 0-10% of a plasticiser e.g. (citrofol BII, DOA).

The swelling hydrocolloid particles preferably consist of one or more water-soluble or water swelling hydrocolloid polymers or gums.

Suitable hydrocolloids include synthetic polymers that may be either linear or cross-linked, such as hydrocolloids prepared from lactams or polyvinyl pyrrolidone. Other monomers useful to prepare a synthetic hydrocolloid include acrylates, methacrylates and watersoluble amides.

Other hydrocolloidal polymers, either naturally occurring or synthetically prepared, are useful according to the present invention. These materials include polyvinyl alcohol, polyoxyalkylenes, and naturally occurring or synthetically modified hydrocolloids such as polysaccharides, gums, and modified celluloses.

Representative polysaccharides include starch, glycogen, hemicelluloses, pentosans, celluloses, pectin, chitosan, and chitin. Representative gums include Arabic, Locust Bean, Guar, Agar, Carrageenan, Xanthan, Karaya, Alginates, Tragacanth, Ghatti, and Furcelleran gums. Representative modified celluloses include methyl cellulose, hydroxypropyl methyl cellulose, carboxymethyl, cellulose, and hydroxypropyl cellulose.

Preferred hydrocolloids include polysaccharides, such as starch, glycogen, hemicelluloses, pentosans, gelatin, celluloses, modified celluloses, pectin, chitosan, and chitin. Modified celluloses include methyl cellulose, hydroxypropyl methyl cellulose, carboxymethylcellulose, and hydroxypropyl cellulose. A most preferred hydrocolloid is a water soluble or swelling hydrocolloid chosen from the group consisting of polyvinyl alcohols, powdered pectin, gelatin, methyl cellulose, hydroxypropyl methyl cellulose, carboxymethyl cellulose, hydroxypropyl cellulose and mixtures thereof. In one preferred embodiment, the hydrocolloid is carboxymethyl cellulose (CMC).

Suitable swelling colloids are small spherical particles based on cross-linked polyacrylic acid polymers. Examples of such materials may be found in U.S. Patent No. 4,867,748, EP 0 122 344, and US patent application No. 2004065232.

Sometimes the skin for attachment of the adhesive device may be moist or even wet. In these circumstances, the normal adhesives may not give a sufficient strong and permanent attachment of the adhesive device. Specialised adhesives useful in these circumstances are hydrogel adhesives. Such adhesives are based on hydrophilic polymers and extenders enabling an even uptake of moisture over the complete skin-contacting surface of the adhesive. A wide range of compositions of such hydrophilic

adhesives exists. Hydrophilic polyacrylates with high content of acid groups optionally being partly neutralised, is a major representative in this group of adhesives. These adhesives may be inherent adhesive or may be formulated with tackyfiers and extenders to the desired adhesive properties in dry conditions. When getting moist, the adhesiveness will increase vastly depending on the formulation as the uptake of water will transform the adhesive to a more plastic state. Alternative adhesives are based on polymers like polyvinyl pyrrolidone, polyvinyl alcohol, polyethylene oxide and the like. Amphiphilic polymers or polymers which may be chemically cross-linked by radical polymerisation may be added to improve the cohesion of the adhesive and extenders like polyethylene glycol, polypropylene glycol and glycerol are typically preferred.

Adhesive compositions based on polydimethylsiloxane (PDMS) have been known since the 1970's. Recently a new subclass of PDMS based pressure sensitive adhesives has developed namely soft silicone adhesives. Soft silicone adhesives (SSA' s) are two-part, solventless adhesives based on a cross-linked, silicone elastomeric structure. The cross-linking is a result of an addition reaction between a polydimethylsiloxane with vinyl groups and hydrogen functional siloxanes. The cure reaction is catalysed by a platinum complex and can occur at room temperature or can be accelerated at elevated temperature (80 degree C to 145 degree C) without the formation of by-products. Such adhesives are characterised by being soft and by conforming to the surface structure of the skin, whereby quickly wetting of the skin is achieved. Because the viscous component is minimal, the material does not flow and only small dissipation of the energy occurs when deformation pressure is applied. The result is an immediate debonding, which happens at low-peel or shears force, which for some instances may be advantageous.

Apart from being excellent skin adhesives PDMS based pressure sensitive adhesives may have the further properties of being reusable, since they can be cleaned with tap water and be reapplied to the skin.

The pressure sensitive adhesive used for making the adhesive body of the invention could also be a PDMS gel often described as a tacky gel. Examples of such commercially available systems are Dow Corning 7-9800 A&B, from Dow Corning HealthCare US or SilGel 612 from Wacker-Chemie GmbH, Burghausen, Germany, and MED-6340 from NuSil Technology, Carpinteria, USA.

The above mentioned pressure sensitive adhesive can either be used in a non-foamed version or in a foamed version. When gas bubbles are introduced into pressure sensitive adhesives during the manufacturing process a lightweight, cellular structure is produced. Such a pressure sensitive adhesive is more flexible than the non-foamed versions. (see US patent No. 6,326,524 and US patent application No. 2004065232).

In general the adhesive body of the present invention has the desirable elastic, adhesive, moisture transmitting and/or absorptive properties as well as a high conformability and flexibility. The flexibility provides a composition that has the ability to conform to the curvature of body parts while retaining its adhesive properties even under movements. The high initial tack at room temperature provides for easy application of the adhesive device.

The adhesive device of the invention has on the upper surface one or more cover layers of any nature, preferably only one cover layer, to protect against adhesion to linen, clothes and other environment.

As a cover material, it is preferred to use a film in the form of a thermoplastic polymer film or a woven or non-woven layer. The cover layer is preferably made of an elastic material. The cover layer is suitably capable of transmitting moisture and may e.g. be made from polymers such as polyolefin types e.g. polyethylene, polypropylene or polybutylene, polyamide such as nylon, polyurethane, polyvinyl acetate, polyvinyl chloride, fluorinated polyvinyl compound, polyvinylidene chloride, polyvinyl alcohol, ethylene vinyl acetate, cellulose acetate or other thermoplastic polysaccharides, polyether block amides like PEBAX , block copolymers like styrene-isoprene-styrene block copolymers or ethylene acrylate block copolymers, polyesters such as polyethylene terephthalate (PET) or derivates thereof and any laminates from such polymers. The cover layer may suitably be a thin foam layer like made from polyurethane, polyethylene or polyvinyl acetate.

The cover layer or film protects the integrated /embedded microelectronic components as well as the adhesive body against the environment.
In one particular embodiment of the invention, an antenna can be printed directly on the cover layer by means of conductive ink or printed metal.

Prior to application to the skin a protective release liner covers the skin contacting side of the pressure sensitive adhesive body, in order to ensure that the properties of the adhesive are preserved and that the adhesive surface is not laid open until just before the use. The release liner is suitably a siliconised or fluorinated release liner, such as a siliconised or fluorinated craft paper, polyethylene, polypropylene or polyethylene terephthalate film. Suitably, the release liner is a siliconised polyethylene film, such as medium density polyethylene from the company Huhtamaki.

The microelectronic system comprises a number of components, which may be assembled into one, optionally encapsulated unit, which is incorporated into the adhesive device of the invention. The components of the microelectronic sensing system may also be an assembly of the individual, optionally encapsulated, components located at different positions in the adhesive device. This embodiment of the invention covers the situation where the adhesive devices have all the individual components of the microelectronic device located in different positions, as well as the situation where one or more of the components is located at a position different from the position of the rest of the components which are located at the same position.

When the components of the microelectronic device are located at different positions in the adhesive device, the adhesive device also has the necessary mechanical or electrical connections between the components integrated into the adhesive body.

Thus, according to one embodiment of the invention, the entire microelectronic system is integrated into the adhesive body and is completely covered by the adhesive body on all sides.

According to another embodiment of the invention, the entire microelectronic system is contained in a recess provided in the upper surface of the adhesive body facing the cover layer.

According to another embodiment of the invention, the entire microelectronic system is contained in a recess provided in the adhesive bottom surface of the adhesive body. In another embodiment of the invention, the microelectronic system is contained in a through hole in the adhesive body and is accessible from both the upper surface facing the cover layer and from the adhesive bottom surface.

In an alternative embodiment of the invention, one or more components of the microelectronic system is integrated into the adhesive body and is covered by the adhesive body on all sides and the other component(s) of the microelectronic system is located elsewhere in the adhesive body, the components of the microelectronic sensing system having the necessary mechanical and electrical connection to each other.

According to the above mentioned embodiment of the invention, one or more components of the microelectronic system may be integrated into the adhesive body and covered by the adhesive body on all sides and the rest of the microelectronic system is contained in one or more a recesses (suitably one recess) provided in the upper surface of the adhesive body facing the cover layer.

Alternatively, one or more components of the microelectronic system is integrated into the adhesive body and is covered by the adhesive body on all sides and the rest of the microelectronic system is contained in one or more recesses (suitably one recess) provided in the adhesive bottom surface of the adhesive body.

In another alternative embodiment one or more components of the microelectronic system is integrated into the adhesive body and is covered by the adhesive body and the rest of the microelectronic system is contained in one or more through holes (suitably one through hole) in the adhesive body and is accessible from both the upper surface facing the cover layer and the adhesive bottom surface.

In still another embodiment one or more components of the microelectronic system is integrated into the adhesive body and is covered by the adhesive body, while other components of the microelectronic system is contained in one or more through holes (suitably one through hole) in the adhesive body and is accessible from both the upper surface facing the cover layer and the adhesive bottom surface, and the rest of the microelectronic system is contained in one or more recesses (suitably one recess) in the upper and/or bottom surface of the adhesive body.

In still an alternative embodiment one or more components of the microelectronic system is contained in one or more through holes (suitably one through hole) in the adhesive body and is accessible from both the upper surface facing the cover layer and the adhesive

bottom surface and the rest of the microelectronic system is contained in one or more recesses (suitably one recess) in the upper and/or bottom surface of the adhesive body.

In another suitable embodiment one or more components of the microelectronic system is contained in one or more recesses (suitably in one recess) in the upper surface of the adhesive body and the rest of the microelectronic system is contained in one or more recesses (suitably one recess) in the bottom surface of the adhesive body.

Where the microelectronic system or components thereof is placed in the upper surface of the adhesive body, they are suitably formed with an upper surface following the contours, or shaped to fit the upper surface of the adhesive body. This may be achieved by proper encapsulation of the components.

As mentioned above, the individual components, groups of individual components or all the components of the microelectronic system may be encapsulated before they are embedded into the adhesive body. Encapsulation is chosen when additional protection of the components from the environment and/or the reverse is desired, e.g. when already present in the adhesive body or during the production process leading to integration into the adhesive body. The encapsulated components of the microelectronic system are connected to each other via the necessary electrical and/or mechanical connections.

In some cases it is required that the micro electronic system or components thereof are protected from humidity and/or perspiration in the adhesive since this will initiate corrosion, or needs shielding from exterior influence for other reasons. In such cases the micro electronic system or components thereof is encapsulated.

A number of encapsulation techniques are known and includes coating, hot-melt encapsulation, ceramic encapsulation and glass encapsulations. Other methods for encapsulation of electric components are known in the art.

The microelectronic system or components thereof is suitably encapsulated in a polymer film, a polymer foil, or a polymer coating or the microelectronic system or components thereof is moulded into a polymer material, or is encapsulated in a glass or ceramic material.

Encapsulation by coating typically involves coating the component(s) with materials such as epoxy, PDMS (silicone), acrylate, polyurethane or UV curing resins.

Encapsulation in silicone, such as PDMS, is particularly preferred when the microelectronic components is to be placed in a through hole or a recess in the adhesive body and where it is desirable to enable easy removal or replacement of the encapsulated microelectronic component(s), as the silicone surface is easily released from the adhesive of the adhesive body. Other materials, which are easily releasable from the adhesive, may also be used for the encapsulation.

Hot-melt encapsulation typically involves incorporation of the microelectronic system or components thereof in a thermoplastic material by injection moulding. The thermoplastic material used may be selected from Styrene-block copolymers, polyurethane, ABS (acrylonitrile-butadiene-styrene copolymer), SAN (styrene-acrylonitrile copolymer), polyvinylchloride, PDMS, POM (polyoxymethylene), polystyrene, polyester, polyacrylate, polyolefines; e.g. polyethylene or polypropylene.

The components of the microelectronic system require interconnection. Each system may consist of one or more discrete components, which need to be assembled mechanically and electrically. The mechanical or electrical connection may be established by PCB (printed circuit board), snap locks, thin flexible PCB, glue etc.

In one embodiment as described above, all parts of the micro electronic sensing system is integrated in the adhesive body during production, meaning that the adhesive device with the microelectronic system has a disposable nature.

The adhesive device according to the invention may also be constructed in such a way that components of the microelectronic system may be exchanged during the lifetime of the adhesive device or may reused in a new adhesive device.

Certain components of the micro electronic system are integrated into the adhesive body during production whereas the remaining components is applied to the adhesive device of the invention afterwards, just prior to attachment on the skin, or after attachment to the skin. The components applied to the adhesive body after production of the adhesive body is typically exchangeable, or reusable.

The component, which may be exchanged, is for example the energy source, e.g. the battery.

In a particular embodiment of the invention the entire micro electronic system is exchangeable or reusable and may be applied to the adhesive device just prior to attachment or after it has been applied to the skin.

Suitably, the exchangeable component(s) or the reusable component(s) is encapsulated as described above and forms a package, which fit a recess or hole in the adhesive body.

In the case of exchangeable or reusable components they must have some sort of secure attachment to the adhesive body during use. Such attachment may be provided by an adhesive, for instance by the pressure sensitive adhesive of the adhesive body already present in the indentation, the cavity of the hole in the adhesive body.

In this case it may be preferred that the encapsulation material is a material which does not adhere too strongly to the adhesive of the adhesive body, see above.

Alternatively, the package of the encapsulated, exchangeable or reusable components is attached to the adhesive body via mechanical couplings to the adhesive body. The above-mentioned encapsulated package containing the replaceable or reusable component(s) could thus be fitted into the adhesive body by a snap lock mechanism.

The encapsulation function as a housing for the microelectronic system or components thereof and is suitably formed of from injection-moulded polymer material, but could in principle be of any material and any construction.

The package of encapsulated microelectronic component may have any suitable shape, suitably three-dimensional shape, fitting a recess or through hole in the adhesive body. On one embodiment the encapsulated electronics will have the shape of a rod shaped capsule with rounded ends.

As mentioned above, the present invention uses invasive as well as non-invasive techniques for acquiring physiological data. In the case of non-invasive measurement one

or more metal electrodes may be used for the skin contact. However, any conductive material may be used for the skin contact, such as conducting polymers, conducting hydrogels and electrolytes. In case of invasive measurements regular needles or micro needles may be used. Such invasive techniques are already well known today e.g. for measuring oxygen or blood glucose.

By combining well-described components, all sorts microelectronic sensing systems may be designed and incorporated into the adhesive device of the invention. Examples of systems suited for embedment in adhesive device are systems suitable for measurement of biosensor signals, EKG, EMG, EEG, blood glucose, pulse, blood pressure, pH and oxygen.

The micro electronic system incorporated into the adhesive device of the invention typically requires the following components: Communication components, CPU (central processing unit), power source, storage components, transducer components, interconnections and optionally actuator components.

The CPU (Central Processing Unit) controls and communicates with the components of the microelectronic system. The CPU handles the execution of application software, data decisions making (like data signal processing), A/D conversion, DSP (digital signal processing), routing, timing, power management, sleep function, interruption.

The CPU is the component of the microelectronic system controlling other components and making the appropriate data analysis. In general, the more speed and data analysis required, the more power is needed. Therefore a sleep function is often used in order to save power. At certain times or if certain events happen (triggered by a very low power monitoring subsystem) the CPU wakes up, makes the necessary calculations, communicates with relevant components and return to sleep mode. Depending on need very rudimentary CPU to a full-fledged microcontroller can be used according to the invention.

The communication components control all communication to and from the microelectronic system. Suitably, the microelectronic system is a system enabling wireless communication with a receiver unit placed at a distance from the adhesive device. However, the present invention is not limited to wireless communication, such as RF-

wireless communication. Other communication means could be audible or optical communication means. The component includes the necessary electronics for achieving this wireless communication but also the antenna along with the necessary hardware and software.

The antenna may be of different shape and form depending on frequency, power and signal form. Some antennas are useful for communicating information a few cm, others range several meters. Examples of antennas are; a coil around a small ferrite core (e.g. less than 4 mm in diameter, a flat coil with turns (diameter typically 10 mm or more), single and double wire radio antennas such as monopole or bipole antennas, and an antenna integrated in the adhesive.

An antenna only having few turns and a large diameter e.g. 50 mm may be laminated and integrated into the adhesive body or printed or directly on the cover layer of the adhesive device. The antenna is typically made of a metal such as copper or aluminium but could also be of conductive ink.

The power source consists of power regulating electronics, recharge electronics and an energy source, typically an internal or exchangeable battery. However other means of getting power to the microelectronic system may be suggested, such as kinetic energy conversion, fuel cells, isotope radiation, solar cells or via a radio frequency (RF) link. Further the antenna may be used for loading energy to the microelectronic system.

Preferably the power source is a battery, and may be for one time use or it may be rechargeable.

The storage component is for storage of the embedded system software and/or storage of data acquired during operation of the device. The storage component may be a part of the CPU, a component of its own or an exchangeable storage device such as FLASH RAM that can be removed and exchanged.

The transducer component is a component designed to convert energy from one form to another. The transducer is typically, but not necessarily, the sensor or sensing part of the microelectronic sensing system. A transducer may thus be able to convert for example a

physical input and the transducer will usually but not necessarily convert this energy into electrical form to be interpreted by the CPU etc.

Examples of the physical input a transducer may convert is acceleration, chemical/gas, flow, humidity, inertia, capacitance, conductance, conductivity, current, impedance, inductance, pH, resistance, resistivity, voltage, photo detection, light, magnetisme, pressure, angular, linear position, velocity, temperature, sound and mechanical force.

A tangible representative of the transducer is the detecting component. The detecting component is typically selected from electrodes (polar, bipolar), pressure sensors, needles with electrodes, accelerometers, photo detectors, microphones, ion specific field effect transistors (ISFET), a NTC (negative temperature coefficient) resistors, band gap detectors, ion membranes, enzyme reactors or condensers.

In one embodiment of the invention the transducer includes a detector for non-invasive detection, such as an electrode.

In another embodiment of the invention, the transducer includes an invasive detector, such as a needle containing an electrode.

An actuator is the reverse of a transducer. It converts energy from one form to another in much the same way as a transducer but in the reverse order. Usually it converts electric signals to physical signals. A tangible representative of an actuator is e.g. electrodes (for instance for neural- or neuro-stimulation), pumps, injection needles, light emission diodes (LED) or another light source, loudspeakers, current generators or chemical synthesizers. A possible use of actuator is at certain events decided by the CPU to activate an alarm in the microelectronic system, such as loudspeaker or LED, or to indicate low battery.

Thus, the actuator may be used as a component in the system reacting to the input obtained from the transducer component such as an alarm (visible and audible), injection pump, valve etc. It can either be a one time use, a multiple use or continuous use actuator.

Many sensing systems are only informative systems transmitting information about the physical condition of a mammal and in this case an actuator is not needed.

The microelectronic system will be modular build in the sense that in a device for a given application only some of the components may be needed. Some applications will utilize fewer components and some applications may use all components. These components can be fitted into same physical ASIC (application specific integrated circuit), electrical system or subsystem, such as but not limited to, PCBs (printed circuit boards), flexible PCBs, thick film, thin film, or ceramic technologies or the system or its components may be separately encapsulated

RFID (Radio Frequency IDentification) tags are commercially available in various sizes, ranges and functionality. When the RFID reader applies the appropriate field (e.g. an inductive field) the basic RFID tag return a bit sequence. The sequence is programmed prior to use. RFID range varies from 1 cm to app. 2 meter for passive tags (no power source included) to over 100 meters for active tags (power source included). More sophisticated RFID tags available have storage components where data can be read or stored.

The RFID tag may be incorporated into the adhesive body either as a standalone part or in combination with other microelectronic components. Complex microelectronic systems can easily be made to include various forms of RFID tags without adding significantly to the complexity or price of the system. In a complex system the tag can be used as a simple track and trace component for identification of the product, such as shelf life, life time, however it can also be utilized for identification for other systems in sensor networks.

For a stand-alone solution the RFID tag consist basically of a RF chip and a coil. Suitable forms of the RFID tag is a RFID tag encapsulated in a glass housing, a RFID tag encapsulated in plastic/epoxy (typically pill shaped), a flat RFID tag with coil and a RF chip laminated between 2 polyimide layers, or a flat RFID tag with large coil antenna with few turns printed on or in the adhesive body and with the RF chip interconnected to the antenna without any further protection/encapsulation.

These systems can be completely integrated within the adhesive bodyduring production of the adhesive body.

The above-mentioned flat RFID tag may be sandwiched between 2 layers of pressure sensitive adhesive during production. As the RF chip is very small (1 mm x 1 mm) and the coil is flexible, no rigid encapsulation is needed. The glass encapsulated RFID tag has very good chemical resistance and small size to ensure no discomfort. The RFID tag encapsulated in plastic or epoxy may be of more complex design and can be added both during and after production of the adhesive body of the invention.

The encapsulated RFID tag is a component, which may be reused, in one or more adhesive bodies. The encapsulated RFID tag is transferred from one adhesive body to another and thereby reused time after time, and is ideal for storing person specific data.

Normally embedded microelectronic systems incorporate some kind of sensor in its system, however this is not necessary for all applications.

The adhesive device of the invention may also be part of a network of adhesive sensor devices placed on different locations on the body. These individual adhesive devices may vary in complexity ranging from a small basic sensor system to more complex system, depending on location and sensing property. Some adhesive devises of the network have reduced functionality called RFD (reduced function devices) whereas other devices are FFD (Full Function Devices).

The FFD devices may function at any topology and be the coordinator of the Network, or it may be a coordinator that can talk to any other device. A RFD device is limited to star topology, it cannot become a network coordinator, it talks only to a network coordinator and has very simple implementation.

FFDs may be a dedicated network coordinator acting as communication Hub, gateway or router within the Body Area Network (BAN) and handling communication with external unit(s). A communication Hub or gateway may have large storage capacity and store data from the sensor network, and when in proximity with external unit or when otherwise appropriate wireless transmit these data.

These hubs are easily integrated within the adhesive body as no skin contact or actuator is needed, and may be placed strategically on the body. As hubs will generally be larger and more centrally placed on the body, it is of great advantage that the microelectronic

hub may be completely integrated within an adhesive body as this reduces discomfort and visibility.

In case of person monitoring, the microelectronic system could incorporate GPS technology. The system is either data logging the positional data for later analysis or could transmit (e.g. via the mobile net) position. Such a system within an adhesive could be place in an inaccessible location on the body.

A GPS device incorporated in an adhesive body of the invention need not be a single device in itself, but could be an add-on to an adhesive devices comprising other microelectronic systems, so the system can transmit GPS at certain event such as alarms.

Thus, the adhesive device may also contain a micro electronic system where no physical contact between the detector and the skin of the mammal is necessary. Systems that do not necessarily use transducers with a detecting element are Network Hubs, network coordinators, gateways and GPS (Global Positioning System).

Accordingly, microelectronic systems useful for use in the adhesive device of the invention could be:

A glass encapsulated RFID tag comprising communication components and a CPU. The glass encapsulated components may suitably be embedded in the adhesive device as shown in figure 1.

An epoxy or plastic encapsulated RFID tag comprising communication components and a CPU. The epoxy /plastic encapsulated components could for example be embedded in the adhesive body as shown in figure 1 or 2.

A coil antenna and a RFID tag comprising communication components and a CPU laminated between two polyamide layers. The system may be embedded in the adhesive body as illustrated in figure 1A.

A coil with few turns and a non-encapsulated passive read/write RFID tag comprising storage and communication components and a CPU. The system may be embedded in the adhesive body as illustrated in figure 1A.

A passive read/write RFID tag comprising storage and communication component(s) and a CPU encapsulated in an epoxy or plastic pill. The system may be embedded in the adhesive body as illustrated in figure 2.

An active read/write RFID tag encapsulated in a epoxy/plastic pill comprising storage and communication components, a CPU and a battery. The system may be embedded in the adhesive body as illustrated in figure 1.

RFID tags of the above-mentioned type are commercially available.

The microelectronic system may also be a gateway comprising storage and communication components, a CPU and a battery encapsulated in plastic and working as a dedicated network coordinator for transmission of data to a central unit (CU). Such a microelectronic system may for example be embedded in the adhesive body as illustrated in figure 1.

The microelectronic system may also be a system comprising storage and communication components, a CPU, battery, GPS, components for wireless synchronisation of real time clock for data logging of GPS data, optionally encapsulated in plastic, or a system comprising storage and communication components, a CPU, battery, GPS, components for wireless synchronisation of real time clock for data logging of GPS data, mobile net for data logging and transmission of data and position to mobile phones, optionally encapsulated in plastic. These systems may also be embedded in an adhesive body as illustrated in figure 1.

The adhesive device according to the invention may also be used for applications where body implants are applied electrical power and electrical data communications via wireless means across the skin barrier (trans-cutanously). In these cases it is important to fix the adhesive device at an exact spot on the skin surface for long periods of time with minimal annoyance or inconvenience for the person carrying the device.

A typical example of wireless trans-cutaneous power transfer and electronic data communication is in implanted nerve stimulators for people who suffer from disable control of their muscles in the lower part of their leg (the drop foot syndrome). The drop foot

stimulator is implanted inside the leg and has direct contact the nerves controlling the relevant muscles. The implant is typically powered wirelessly by means of an electromagnetic coupling between a coil or an antenna inside the leg and a coil or antenna placed nearby on the outside of the body on the skin surface.

The coil or antenna is connected to the electronics providing the needed power and control signals. The timing for the simulation signal is normally controlled by a pressure sensitive switch at the heel of the person or in his shoe. Often the transmission of the signals from the switch to the simulator placed on the skin of the leg is wireless.

These drop foot simulators will be substantially improved by using the adhesive device described in the invention. It enables reliable power and data transfer because of the very stable fixation of the external part of the simulator on the skin surface for long periods of time with minimal inconvenience. Further it can also enable better long-term fixation of the switch placed on the foot.

Thus, in one embodiment, the microelectronic system is useful for nerve stimulation and comprises storage and communication components, a CPU, power source and transducer for transmitting data and power to implant for nerve stimulation. The system may suitably be embedded in the adhesive body as illustrated in figure 3.

In another embodiment, the embedded microelectronic system is useful for surface electromyography (sEMG) or invasive electromyography. In both cases the transducer is a relatively simple 2-3 electrode device. The signal measured is a direct voltage generated by a muscle or a muscle group. In order to understand this signal it must be analysed either by the microelectronic system or stored for future analysis.

The data collected are transmitted to a Central Unit (CU) either when relevant, when certain events occurs or at certain time intervals. The CU is suitably a portable hardware device with wireless reception/sending capability, such as but not limited to a PDA (personal digital assistant), a mobile phone or other dedicated hardware.

The transducer is suitably designed to overcome or neglect the difference from time to time of the surface resistance of the skin. Dry skin has resistance of e.g. 500 kOhms and sweaty skin could be as low as 500 Ohms. This problem may be over come by utilizing a

high impedance amplifier, where impedance is above 500 MOhms. The transducer may be designed to activate other system components on the first skin contact thereby ensuring longer lifetime.

The central processing unit (CPU) handles the amplification (e.g. x30-x1000) of the transducer signal, typically by differential instrumentation amplifier with rejection of common modes (unwanted signals/noise that is common for both electrodes), filtered either analogically or digitally. The CPU handles conversion of analogous signal to digital signal. Signal analysis such as rms (root mean square), FFT (Fast Fourier Transformation) and digital filters combined with software are employed to achieve a data decision on certain events.

Furthermore the CPU could employ timers or sleep mode, so measurement is only during certain events or only a fraction of each second or other time period, thereby saving power.

The microelectronic system also comprises storage components for storage of Software and EMG data storage in those cases where, only some or no data are transmitted wireless during data acquisition. These data may be transmitted at a later time.

The power source is thought to be either a single use battery as the CPU ensures long lifetime due to power down in inactive periods, or a rechargeable battery. The rechargeable battery is recharged either through a RF link or by placing the microelectronic system in a recharge cradle when the system is not in use. Several weeks of lifetime after activation are possible with one battery or charge up.

Data is transmitted to Central Unit with a protocol or method that can ensure no corruption of data. Furthermore after activation battery life condition and/or a data burst are transmitted in order validate operational status of the system. On request the system will transmit storage data.

The microelectronic system for electromyography may optionally include an actuator, which at certain events decided by the CPU activates an alarm in the microelectronic system, such as loudspeaker or LED. The event activating the actuator could also be

low battery.

According to this embodiment of the invention the various components are interconnected mechanically and electrically and may be encapsulated into a module. However, various components may also be integrated separately into the adhesive body. These components could be but is not limited to, the battery, the antenna and the actuator.

The various components could also be mounted on PCB (printed circuit board) or flexible PCB and coated with a protective layer and directly be embedded in the adhesive.

Thus, in a specific embodiment of the invention, the microelectronic system is a system useful for electromyography and comprises a transducer (2-3 electrodes and an Instrumentation Amplifier), a CPU (µ Controller e.g. ATMEGA 128L), a power source (e.g. battery), communication (e.g. to CU) and storage components and an actuator (LED). This system may be embedded in the adhesive body as illustrated in figure 3 and 3A.

During sport or fitness exercise different or several of the same microelectronic systems may be used in combination. Furthermore several transducers could be used in the same adhesive device.

A fitness sensor network may thus consist of:

Adhesive devices with a muscle activity (sEMG) sensor, one for both sides of the body (arms, legs etc). The electromyography system could be designed in such a way to determine the fatigue of the muscles and indicate when muscle growth is optimal or when exercise has no benefit. Frequency analysis of the sEMG signal may be used to achieve the desired output of the measurements. Typically the adhesive devices are placed on muscle groups that are actively exercised.

Two or three adhesive devices of the invention comprising a Heart Rate (ECG) sensor system of for monitoring heart beat and heart pulse shape.

Adhesive devices comprising microelectronic systems for determining levels of fatigue poisons in muscles.

A sensor Hub/gateway centrally located on the body for storing and routing signals to either a central unit or directly communicating with fitness hardware.

The microelectronic system may be reusable from one fitness session to another with change or charge up of battery.

Thus, the adhesive device according to the invention may suitably be used for measuring physiological conditions that relate to diseases, health care surveillance, rehabilitation, sports medicine or general surveillance. Typically applications will be for patients at risk for instance when suffering from weak heart, epilepsy, fever and fever spasms, diabetes, apoplexy, arteriosclerosis and muscular dystrophy. Applications may be associated with general monitoring for optimising medication, for registering of the disease or for alarming. Other applications will be for rehabilitation in respect to monitoring of physical work, muscle strength, lung capacity, or in the sports medicine for determination of work and repetition, acceleration, heart rate, muscular stress and strength, orientation etc. Yet other applications will be for surveillance of objects or mammals in motion. Mentally disable patients or individuals like elderly people suffering from dementia will be typical for such applications.

The adhesive device according to the invention will preferably be wireless as this will be meaningful in respect to obtaining as smooth a shape and surface of the device as possible and still achieving the protection of the microelectronic system. In certain occasions it may, however, be important to be able to interconnect the devices by wires. This may especially be an option when the microelectronic system is divided in two parts each being present in an adhesive device as defined in the invention.

The microelectronic sensing system or the components thereof may be incorporated into the adhesive body either during production of the adhesive body, or after production of the adhesive body, e.g. just prior to application of the adhesive device to the skin, or after application of the adhesive device to the skin.

As described above, parts of the adhesive device such as parts of or the entire microelectronic system may be exchangeable or reusable.

Thus, in one aspect of the invention the present invention discloses a device comprising at least an adhesive element and a power source element, said device adapted to attach an electronic circuit, such as the microelectronic system, to a surface and to power said electronic circuit, wherein at least one of the device elements is releasable attachable to the electronic circuit; the power source element is electrical connectable to the electronic circuit; and the adhesive has at least a first area for adhering to the surface.

Such a device as described may attach and power the electronic circuit to a surface, such as e.g. the skin of a mammal, for a specific purpose. When the specific purpose is fulfilled the device and the electronic circuit is removed from the surface and the device is separated from the circuit and disposed. Thus, the elements forming the device, which are relative cheap compared to the electronic circuit, is disposed while the electronic circuit may be reused together with a new device according to the invention for attaching the electronic circuit to a surface and powering the circuit. Advantageously this allows reducing costs considerably while also protecting the environment as more components are reused than done until now.

By the terms 'releasable attachable' and 'releasable connectable' it should be understood that the device and the electronic circuit may be temporarily attached in such a way that the risk of unintentionally separating them is minimal. However the device and the electronic circuit should be attached in such a way that they may be separated if desired.

Furthermore, by the term 'electrical connectable' it should be understood that the power source element and the electrical circuit is arranged in such a way that an electrical current may be transmitted between them. This may for example be done by use of standard electrical contacts, typically made of copper alternatively gold or silver plated, or the electrical connection may be provided in a wireless manner where the power source induces a current in the electrical circuit.

Typically the electronic circuit is a microelectronic system formed of a number of microelectronic digital components and /or analog components connected with appropriate wiring. The components are typically arranged on a print circuit board whereon the proper traces and tracks are etched, electroplated, or otherwise provided on the board. Digital components may for example be microprocessors, storage elements such as RAM-blocks

and analog components may for example be resistors and capacitors provided on the print board.

In one embodiment the power source element is attached to the adhesive element and the adhesive element has a second area for adhering to the electronic circuit.

By attaching the power source element and the adhesive element to each other only one physical part is provided, avoiding that the user has to keep track of both the power source element and the adhesive element and spend time on applying both. Thus a small and discrete device, which is convenient for the user, is provided. Furthermore the electronic circuit may be adhered to the adhesive element for improved handling, as only one unit will have to be manipulated when applying the electronic circuit to the surface.

Advantageously a first peel force between the second area and the electronic circuit is smaller than a second peel force between the power source element and the adhesive element. This allow for easy separation of the microelectronic circuit from the device after use.

To further ensure that the power source element and the adhesive element do not separate from each other the power source element may at least partly be contained in the adhesive element.

By 'contained' it should be understood that the power source may be fully or partly embedded in the adhesive. When fully embedded only electrical contacts are exposed through the adhesive or thin flexible electrical wires are embedded in the adhesive extending from the power source to an outer surface of the adhesive where it may be brought into contact with the electronic circuit. Furthermore, within the meaning of the term contained the power source may also be partly embedded in the adhesive thereby exposing a larger section through the adhesive. This allows for a large contact surface between the electronic circuit and the power source while at the same time being safely attached to the adhesive.

To protect the different parts of the electronic circuit it will typically be encapsulated, for example by coating it in silicone or hot-melt polymers. The encapsulation may for example be formed as a housing containing at least a part of the electronic circuit. In one

embodiment the housing may be formed of a proximal housing part and a distal housing part. The device is adapted to be releasable connectable to said housing.

A number of encapsulation techniques are known and includes coating, two component polymer, hot-melt polymer encapsulation, ceramic encapsulation and glass encapsulations. Other methods for encapsulation of electric components are known in the art.

The microelectronic system or components thereof is suitably encapsulated in a polymer film, a polymer foil, or a polymer coating or the microelectronic system or components thereof is moulded into a polymer material, or is encapsulated in a glass or ceramic material.

Encapsulation in silicone, such as PDMS, is particularly preferred when the microelectronic components are to be placed in a through hole or a recess in the adhesive body and where it is desirable to enable easy removal or replacement of the encapsulated microelectronic component(s), as the silicone surface is easily released from the adhesive of the adhesive body. Other materials, which are easily releasable from the adhesive, may also be used for the encapsulation.

In order for the adhesive element to be easily released from the housing after use the housing may advantageously be made from a material, or coated with, which allows the housing to easily release. Such a material may for example be a silicone, which often is used for release liners in different adhesive applications.

In yet another embodiment the at least one power source element is adapted to be received in a recess formed in the distal housing part. At least one electrical contact is provided in the distal housing providing electrical connection between the power source element and the electrical circuit.

By providing a recess as described above the power source element is protected from being displaced and thereby losing electrical contact with the circuit. The recess also creates a flush assembly when the power source is placed therein giving it a smooth surface which will not get caught as easy as from a surface where the power source would protrude.

Many types of electronic circuits having many different applications and which is powered and attached to a surface may be used with the device according to the invention. The device may after use be disposed but the electronic circuit may be reused. In one embodiment the device is thus adapted to be releasable connected to electronic circuit, which is a sensor circuit, said sensor circuit is to be attached to the body surface of a mammal, typically the skin.

By the term ' sensor' or 'sensoring' it should be understood that a parameter of the ambient environment of the electronic circuits is detected by the sensor circuit. Such parameters may among many for example be temperature, humidity, electrical signal, electrical fields, light, noise, biosignals and magnetic fields.

Thus, the invention also relates to a sensor assembly adapted to be attached to the body surface of a mammal, comprising; a sensor circuit, comprising a number of electrical components; at least one power source element for powering at least one of the electrical components; at least one adhesive element for attaching the sensor assembly to the body surface of a mammal; and that at least one of the power source element and the adhesive element is releasable connected to the sensor circuit.

Thus, the sensor assembly provides the advantages as disclosed above when different elements are disposable, such as the device comprising the power source and the adhesive element, and others are reused, such as the electronic circuit.

In one embodiment of the sensor assembly the sensor circuit is at least partly contained in a housing where the housing is formed of a proximal housing part and a distal housing part. Advantageously a sensor assembly may be provided where a first peel force between the adhesive and the housing is smaller than a second peel force between the adhesive and the battery. This allows for easy separation of the sensor circuit from the adhesive and power source elements.

Typically the sensor assembly will comprise at least one transducer attached to a proximal surface of a proximal part. Together with a distal part the proximal part makes up a housing, as described earlier, for protecting at least a part of the sensor circuit. This transducer will transform different physiological signals into electrical signals. Such

transducers may for example potentiometric, caliometric, conducmetric, chemomechanical or optical.

To prevent that the power source accidentally moves out of electrical contact with the sensor circuit a recess may be formed in the distal housing part, the recess is adapted to receive the at least one power source and that at least one electrical contact is provided in the distal housing providing electrical connection between the at least one power source and the electrical components. The recess thus protects the power source from outside movement, for example when the adhesive moves due to movement of the surface whereto the sensor assembly is attached. Additionally, by protecting the power source from outside movement the electrical connection between the power source and the microelectronic circuit is also protected from disconnection.

In another aspect the present invention relates to the use of a device comprising an adhesive element and a power source element, and where the device is used for attaching an electronic circuit to a surface and to power said electronic circuit, wherein said electronic circuit is releasable connectable to the adhesive element and the power source element.

Many sensors are connected to the monitoring systems with wires. The disadvantage of such a system is that the patient does not have freedom to move since the wires are attached to the sensors on the body and connected to a monitoring system. Whenever the patient wants to move he must be careful not to dislodge any of the wires attached to the sensors, and he must further pick up the monitoring system and carry it along.

Furthermore, an isolated power source, such as a battery, where no external wiring is necessary is preferred. Such isolated power source elements preferably used with the present invention are well known in the art.

In general, batteries may be divided into primary batteries, which are single use and secondary batteries, which are rechargeable.

Primary batteries are produced in various types based on different combinations of anode, cathode and electrolyte materials. Common chemistries for primary batteries include zinc-carbon, zinc chloride, alkaline manganese dioxide, silver oxide, zinc / air and lithium in

these combinations: lithium / sulfur dioxide (Li-SO2), lithium / thionyl chloride (Li-SoCL2), lithium / manganese dioxide (Li-MnO2), lithium / carbon monofluoride (Li-(CF)n), lithium / copper oxide (Li-CuO), and lithium / iodine (Li-I2).

Secondary batteries are rechargeable and are typically based on Nickel Cadmium (NiCd), Nickel Metal Hydride (NiMH) or Lithium–ion technologi. Secondary batteries usually have more active chemistries that need special handling and disposal.

Many battery sizes and cell casing exist, including standard cylindrical cells, multi-cell batteries, coin cells, pouch cells and thin film batteries.

Standard cylindrical cells and multi-cell batteries are known from common household appliances, e.g. flash lights and remote controls. This group includes the well known sizes AA, D, C, and 9V rectangular.

Coin or button cells are typically small, round and a few millimetres high. This group is often found in watches, hearing aids and memory backup. Since they are based on solid-state cathodes, these systems are considered very safe.

Duracell, Panasonic, Sony and Energizer are some of the major manufacturers of standard and coin cell batteries.

Alternatively, using pouch casings along with Lithium Polymer cells with solid electrolytes can provide another type of batteries. This provides a low cost bendable construction. The batteries are characterized by a high energy density in addition to being re-chargeable. The solid electrolyte permits safer, leak-proof cells. The foil construction allows very thin and lightweight cell designs.

Bullith Batteries manufactures flexible batteries based on this technology.

Yet another type of batteries are thin film batteries, which are based on the printing of solid state lithium polymer chemistry on a variety of substrates. They can be printed directly onto plastics, thin metal foils or paper resulting in ultra thin and flexible power sources. The batteries can be made in any shape or size, but are generally limited in energy

storage and current capacity. The batteries are very safe as they contain no caustic chemicals, cannot overheat, explode or cause electrical shock.

The Israeli company Powerpaper are selling products based on thin film technologies. Other companies producing this type of batteries are Oak Ridge Micro Energy Inc. and Infinite Power Solutions.

In one embodiment the adhesive element is formed as a three-dimensional adhesive body as described earlier, i.e. the adhesive element has a considerable thickness, typically several times thicker than the backing layer whereon it is applied.

The pressure sensitive adhesive making up the three-dimensional adhesive body is suitably a mouldable thermoplastic or chemically curing pressure sensitive adhesive having a flexibility enabling the adhesive device to conform to the curvature of body parts while retaining its adhesive properties even under movements.

The backing layer may furthermore function as a cover layer, where said backing/cover layer is provided to function as base wherein the adhesive is applied and to protect the adhesive from the outer environment, e.g. against adhesion to linen, clothes or moisture.

Furthermore, an electromechanical display system may be applied to the cover layer. Such display system may allow the user to test the charge of battery, either before adding the powered adhesive to a microelectronic system and during use.

Simple battery indicators known in the art may thus be used. For example a foil consisting of two contact electrode and a conductive thermochromic ink, typically liquid crystals or leucodyes, may be used.

When for example using a common coin battery, one electrode is in contact with the anode of the battery and the other electrode in contact with cathode of the battery. By pressing the contact device on top of battery the battery test circuitry is closed and the thermochromic ink will light up indicating battery status.

The cover layer or film protects the integrated /embedded microelectronic components as well as the adhesive body against the environment.

The adhesive device of the invention may be constructed in a number of ways, as it will be described in more detail below. Common for all constructions are that the three-dimensional geometries provide good protection for the microelectronics and at the same time give the device as smooth a surface as possible. Especially the shaping of the edges of the device need paid attention, otherwise linen will easily stick to them and cause rolling. Therefore the outer rim of the adhesive device with the embedded micro electronic system must be shaped to thickness less than half of the thickest part of the device, normally the central part comprising the microelectronic electronic system.

Detailed description of the drawings

Figure 1 shows a die section of the shape of a typical representative of the adhesive device according to the invention. CT relates to the maximal thickness of the device and PT to the thickness in the periphery of the device. The device does not necessarily need to be shaped symmetrically.

Figure 2 has a box showing the part of the adhesive device, which is illustrated in figures 3-12. As illustrated in figure 2 the electronic parts 101 are embedded in an adhesive body 102 with a cover layer 103 and a release liner 104.

In one embodiment of the invention, all the electrical components are assembled in one unit, which is embedded in the adhesive body and is covered on all sides with the pressure sensitive adhesive, essentially making it a disposable pad. As illustrated in figure 3 an assembly of electronic parts 101 are embedded in an adhesive body 102 with a cover layer 103 and a release liner 104.

Figure 4 illustrates that the components of the microelectronic sensing system may be positioned at different locations within the adhesive body, provided there is the required mechanical or electrical connection between the components. All components are completely embedded in the adhesive body and are covered on all sides by the pressure sensitive adhesive of the adhesive body.

The integration of all microelectronic components within the adhesive body is useful for cheap throw away one time one use devices. Because of the short usage time of the

adhesive device the electronics need little or none extra protection, such as encapsulation. The adhesive body itself acts as protection of the microelectronic components.

Even though all the components of the microelectronic system are covered on all sides with the adhesive body, several sensing applications (humidity, optical or chemical/gas) are still possible.

Systems, which may be covered on sides, may also be a RFID TAG, a Network Hub, a network coordinator, a gateway, or other systems capable of collecting, communicating and/or transmitting data. These systems would often need some kind of activation to start the system, such as a pressure contact or magnetic contact to overcome the need for large shelf life compared to the active period.

Figure 5 illustrates an embodiment of the invention where the microelectronic system is embedded/applied into a recess in the adhesive body. The recess is positioned in the upper surface of the adhesive body. The microelectronic system may be embedded/attached during fabrication of the adhesive body, just before or after the adhesive device has been attached to the skin. According to this embodiment of the invention, the microelectronic system may be reused.

Figure 6 shows a microelectronic system analogous to the system of figure 5, however, in figure 6 the system consists of two parts. One part, the upper, is exchangeable of reusable and the lower is embedded in the recess of the adhesive from start. The upper part may for instance be the power supply.

Figure 7 illustrates an embodiment where some components of the microelectronic system is embedded within the adhesive device during production and some components are applied in a recess in the upper surface of the adhesive body, i.e. are exchangeable or reusable. According to the invention one or more component(s) may be embedded within the adhesive body and one or more component(s) may be present in a recess at the surface of the adhesive body. The necessary mechanical or electrical connection between the components are also embedded in the adhesive body. Although the figure only illustrates one, there may be two or more recesses in the upper surface of the adhesive body and there may be two or more components integrated into the adhesive body.

The exchangeable parts in the recess may be locked in the recess by the adhesive properties of the pressure sensitive adhesive in the recess. In an alternative the microelectronic components in the recess is encapsulated in a coupling or plug designed to fit into a lock, such as a snap lock, present in the recess.

Figure 8 illustrates an embodiment of the invention where the microelectronic system is embedded/applied into a recess in the adhesive bottom surface of the adhesive body. The microelectronic system is embedded/attached during fabrication of the adhesive device or just before attaching the adhesive device to the skin. This system is typically used where it is required that some of the components of the system are in contact with skin either non-invasively or invasively.

Figure 9 illustrates en embodiment where some components of the microelectronic system is integrated within the adhesive device during production and some components are applied in a recess in the lower surface of the adhesive body, i.e. are exchangeable. According to the invention one or more component(s) may be integrated into the adhesive body and one or more component(s) may be present in a recess at the surface of the adhesive body. The necessary mechanical or electrical connection between the components are also integrated into the adhesive body. Although the figure only illustrates one, there may be two or more recesses in the bottom surface of the adhesive body and there may be two or more components integrated into the adhesive body at different locations.

Figure 10 illustrates an embodiment where some components of the microelectronic sensing system is integrated into the adhesive device during production and some components are applied in a recess in the bottom surface of the adhesive body, i.e. are exchangeable or reusable. According to the invention one or more component(s) may be integrated separately into the adhesive body and one or more component(s) may be present in a recess at the surface of the adhesive body. Although the figure only illustrates one, there may be two or more recesses in the bottom surface of the adhesive body.

This construction is suitable where the transducers or actuators utilize skin contact or skin penetration (e.g. electrodes and needles), whereas the rest of the microelectronic system may be embedded in the adhesive body (batteries, antenna, electrode, A/D converter, amplifier). This configuration also has several production advantages.

Thus, figures 8, 9 and 10 illustrates a construction where the exchangeable part e.g. the battery, is attached to the adhesive part facing the patient. Prior to mounting the adhesive sensor device on dermis of the mammal the protective release liner is removed, the exchangeable battery is coupled to the rest of the microelectronic system enabling the electronic system to function. Thereafter the adhesive part of the device and the whole construction is mounted on the dermis of the patient.

After use the exchangeable part e.g. the battery, is replaced and the adhesive device may be used in the context of a new monitoring of the patient.

In order to be able to remove the battery following detachment of the adhesive device, the inner part of the recess in the adhesive device could be coated with a PDMS curable coating or other non-adhesive coating; this operation will facilitate the exchange of the battery.

The battery as well as other exchangeable components, such as the chip, may be present in a recess in the bottom surface of the adhesive body. According to this embodiment, it may be an advantageous to have the exchangeable microelectronic parts contained in a capsule, e.g. embedded in an injection-moulded capsule.

Just prior to mounting the capsule containing the microelectronic components the release liner is removed and the exchangeable capsule is attached to the adhesive body in the recess of the adhesive construction. The microelectronic components may be coated with curable PDMS or other non-adhesive coating in order to facilitate detachment of the exchangeable capsule.

When the microelectronic components have a longer life than the adhesive body, the cheap components, such as the transducer, the antenna or the power source, may be integrated into the adhesive body and the components that may be reused are placed in a recess before use.

Another application is where customised preparation or programming of the system is done prior to application.

The features and applications described in connection with figure 3 apply equally well to the embodiment illustrated in figure 5 and vice versa.

Figure 11 illustrates the integration of a microelectronic system within a through hole in the adhesive body providing access to the microelectronic system from both the upper surface and the bottom surface of the adhesive body. The application of the microelectronic system is possible both during production/fabrication of the adhesive or just prior to application to the skin, and/or after application to the skin.

Figure 12 illustrates a system where two components or assemblies of components of the microelectronic system are connected in some way. One of the components may be integrated during production, whereas the other is applied afterwards.

Alternatively, the components or assemblies of components are applied afterwards. This is useful where different lifetime make is feasible to exchange electronic components at different times, such as battery or transducer. Mechanical and/or electrically interconnection schemes such as snap locks or plugs are advantageous in this configuration.

The system illustrated in figure 4 is useful where skin contact and simultaneous access to electronic components from the upper surface is needed. One or both subsystems can be reused.

The features and applications described in connection with figure 5 and 8 applies equally well to the embodiment illustrated in figure 11 and vice versa.

Figures 13 - 18 illustrates an embodiment of the invention where an antenna, a central processing unit, a battery and electrodes are embedded in an adhesive device.

Figure 13 illustrates the two-dimensional shape of the device indicating a cross-section by A-A.

Figure 14 illustrates the position of the antenna 109 placed in the outer part of the adhesive device and being connected to the central part of the microelectronic system.

In Figure 15 the third dimension is shown in cross-section along the line A-A in figure 13. The circle B from the rim of the device is further magnified in figure 16 and the circle C of the centre is likewise magnified in figure 17.

Figure 16 shows more in detail the building of the antenna lying embedded in the adhesive. This clearly shows the cover film 103 and the release liner 104 for the adhesive 102.

Figure 17 shows the position of the central part of the microelectronic system 1 with a battery 105, a CPU 106 and protruding the adhesive the electrode 107. The battery and the CPU is enveloped in a transparent silicone rubber 108.

Finally figure 18 illustrates the adhesive device in a perspective.

There are other ways of constructing an adhesive device having an embedded micro electronic system, that fulfils the basic requirement of a three-dimensional construction and the drawings may thus not be construed as limiting.

One special advantage of the invention is the simple and inexpensive way of preparing an adhesive body having a three-dimensional shape from a pressure sensitive adhesive.

As mentioned above, the pressure sensitive adhesives are either a thermoplastic pressure sensitive adhesive or it is a chemically curable adhesive that has the ability to be moulded into a three-dimensional shape.

The thermoplastic pressure sensitive adhesive may typically enter a fluid condition and achieve a moderate viscosity at above 100-120 deg C i.e. above the glass transition temperature of the composition, which makes it easy to mould the adhesive composition to the desired shape. One example may be direct moulding. In a first step the cover layer is provided in the desired shape at temperatures just below the glass transition temperature of the cover film and then the necessary amount of adhesive is filled the into the mould to fill up the mould. The filling of the mould may be in two steps whenever appropriate. This will allow partly filling with the molten adhesive in a second step, placing the electronic parts in a third step and eventually filling and covering the electronic parts

with the remainder of the adhesive in a fourth step. As a last step a release liner is applied and then the adhesive device is punched out of the mould.

Alternatively the adhesive laminated with the cover film may be processed through compression, pressing or moulding into the desired geometry or shape at elevated temperature, but slightly below the glass transition temperature of the adhesive. Optionally the microelectronic system may be placed between two layers of adhesives and then moulded. The moulding is performed in the press at elevated temperature and if desired with the microelectronic system placed in the mould preferably in the centre of the mould.

In the special embodiment where exchangeable or reusable components are a part of the adhesive device, a female and a male part of a moulding shape is required.

In another embodiment of the invention curable pressure sensitive adhesive is cast in the desired shape. The casting may follow the same principles as of above allowing a partial filling step of the mould with the cover film, applying the electronic components and thereafter complete the filling of adhesive in the mould and finally concluding with placing the release liner, curing if necessary and die cutting.

Another method is moulding by compression of adhesives having high or very high viscosity. A primary layer comprising a pressure sensitive adhesive e.g. a hydrocolloid containing block copolymer on a cover film taken from a roll enters the processing equipment as a first step, the pre-assembled, optionally encapsulated micro electronic components is placed with the appropriate distance in a second step, in a third step, a secondary layer of the same or another pressure sensitive adhesive is laminated to the first layer of pressure sensitive adhesive enclosing the microelectronic part between the layers, in a fourth step said laminate is formed in a hydraulic press into a shape containing multiple projections centred upon the microelectronic part and in a fifth step the individual projections are die cut to final devices.

The pressure sensitive adhesive devices can be produced according to a continuously process as described in US 6726791.

Figs. 19, 20 and 21 shows one embodiment 1 of a sensor assembly according to the invention. Figure 19 shows the sensor assembly in an exploded view. Figure 20 shows the assembly seen in section along line XX – XX in Fig. 19 when the sensor assembly is assembled. Fig. 21 shows the sensor assembly seen from the skin side, also referenced to as the proximal side, i.e. the side of the sensor assembly, which is to be attached to the skin.

The sensor assembly 1 consists of a sensor device 2 and housing element 3 which contains a microelectronic circuit 4. The sensor device 2 is made up by an adhesive element 5 and a power source element in the shape of a coin cell battery 6.
The housing element 3 is made up of a distal part 7 and a proximal part 8. A recess 9 is formed in the distal part. The recess has a circumference, which is slightly larger than the circumference of the coin cell battery allowing the coin cell battery to be received in the recess.

In the recess there is provided two electrical contacts 10a,10b for electrically connecting the microelectronic circuit 4 and the battery 6 when the battery is placed in the recess. The microelectronic circuit is made up of a number of components arranged on a print board 11. Every component will not be described herein as the circuit is well known in the art and as such not a part of the invention in itself. In general it can be mentioned that the circuit comprises an antenna 12 formed by a number of windings of a conductive material printed on the print board. The antenna transmits and receives data from a central unit placed within communication range. The central unit may for example be a personal computer which gathers data from the sensor assembly. The data is then processed according to known processes and algorithms.

The antenna 12 is connected to a microprocessor 13, which receives signals from a first transducer 14 and a second transducer 15. The first and second transducer extends from the print board through the proximal part and terminates on the proximal surface of the proximal part. Thus, when the housing is placed on the skin the first and second transducer contacts the skin surface. In order to reduce interference between the first and second transducer a barrier element 16 is placed on the proximal surface of the proximal part between the two transducers. The barrier element is formed of a dielectric material and is a well known measure in order to avoid so-called cross talk, typically causing unwanted interference, between two electronic components.

When used the battery is placed in the recess, whereby the battery is placed in contact with the electrical contacts 10a, 10b and thereby powers the microelectronic circuit. The adhesive element is then applied on the distal side of the distal part of the housing and the distal side of the battery. This secures the battery in the recess and connects the adhesive element, the power source element and the housing element into a sensor assembly. As can be seen the adhesive element has a circumference which is larger than the circumference of the housing which provides an adhesive proximal surface 17 which can be applied to the skin surface of a person or other mammal.

When the sensor assembly later is removed the adhesive element is separated from the housing element the battery is removed along with the adhesive element as the distal surface of the battery is adhesively attached to the adhesive element. The adhesive element and the battery can then be disposed and the housing element may be cleaned and stored for later use.

The adhesive element is covered by a cover layer 18 in order to protect the adhesive element from adhering to unwanted surfaces, such as the inside of worn clothing articles. The cover layer 18 also functions as backing layer whereon the adhesive material 19 is disposed during production.

Fig. 22a shows another embodiment 30 of a device according to the invention. Fig. 22b shows a section of Fig. 22a in an enlarged view. The device is made up by a two-dimensional adhesive element 31 and a power source in the shape of a coin cell battery 32 adhered to the adhesive element.

The adhesive element is formed of a backing layer 33. On the proximal side of the backing layer there is provided a first adhesive layer 34, which is covered by a first release liner 35. The distal side of the backing layer there is provided a second adhesive layer 36 to which the battery is adhered. A second release liner 37 covers the rest of the distal side of the adhesive, whereon the battery is not attached.

When applied to a surface, such as a skin surface of a person, the first release liner 35 is removed. This exposed the first adhesive layer, which may be adhered to the skin surface thereby attaching the device 30 to the skin surface. The second release liner is then

removed exposing the second adhesive layer. Not shown in the drawing, a housing containing a microelectronic system is then attached to the adhesive layer while at the same time an electrical contact on the housing is brought into electrical connection which the battery 32.

Although such a housing as described above do not have any surface contact such as the housing described with reference to Fig. 19, the housing may still comprise sensor technology. Such sensors may simply measure the ambient temperature or the device may be applied under the nose and a sensor for measuring the breathing rhythm through the nose may be applied on the device. Alternatively the sensor may apply skin contacting transducers outside the circumference of the device, while still being adhered thereto.

Fig. 23 shows yet another embodiment 40 of a two-dimensional device according to the invention and Fig. 24 shows a sectional view of the third embodiment along line XXIV – XXIV in Fig. 23. Here the power source element is formed as a thin film battery 41 being an integrated part of a backing layer 42.

On the proximal side of the backing layer there is applied a first adhesive layer 43 which is covered by a first release liner 44. The distal side of the backing layer is covered by a second adhesive layer 45 which is covered by a second release liner 46. The second adhesive layer is interrupted in an area 47 allowing access to contacts 48a and 48b which provides electrical contact to the thin film battery.

When used the device 40 described with reference to Fig. 23 is applied in the same way as the device 30 described with reference to Fig. 22.

It should be understood that different types of adhesives may be used on respectively the proximal side of the backing layer and the distal side of the backing layer. While the proximal side is attached to the skin surface and thus preferably should be skin friendly, the adhesive on the distal side should preferably be of a type which provides optimal attachment to a electronic circuit or a housing containing such circuit while still allowing the device to be separated there from after use.

Although the above embodiments describe releasable attachable means in shape of adhesive attachment for connecting the device to the electronic circuit other types of

release attachable means may be used. Such releasable attachable means can for example be mechanical such as a snap lock arrangement between the battery and the recess in the housing, where the recess is formed with protruding ribs which couples with the battery. Alternatively additional coupling means may be provided on the device for coupling with complementary coupling means on the electronic circuit or the housing containing the electronic circuit, and may for example be in the shape of bayonet coupling, hooks, frictional couplings or threaded couplings.

Experimental Section

Example 1

Three batches of adhesive were produced. The adhesives were prepared by standard hot melt procedure in a Herman Linden z-blade mixer (Machine type LK 110.5), by mixing the components of elastomer (Kraton), one third of the plasticiser (DOA) and the resin (Arkon) at 130 degree C until a homogeneous mixture was achieved (30-50 minutes). The rest of the plasticiser and the hydrocolloid filler (CMC) was added and the mixture was blended for 20 minutes.

	Recipe 1	Recipe 2	Recipe 3
Kraton 1161 (Shell)	18,0	19,0	15,0
Arkon P90 (Arakawa	32,0	36,0	
DOA (Dioctyl adipate)	5,6	7,5	
Vistanex® LM-MH (Exxon)			45,0
CMC: Blanose 9H4XF (Hercules)	44,4	37,5	40,0

Example 2

Moulded bodies of the adhesives of example 1:

Each of the adhesives according to claim 1 were applied on to a 35 micrometer thick cover film of polyethylene and a siliconised polyethylene liner was applied to the opposite side of the adhesive patch and pressed to the desired shape according to any of the illustrations 1-3 in a for the shape designed mould at 90 degree C by altering the non-cavity holding

mould to give the shape of the recess. The centre of the adhesive device was 3.4 mm and the thickness of the outer rim 0.4 mm.

Example 3

Moulded silicone pressure sensitive adhesive body:

Dow Corning 7-9800 A&B (mixing ration between A and B is 1:1 by weight) were used for production of a PDMS based adhesive body. A mould having a triangular shape (each side of the triangular mould having a distance of 300 mm, the center part having a thickness of 0,5 mm and the edge having a thickness of 0,1 mm) was used. The components were thoroughly mixed and applied on a 50 µm cover layer of silicone rubber lining in the female part of a triangular mould and a male mould part was placed on top, said part lined with a low density polyethylene release liner. The adhesive was cured in an oven at 100 degree C for 15 minutes. After curing the adhesive was punched out of the mould and a dent in the centre of the adhesive body device for embedment of an electronic sensing system was punched out.

Example 4

Moulded thermoplastic PSA adhesive body:

The components of recipe 2 in example 1 were mixed in a Herman Linden mixer and while still hot and soft, the resulting dough-like material mass was removed from the mixer and placed on a thermoplastic polyurethane cover film placed in the cavity of a moulding form and a release liner is placed on top. The second part of the mould was plane. The adhesive is compression moulded at approximately 90 degree C and 100 bar. The release liner was removed and an encapsulated microelectronic sensing system was placed at the centre of the adhesive body within the mould, the release liner was reapplied and the moulding step was repeated. Finally the resulting sensor pad was punched out.

Example 5

Moulded thermoplastic PSA adhesive body with integrated RFID-tag:

A pressure sensitive adhesive according to recipe 2 in example 1 were mixed in a Herman Linden mixer and while still hot and soft a minor part of the material was removed from the mixer and placed on a cover film towards the female part of a mould and a release liner was placed on top and thereafter the male part of the mould having a small protrusion

over the area corresponding to the microelectronic system of the product was applied. The whole construction is compression moulded at approximately 90 degree C and 100 bar. Hereafter the release liner was removed and a RFID tag encapsulated in polypropylene was placed in the recess of the pressure sensitive adhesive and the mould was filled up with the remaining adhesive. A release liner is attached again and the whole construction was compression moulded again. The resultant pad was punched out. The thickness of the outer rim was 0.2 mm, the central thickness was 2.5 mm and the shape was circular with a diameter 40 mm.

Example 6

In this example the micro electronic system embedded into the adhesive body consist of both the RFID tag and communication and storage components. In order to protect the micro electronic system the components are encapsulated in polyethylene. The components are integrated in the PSA during a continuous process as described in US 6726791. The primary layer comprises the cover film with pressure sensitive adhesive, the secondary layer is the encapsulated micro electronic part; and the third layer is of a mouldable layer pressure sensitive adhesive; the whole construction is combined in the moulding cavities.

Example 7

Preparation of a Hydrogel adhesive composition:

3.5 grams of PVP K-90, 17.5 grams of PVP K-25, 3.5 grams of Pemulen TR2 and 28 grams of PEG 400 were mixed as a premix. Initially the premix of the plastizicing glycols, the PVP and the cross-linked polyacrylic acid were added and mixed in a Brabender mixer at 100 degrees C for 10 minutes. Then 17.5 grams of the amphiphilic polyurethane (Tecogel 2000) was slowly added in order to ensure complete mixing of the components. After 20 minutes' mixing a macroscopically homogenous mixture was obtained. The hot adhesive from the mixing chamber was moulded into a circular adhesive body (diameter 4 cm) with a dent for a later applied micro electronic system. The thickness of the pad is 3 mm at the centre and the thickness is gradually decreasing to 0,3 mm at the edge of the pad. The adhesive device was compression moulded between a sheet of silicone paper and a 30 μm PU cover film.

Example 8

A microelectronic sensing system for invasive measurement of oxygen:

An adhesive according to example 1 recipe 2 was used embedment of a micro electronic system consisting of an oxygen electrode, a central processing unit, a transmitter and a battery. The shape of the adhesive body is oval (70 x 30 mm) having a centre thickness of 5 mm, an edge of 0,3 mm and an essential linear increase in thickness from the edge to centre of the pad. The adhesive body has a centrally placed through hole and a dent in the skin-contacting part of the surface of the adhesive body for the silicone covered micro electrical components.

The CPU, the battery and the transmitter are as described in the examples 11. The oxygen electrode was oxygen electrode product number 723 (from Diamond General, Development Corp. US).
The CPU, transmitter and battery were electrically connected and thereafter covered with a thin layer of polymeric silicone, only the electrical contact of the CPU to the electrode, remains uncoated.

The tip of the electrode in the sensing device is surrounded with a medical needle with outer diameter of 0,7 mm.

During use the electrode and the needle are positioned in a way where the electrical contacts of the CPU are connected with corresponding contacts of the electrode.

During application of the measuring device the partly silicone covered micro electronic system was firstly applied onto the adhesive body in the dent at the skin contacting side of the device. The device is applied to the skin. The needle is then positioned from the outside through the hole in the adhesive by penetrating the skin in a second step and the electrode partly enveloped in a plug is mounted through the hollow centre of the needle as a third step creating electrical contact to uncoated connections of micro electronic system. The plug part of the electrode fits the smooth curvature of the cover film without introducing recesses.

During use, the electrode may be rinsed and reapplied according to needs for achieving correct signals.

Example 9

Microelctronic hub embedded in adhesive sensor device according to the invention:

An adhesive according to example 1 receipe 1 was moulded in a first layer forming an oval shell (50 x 80 mm) having a smooth surface to one side. This surface is declining in slope towards the outer periphery and is covered with a 30 µm thin film of polyurethane i.e. placed between mould and adhesive. The opposite side of the adhesive body was formed with a centrally soft shaped indentation of approximately 2 x 10 x 15 mm for applying the microelectronic system. A siliconised release liner of polyethylene was placed on the surface with the indentation. In a second step the release liner was removed, an antenna is placed at the outer periphery of the adhesive body and the CPU and the battery was placed in the central indentation. In a final step a second layer of adhesive was applied to embed the antenna at the area of the outer periphery but not the components in the central indentation. A release liner is applied and the complete construct which was die cut to the final size. The antenna is connected to the central microelectronic parts through electrical contacting elements making reuse of the central part possible. The antenna is encapsulated in thin polyethylene terephthalate (PET)-plastic and the central microelectronic parts are encapsulated in silicone rubber.

Example 10

Microelectronic hub:

A construction with microelectronic hub in which the antenna as well as the battery is completely integrated in the pressure sensitive adhesive of previous example 1. This is done by letting the adhesive of the final step in example 9 cover the antenna as well the central microelectronic parts.

Example 11

An adhesive device having embedded a microelectronic system for human temperature sensing and alarm with no remote communication

An adhesive according to example 1 recipe 2 was used for embedment of a micro electronic system consisting of an temperature sensor, a central processing unit, a transmitter, battery and an OLED (Organic Light emitting Diode). The shape of the adhesive body is round (30mm) having a centre thickness of 5 mm, a peripheral edge of 0,2 mm and an essential linear increase in thickness from the edge to centre of the pad.

The adhesive body has a dent in the skin-contacting part of the surface for the silicone covered micro electrical components.

The CPU is a µController ATMEGA 128L, an AVR 8bit RISC processor from ATMEL,
Battery is an Panasonic Coin cell CR3202.
OLED flexible colour display is from OSD (One Stop Display) part #OSCC 130-0.
Temperature sensor is from Pasport Ps-2125

During use the temperature sensor continuously monitors human skin temperature. At certain events determined by the micro-Controller influenced by time of day, temperature gradient compared to stored data, the system will give a visual alarm in form text or lights of relevant information at the flexible display.

The system is integrated into the adhesive and activated when peeling off the release liner and will function until end of battery.

Example 12

An adhesive device having embedded a microelectronic system for human temperature sensing and alarm with no remote communication is constructed according to example 11.

The construction of the adhesive device is identical to the one of example 11 except that instead of the OLED flexible colour display for signalling a temperature change an EL (Electro-lumiscent Lamp) is used as the signalling part in the surface of the device. The part is an EL Lamp Part #: 300210KIT from Being Seen Technologies.

During use the temperature sensor continuously monitors human skin temperature. At certain events determined by the micro-Controller influenced by time of day, temperature gradient compared to stored data, the system will give a visual alarm in the form of a light.

Example 13

In one embodiment illustrated with reference to Figs. 19 – 21 the adhesive material 19 is a pressure sensitive adhesive (PSA) consisting of a hot-melt processable styrenic block copolymer with hydrocolloids, the battery is a metal cased coin cell battery and the housing is coated with a layer of PolyDiMethylSiloxane.

In Example 13 below, the peel forces between the PSA and the surface, the battery and the housing were determined:

The PSA is a hot-melt processable Styrenic block copolymer with hydrocolloids, which is thermo formed into the desired shape. The PSA designated A, has the following composition: 25% Kraton D1107 (Kraton Polymers), 35% Arkon P90 (a hydrogenated polycyclopentadiene from Arkawa Ltd.) 8 % DiOctylAdipate and 32% sodium carboxymethylcellulose.

In order to illustrate the peel force between the different parts the peel force has been determined via use of FINAT; FTM2, 25mm test sample width, 90 degrees peel angle, test speed of 300 mm/min and a resting time of 30 minutes.

With regard to peel force from skin the following test method was utilized:
Strips of adhesive 25 mm wide were cut from slabs of PSA composition A. A strip of adhesive tape (TESA 4124) was attached in order to prevent stretching of the samples. The samples were taped to a clamp. The skin of the volunteer was prepared by washing the underside of the forearm with diluted soap and allowing to dry at least 2 hours before the PSA was attached. The adhesive side of the sample was placed on the prepared skin. The resting time for the adhesive was 30 minutes. The clamp was attached to the hook of the testing device, an Instron Tensile tester Model 5564. The forearm was placed on a movable support of the testing device, taking care to keep the end of the sample directly under the clamp in order to keep a 90-degree peel angle. The forearm was kept still while the tensile strength tester was activated to pull the adhesive up at a rate of 300 mm/min. The peel value of the steady state part of the resulting graph was recorded and it was confirmed that no residue was left on the skin of the forearm.

The battery was a metal cased Manganese Dioxide Lithium coin cell battery CR2330, from Panasonic, and the microelectronic housing was coated with a layer of PolyDiMethylSiloxane (PDMS); MED-1137 from NuSil Technology.

The peel forces have been determined between the adhesive and the following parts with following results and with three repetitions of the test, where s indicates the standard deviation.

Peel force between A and PDMS coated housing	0,1 N/25mm
Peel force between A and steel	22,5 N/25mm (s= 2,3)
Peel force between A and human skin	2,5 N/25mm (s= 0,25)

Furthermore, different types of materials may be used for different parts of the device and the microelectronic circuit and/or the housing whereby different peel forces may be provided. Thus it would be possible to achieve peel forces between the PSA and the skin in the general range of 1 – 5 N/25 mm, peel forces between the PSA and the housing generally below 1 N/25mm and the peel forces between the PSA and the metal casing of the battery generally above 20 N/25mm.

It can thus be understood, that when the sensor assembly 1 has been applied to the skin of a user it may easily be peeled off after use, by pulling the adhesive element with a force above the peel force between the PSA and the skin. The adhesive element 5 may then easily be separated from the housing element 3 containing the microelectronic circuit 4. As the peel force between the adhesive element and the battery 6 is much higher than between the adhesive element and the housing, the battery is practically inseparable from the adhesive element, and thus the battery will be attached to the adhesive when the adhesive is separated from the housing.

Claims:

1. A three-dimensional adhesive device to be attached to the body surface of a mammal comprising an microelectronic system **characterized by**
(a) a three-dimensional adhesive body made of a pressure sensitive adhesive having an upper surface and a bottom surface;
(b) a microelectronic system embedded in the body of the pressure sensitive adhesive;
(c) one or more cover layer(s) attached to the upper surface; and
(d) optionally a release liner releasable attached to the bottom surface of the adhesive device.

2. An adhesive device according to claim 1 wherein the micro electronic system is a microelectronic sensing system.

3. The adhesive device according to any of claims 1-2 wherein the three-dimensional adhesive body has an essentially planar bottom surface adapted to adhere to the body surface of a mammal and an smooth upper surface, the adhesive device being thickest at the central part of the body and thinnest at the periphery of the body.

4. The adhesive device according to any of claims 1-3 wherein the thickness of the adhesive device at the periphery is less than 50 % of the thickness of the adhesive device where it is thickest, suitably the thickness at the periphery is less than 25 % of the thickness of the adhesive device where it is thickest, preferred the thickness at the periphery is less than 10 % of the thickness of the adhesive device where it is thickest , and most preferred the thickness at the periphery is less than 5 % of the thickness of the adhesive device where it is thickest.

5. The adhesive device according to claim 4 wherein the thickness at the periphery of the adhesive device is more than 0.05 mm, suitably between 0.05 and 0.4 mm and the thickness where the adhesive device is thickest, is between 0.5 and 15 mm, suitably between 1 and 5 mm.

6. The adhesive device according to any of claims 1-5 wherein the angle between the bottom surface of the adhesive device and a line drawn from any point on the circumference of the and the point at the upper surface where the adhesive body is

thickest is below 60 degrees, preferably below 45 degrees and most preferably below 30 degrees.

7. The adhesive device according to any of claims 1-6 wherein the pressure sensitive adhesive making up the three-dimensional adhesive body is a mouldable thermoplastic pressure sensitive adhesive having a flexibility enabling the adhesive device to conform to the curvature of body parts while retaining its adhesive properties even under movements.

8. The adhesive device according to any of claims 1-7 wherein the pressure sensitive adhesive is an adhesive based on polymers selected from block-copolymers such as styrene-block-copolymers, and hydrogenated styrene-block-copolymers, amorphous poly-alpha-olefins (APAO), polyacrylics, polyvinylethers, polyurethanes, polyelhylenevinylacetate, silicone, or from the group of hydrogel pressure sensitive adhesives.

9. The adhesive device according to claim 8 wherein the block-copolymers such as styrene-block-copolymers, and hydrogenated styrene-block-copolymers is selected from Styrene/ethylene-Butylene/Styrene (SEBS), Styrene/Isoprene/Styrene (SIS), and Styrene/Ethylene-Propylene/Styrene (SEPS).

10. The adhesive device according to claim 8 wherein the adhesive is a PolyDiMethylSiloxane based adhesive, such as a PolyDiMethylSiloxane gel.

11. The adhesive device according to any of claims 1-10 wherein the pressure sensitive adhesive making up the adhesive body comprises hydrocolloids.

12. The adhesive device according to any of claims 1-10 wherein the pressure sensitive adhesive making up the adhesive body is a foamed adhesive.

13. The adhesive device according to any of claims 1-12 wherein the entire microelectronic system is integrated in the adhesive body and is completely covered by the adhesive body on all sides.

14. The adhesive device according to any of claims 1-12 wherein one or more components of the microelectronic system is integrated into the adhesive body and is covered by the adhesive body on all sides and the rest of the component(s) of the microelectronic system are located elsewhere in the adhesive body, the components of the microelectronic system having the necessary mechanical and electrical connection to each other.

15. The adhesive device according to any of claims 1-12 wherein the entire microelectronic system is contained in one or more recesses provided in the upper surface of the adhesive body facing the cover layer(s).

16. The adhesive device according to claim 14 wherein one or more components of the microelectronic sensing system is integrated into the adhesive body and is covered by the adhesive body on all sides and the rest of the microelectronic system is contained in one or more recesses provided in the upper surface of the adhesive body facing the cover layer(s).

17. The adhesive device according to any of claims 1-12 wherein the entire microelectronic system is contained in one or more recesses provided in the adhesive bottom surface of the adhesive body.

18. The adhesive device according to claim 14 wherein a one or more components of the microelectronic system is integrated into the adhesive body and is covered by the adhesive body at all sides and the rest of the microelectronic sensing system is contained in one or more recesses provided in the adhesive bottom surface of the adhesive body.

19. The adhesive device according to any of claims 1-12 wherein the entire microelectronic system is contained in one or more through hole(s) in the adhesive body and is accessible from both the upper surface facing the cover layer(s) and the adhesive bottom surface.

20. The adhesive device according to claim 14 wherein a one or more components of the microelectronic sensing system is integrated into the adhesive body and is covered by the adhesive body and the rest of the microelectronic system is contained in one or

more through hole(s) in the adhesive body and is accessible from both the upper surface facing the cover layer and the adhesive bottom surface.

21. The adhesive device according to claim 14 wherein one or more components of the microelectronic system is integrated into the adhesive body and is covered by the adhesive body, other components of the microelectronic system is contained in one or more through holes in the adhesive body and is accessible from both the upper surface facing the cover layer and the adhesive bottom surface, and the rest of the microelectronic system is contained in one or more recesses in the upper and/or bottom surface of the adhesive body.

22. The adhesive device according to any of claims 1-12 wherein one or more components of the microelectronic system is contained in one or more through holes in the adhesive body and is accessible from both the upper surface facing the cover layer and the adhesive bottom surface and the rest of the microelectronic system is contained in one or more recesses in the upper and/or bottom surface of the adhesive body.

23. The adhesive device according to claims 1-12 wherein one or more components of the micro electronic system is contained in one or more recesses in the upper surface of the adhesive body and the rest of the microelectronic system is contained in one or more recesses in the bottom surface of the adhesive body.

24. The adhesive device according to any of claims 1 to 23 wherein the microelectronic system or one or more components thereof is encapsulated in a material different from the adhesive body.

25. The adhesive device according to claim 24 wherein the microelectronic system or components thereof is encapsulated in a polymer film, a polymer foil, or a polymer coating or the microelectronic system or components thereof is moulded into a polymer material, or is encapsulated in a glass or ceramic material.

26. The adhesive device according to claim 25 wherein the polymer used for encapsulation is silicone rubber.

27. The adhesive device according to claims 1-26 wherein the one or more components of the microelectronic system is accessible from outside the adhesive body, and may be replaced by a similar component during the life time of the adhesive device.

28. The adhesive device according to claim 27 wherein the component, which may be exchanged, is the energy source, e.g. the battery.

29. The adhesive device according to claims 1-26 wherein the one or more components of the microelectronic system is accessible from outside the adhesive device, and the component(s) may be reused.

30. The adhesive device according to any of claims 27 –29 wherein the replaceable component(s) or the reusable component(s) is encapsulated and form a package, which fit a recess or a through hole in the adhesive body.

31. The adhesive device according to claim 30 wherein the package of encapsulated, replaceable or reusable component(s) is fixed into the adhesive body by a mechanical doubling, suitably snap lock mechanism.

32. The adhesive device according to claim 30 wherein the package of encapsulated, replaceable or reusable component(s) is fixed to the surface of the adhesive in the recess or through hole of the adhesive body.

33. The adhesive device according to claim 30 wherein the package of encapsulated, replaceable or reusable component(s) is fixed in a recess or through hole in the adhesive body, where said recess or trough hole is provided with an inner non-adhesive surface, such as a PDMS coating.

34. The adhesive device according to any of claims 1-33 wherein the microelectronic system comprises components selected from communication component(s), CPU, power source, storage component(s), transducer component(s), actuator component(s) and mechanical and/or electrical interconnection between the components.

35. The adhesive device according to any of claims 1-34 wherein microelectronic system is a system enabling wireless communication.

36. The adhesive device according to claim 34 wherein the transducer has a detecting element selected from electrodes (polar, bipolar), a pressure sensor, a needle with an electrode, an accelerometer, a photo detector, a microphone, ISFET, an NTC resistor, a band gab detector, an ion membrane, an enzyme detector or a condenser .

37. The adhesive device according to claim 36 wherein the transducer has a non-invasive detecting element, such as electrodes, e.g. steel electrodes.

38. The adhesive device according to claim 36 wherein the transducer has an invasive detecting element, such as a needle containing an electrode.

39. The adhesive device according to claims 34-36 where there is no physical contact between the detector and the skin of the mammal.

40. The adhesive device according to claim 34 wherein the microelectronic system comprises a Network HUB, a gateway or a coordinator system.

41. The adhesive device according to claim 34 wherein the microelectronic system includes a GPS.

42. The adhesive device according to claim 34 wherein the microelectronic system includes a RFID tag.

43. The adhesive device according to claim 40 wherein the microelectronic system is a gateway comprising storage and communication components, CPU and a battery encapsulated in plastic and working as a dedicated network coordinator for transmission of data to a central unit (CU).

44. The adhesive device according to claim 41 wherein the microelectronic system is a system selected from:

- a system comprising storage and communication components, CPU, battery, GPS, components for wireless synchronisation of real time clock for data logging of GPS data optionally encapsulated in plastic, and

- a system comprising storage and communication components, CPU, battery, GPS, components for wireless synchronisation of real time clock for data logging of GPS data, mobile net for data logging and transmission of data and position to mobile phones, optionally encapsulated in plastic,

45. The adhesive device according to claim 34 wherein the microelectronic system is useful for nerve stimulation and comprises storage and communication components, CPU, power source and transducer for transmitting data and power to an implant for nerve stimulation.

46. The adhesive device according to claim 34 wherein the microelectronic system is a system useful for electromyography and comprises a transducer, CPU, power source, communication and storage components and an optionally an actuator.

47. The adhesive device according to claim 1-46, wherein the device comprises a power source element for powering said microelectronic system, wherein

- the adhesive body is releasable attached to one or more of the components of the microelectronic system,
- the adhesive body has at least a first area for adhering to the body surface, and

48. The adhesive device according to claim 47, wherein the power source element is attached to the adhesive body and the adhesive body has at least a second area for adhering to one or more of the components of the microelectronic system.

49. The adhesive device according to claim 48 or 47, wherein a first peel force between the second area and the microelectronic circuit is smaller than a second peel force between the power source and the adhesive body.

50. The adhesive device according to claim 47, 48 or 49, wherein the power source element is at least partly contained in the adhesive body.

51. The adhesive device according to claim 47, 48, 49 or 50, wherein the adhesive device is adapted to be releasable connectable to a housing containing the

microelectronic system and that the housing is formed of a proximal housing part and a distal housing part.

52. The adhesive device according to claim 51, wherein the at least one power source is adapted to be received in a recess, the recess is formed in the distal housing part and that at least one electrical contact is provided in the distal housing providing electrical connection between the power source and the microelectronic circuit.

53. A sensor assembly adapted to be attached to the body surface of a mammal, comprising

- a sensor circuit, comprising a number of electrical components,
- at least one power source for powering at least one of the electrical components,
- at least one adhesive for attaching the sensor assembly to the body surface of a mammal, and
- that at least one of the power source and the adhesive is releasable connected to the sensor circuit.

54. A sensor assembly according to claim 53, wherein the sensor circuit is at least partly contained in a housing and that the housing is formed of a proximal housing part and a distal housing part.

55. A sensor assembly according to claim 54, wherein a first peel force between the adhesive and the housing is smaller than a second peel force between the adhesive and the battery.

56. A sensor assembly according to claim 54 or 55, wherein the at least one transducer is attached to the proximal surface of the proximal part.

57. A sensor assembly according to claim 54, 55 or 56, wherein

- a recess is formed in the distal housing part, the recess is adapted to receive the at least one power source, and
- at least one electrical contact is provided in the distal housing providing electrical connection between the at least one power source and the electrical components.

58. A multi-sensor network comprising one or more adhesive devices according to claims 1-52.

59. A multi-sensor network according to claim 58 comprising an adhesive device comprising a network coordinator, at least two adhesive devices comprising a microelectronic system useful for electromyography and comprises a transducer, CPU, power source, communication and storage components and an optionally an actuator and adhesive devices comprising a microelectronic system useful for suitable for measuring heart rate.

60. A method for producing an adhesive device according to claim 1 having embedded a microelectronic system in an adhesive, said device having a cover film and a release liner characterised by the adhesive body being compression moulded.

61. A method for producing an adhesive device according to claim 1 having embedded a microelectronic system in an adhesive, said device having a cover film and a release liner characterised by the adhesive body being injection moulded.

62. A method for producing an adhesive device according to claim 1 having embedded a microelectronic system in an adhesive, said device having a cover film and a release liner characterised by the adhesive body being formed by reaction moulding.

63. An adhesive device according to claim 1 having embedded a microelectronic system in the adhesive body and being connected to other electronic systems by wiring.

64. The use of a device comprising an adhesive element and a power source element, and where the device is used for attaching an electronic circuit to a surface and to power said electronic circuit, wherein said electronic circuit is releasable connectable to the adhesive element and the power source element.

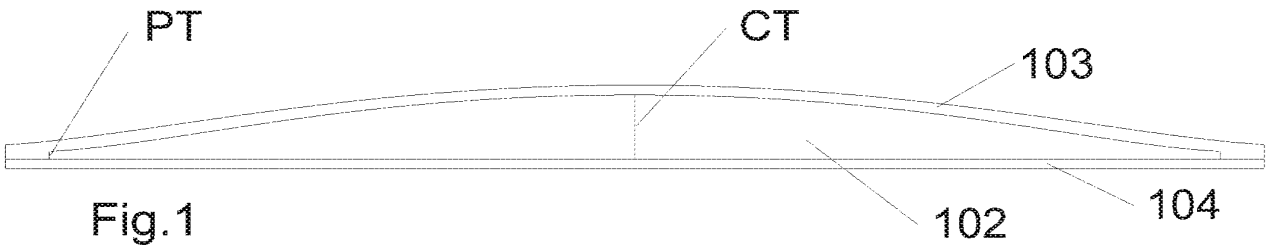


Fig.1

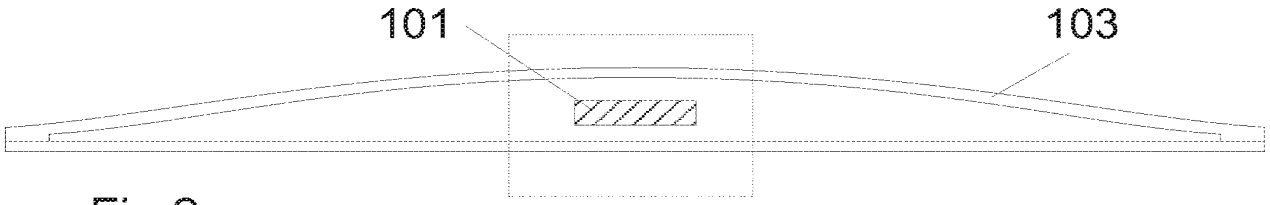


Fig.2

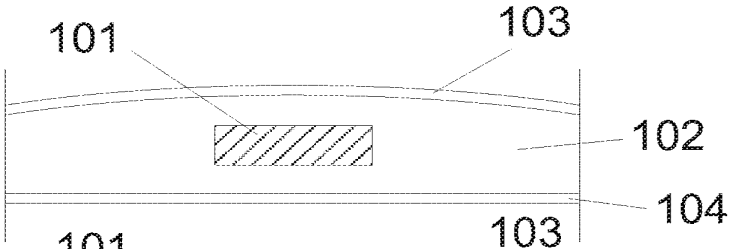


Fig.3

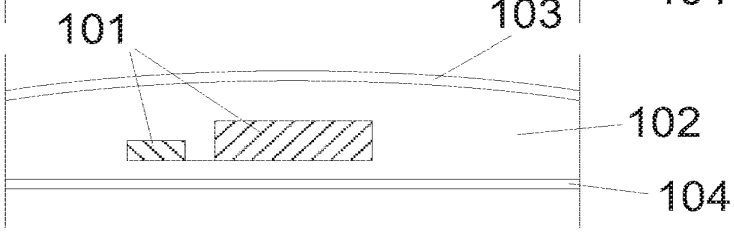


Fig.4

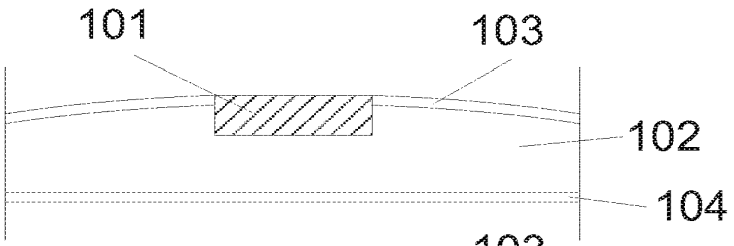


Fig.5

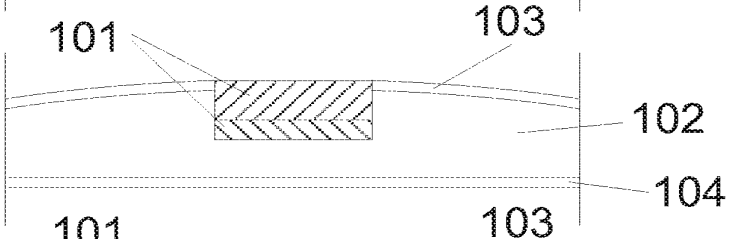


Fig.6

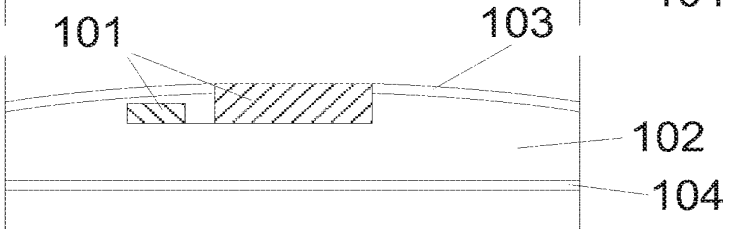


Fig.7

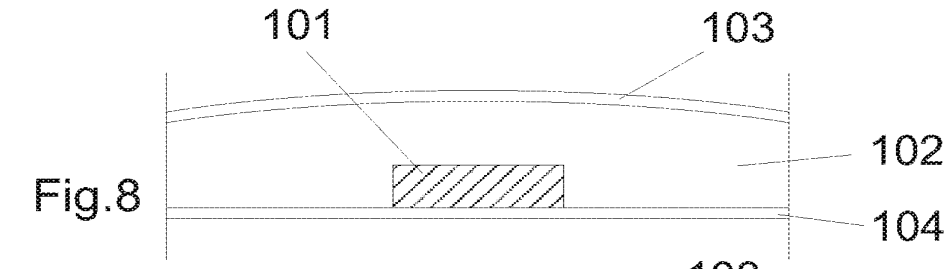


Fig.8

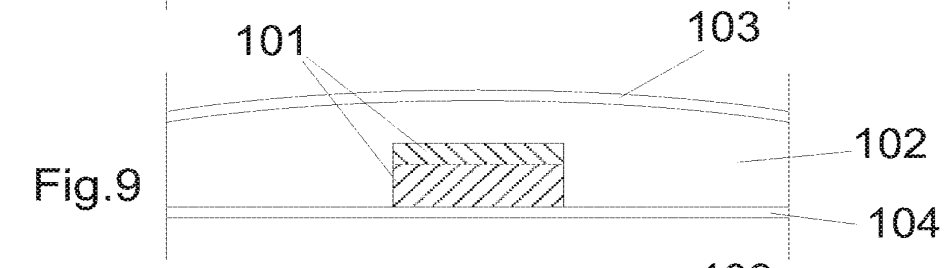


Fig.9

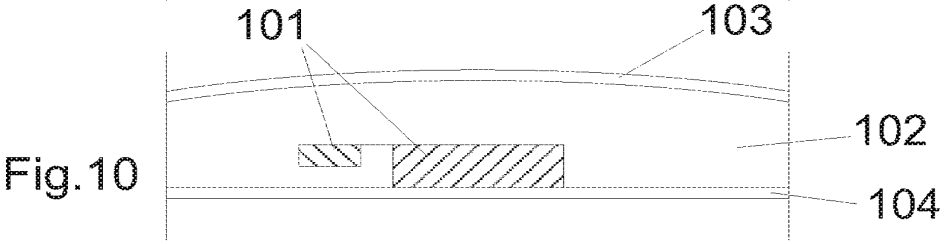


Fig.10

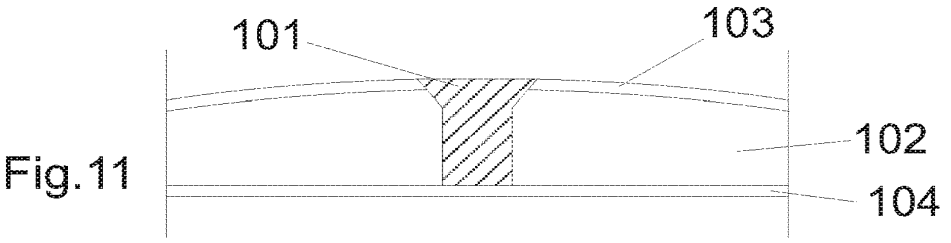


Fig.11

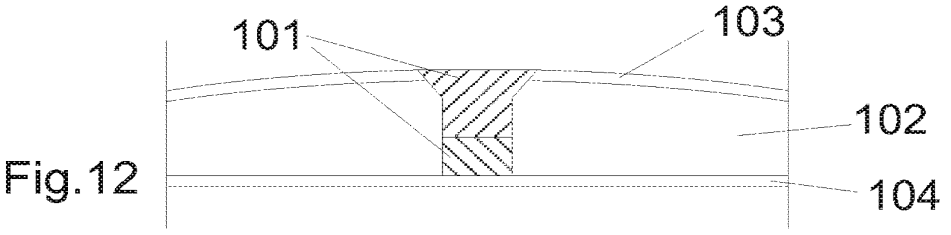


Fig.12

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Fig.15

Fig.16

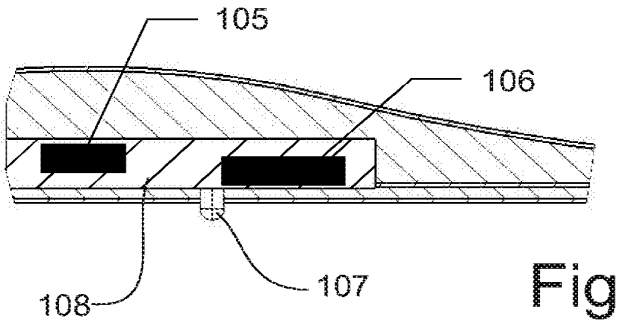


Fig.17

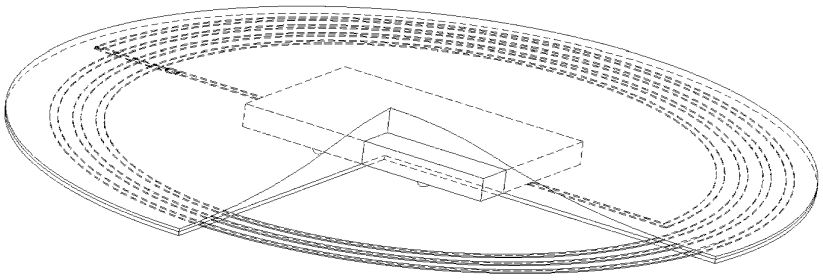


Fig.18

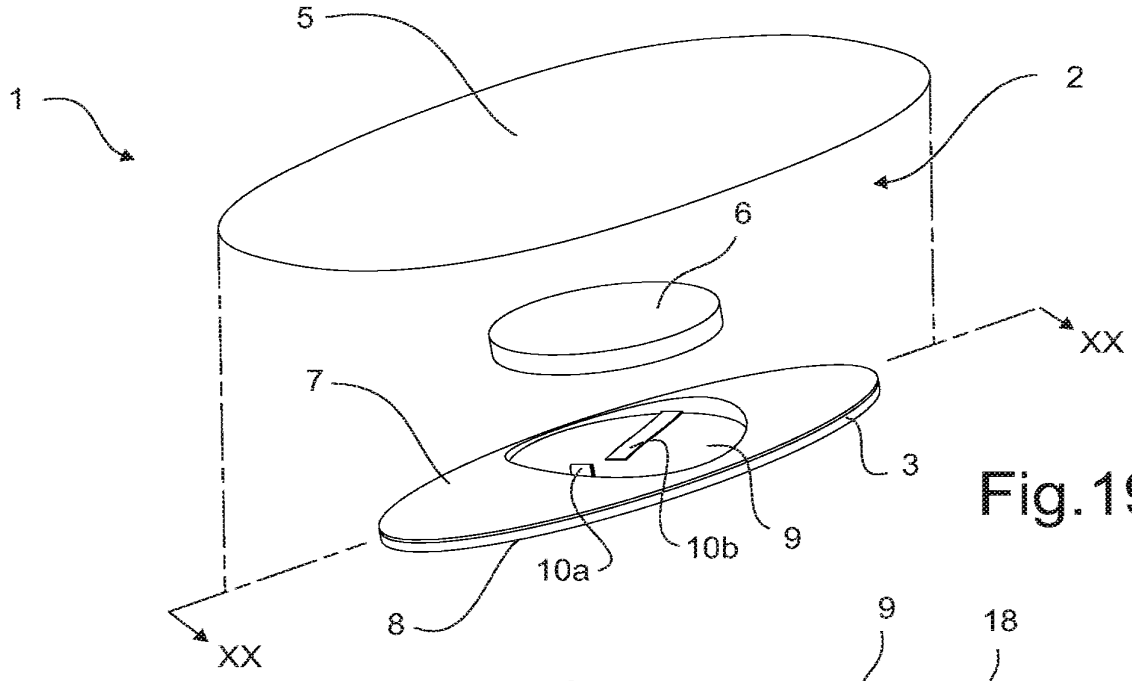


Fig.19

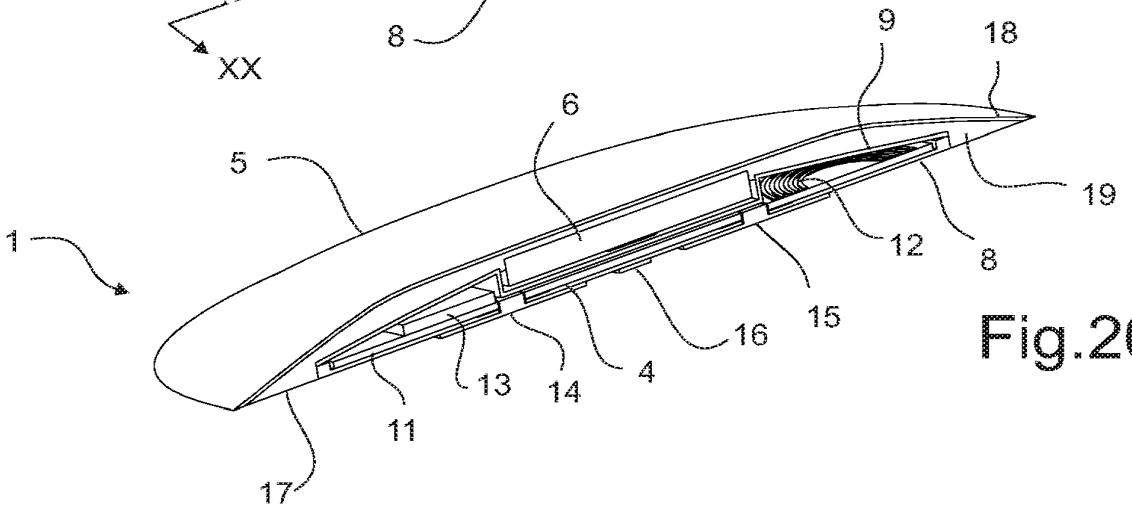


Fig.20

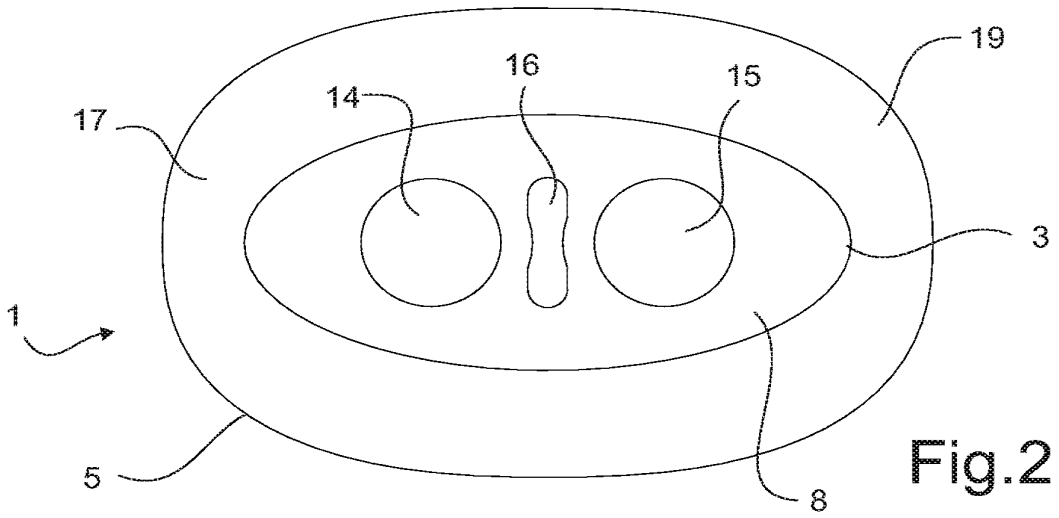


Fig.21

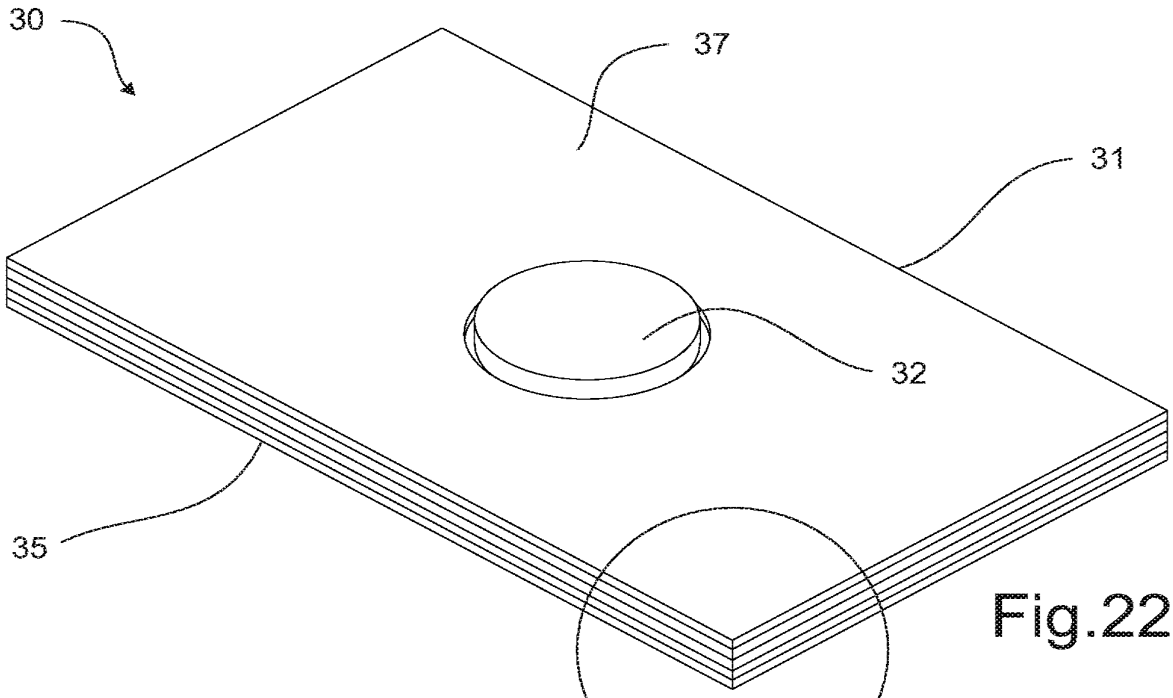


Fig.22a

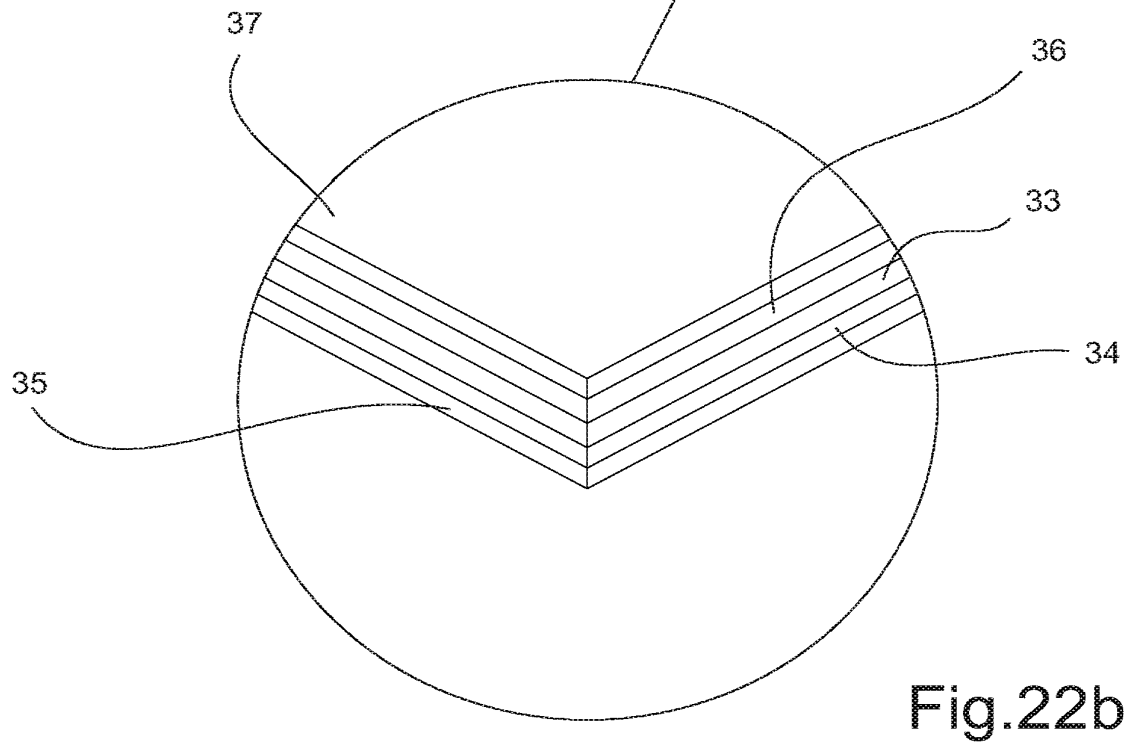


Fig.22b

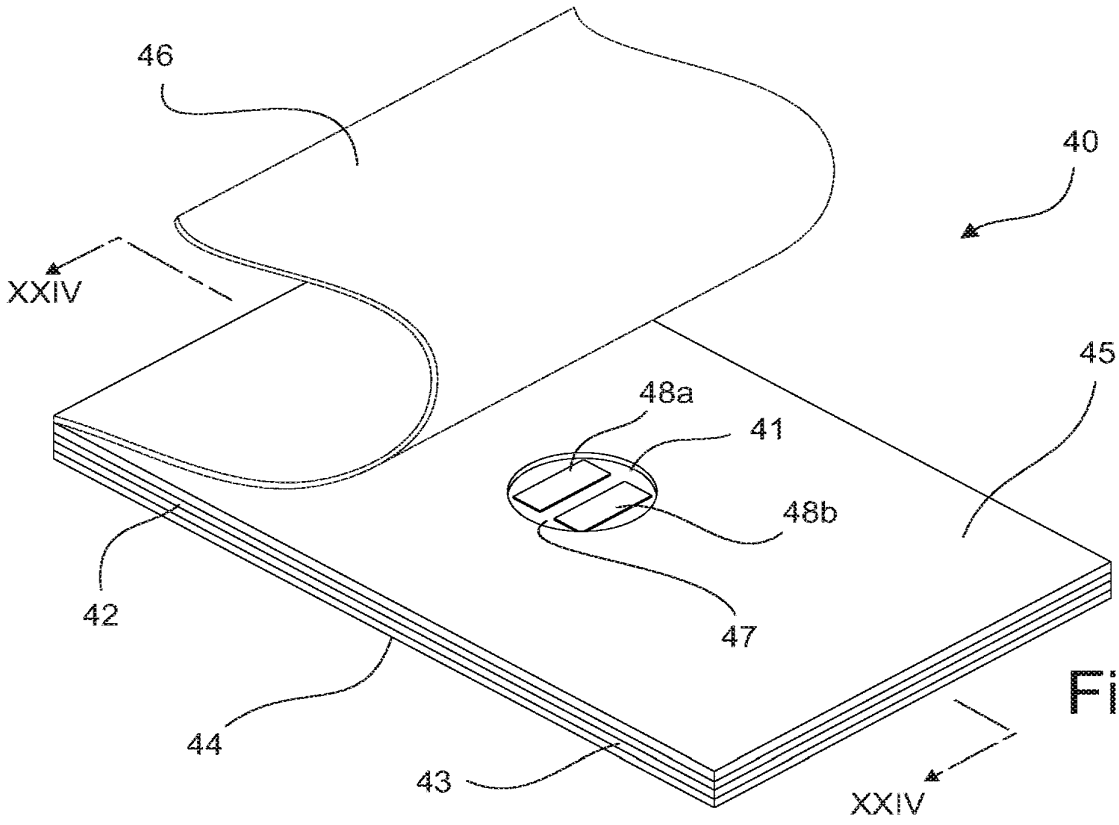

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Fig.23

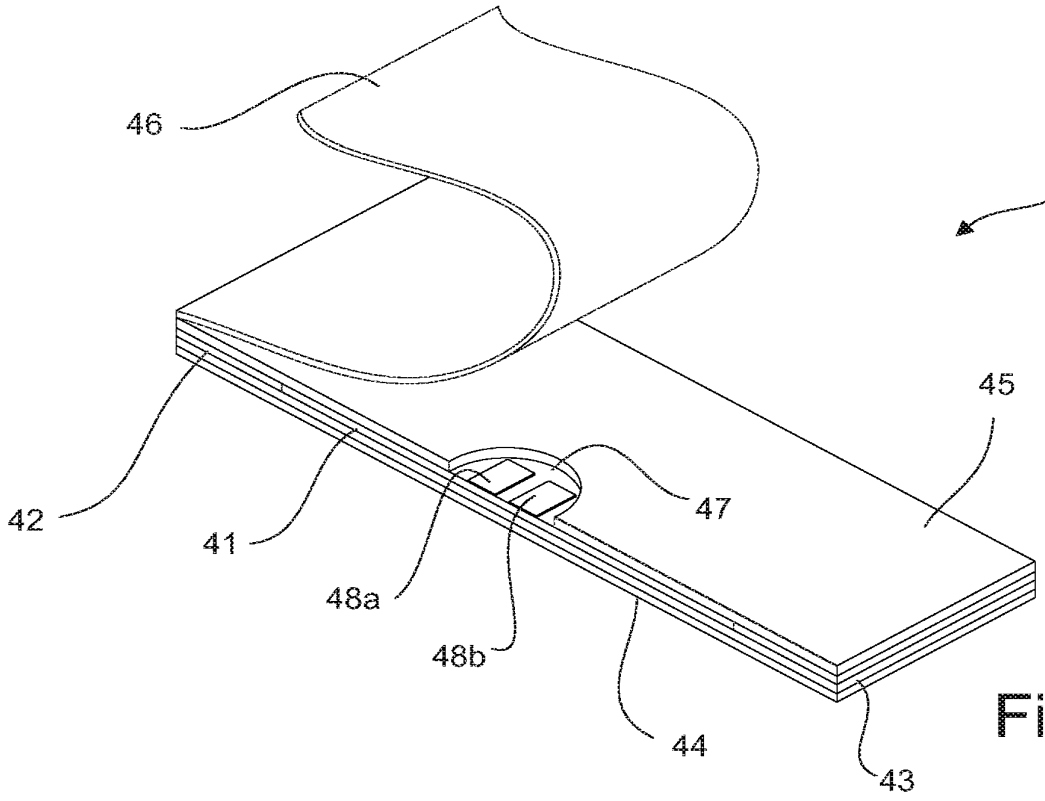

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Fig.24

(12) NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT) VERÖFFENTLICHTE INTERNATIONALE ANMELDUNG

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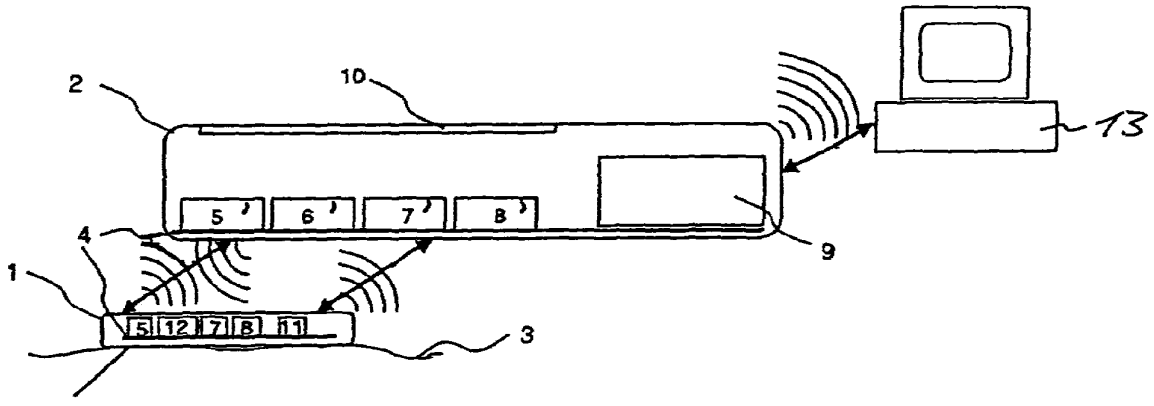
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[Fortsetzung auf der nächsten Seite]

(54) Title: ENERGY-OPTIMISED DATA TRANSMISSION FOR A MEDICAL APPLIANCE

(54) Bezeichnung: ENERGIEOPTIMIERTE DATENÜBERTRAGUNG EINES MEDIZINISCHEN GERÄTS



(57) Abstract: A medical appliance (1) is disclosed for use on and/or in the body of a user and comprises a transmission unit (5) and an activation switch (6) which is connected to the transmission unit (5) and can activate the transmission unit (5) when an activation signal is received by the activation switch (6). Also disclosed is a process for transmitting data between a medical appliance (1) and an external appliance (2), the external appliance (2) activating the medical appliance (1) prior to data transmission when the latter is in an idle state.

(57) Zusammenfassung: Die vorliegende Erfindung betrifft ein medizinisches Gerät (1) zum Einsatz am und/oder im Körper eines Benutzers mit einer Sendeeinheit (5) und einem Aktivierungsschalter (6), welcher mit der Sendeeinheit (5) verbunden ist und die Sendeeinheit (5) aktivieren kann, wenn ein Aktivierungssignal vom Aktivierungsschalter (6) empfangen wurde, sowie ein Verfahren zum Übertragen von Daten zwischen einem medizinischen Gerät (1) und einem externen Gerät (2), wobei das sich im Ruhezustand befindende medizinische Gerät (1) von dem externen Gerät (2) vor der Datenübertragung aktiviert wird.

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GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), eurasisches (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), europäisches (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Veröffentlicht:

— *mit internationalem Recherchenbericht*

Zur Erklärung der Zweibuchstaben-Codes und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.

Energieoptimierte Datenübertragung eines medizinischen Geräts

Die Erfindung bezieht sich auf ein medizinisches Gerät, ein System und ein Verfahren zur energieoptimierten Datenübertragung von und/oder zu dem medizinischen Gerät.

Während des Betriebes eines medizinischen Gerätes, wie zum Beispiel einer auf der Haut eines Benutzers angebrachten Infusionspumpe oder eines Sensors, ist es für einen Benutzer von Vorteil, wenn dem medizinischen Gerät zum Beispiel von einer Fernsteuerung Daten für den Betrieb des medizinischen Gerätes übertragen werden können oder wenn zum Beispiel Sensor-Messdaten an ein externes Gerät übertragen werden.

Ein von einer Fernsteuerung ansteuerbares externes Infusionsgerät ist aus der US 6,551,276 B1 bekannt, wobei das externe Infusionsgerät einen Empfänger aufweist, welcher in einem so genannten Standby-Modus sein kann und automatisch ungefähr alle 2,5 Sekunden aktiviert wird, um festzustellen, ob von der Fernsteuerung ein Funksignal ausgesandt wird, sodass die Funkfernsteuerung ein Aktivierungssignal über eine Periode von zum Beispiel ca. 5 Sekunden aussenden sollte, um von dem Empfänger erkannt zu werden.

Die US 4,395,259 beschreibt ein implantierbares Messgerät, welches eine Einheit zur Abgabe einer Dosis aufweist, wobei ein externes Steuergerät induktiv mit diesem Gerät gekoppelt werden kann, um zum Beispiel die Infusionsrate zu verändern.

Es ist eine Aufgabe der vorliegenden Erfindung ein medizinisches Gerät, ein System und ein Verfahren vorzuschlagen, welche eine Datenübertragung bei einem geringen Energieeinsatz ermöglichen.

Diese Aufgabe wird durch die Gegenstände der unabhängigen Ansprüche gelöst. Vorteilhafte Ausführungsformen ergeben sich aus den abhängigen Ansprüchen.

Ein medizinisches Gerät, wie zum Beispiel ein zum Beispiel subkutaner Sensor, insbesondere ein Glukose-Sensor, eine Pumpe, insbesondere eine Insulin-Pumpe, welche zum Beispiel implantiert, minimal invasiv oder nicht invasiv sein können, oder ein Pen zum Einsatz am und/oder im Körper eines Benutzers weist bevorzugt mindestens eine elektrische oder elektronische Funktionseinheit auf, wie zum Beispiel einen Messsensor, einen Prozessor, einen Speicher oder einen Elektromotor, welcher beispielsweise von dem Prozessor angesteuert werden kann und weist eine Sende- und/oder Empfangseinheit zum Übertragen, also zum Senden und/oder Empfangen von Daten auf, wobei erfindungsgemäß ein Aktivierungsschalter vorgesehen ist, der mit der Sende-/Empfangseinheit und/oder mindestens einer elektronischen Funktionseinheit in Verbindung steht, wobei der Aktivierungsschalter durch ein externes Aktivierungssignal aktiviert werden kann, um zum Beispiel die Sende-/Empfangseinheit und/oder mindestens eine elektronische Funktionseinheit zu aktivieren, sodass beispielsweise eine drahtlose Kommunikationsverbindung hergestellt werden kann, um zum Beispiel Messdaten von einem Sensor an ein externes Gerät zu übertragen oder zum Beispiel Steuerdaten zur Einstellung einer Basalrate oder zur Abgabe eines Bolus an eine Insulin-Pumpe zu senden oder die durch die Kommunikationsverbindungen verbundenen Geräte zu synchronisieren. Erfindungsgemäß wird die Kommunikation nur bei Bedarf, also „on demand" aufgenommen, wobei durch die für die Datenübertragung erforderliche Aktivierung des Aktivierungsschalters sichergestellt werden kann, dass nur dann eine Kommunikation aufgebaut oder hergestellt wird, wenn Empfänger und Sender, also das medizinische Gerät und ein externes Gerät, wie zum Beispiel eine Steuervorrichtung oder die jeweiligen Eingabe-/Ausgabeeinheiten davon, entweder in direktem physikalischen Kontakt miteinander stehen oder so relativ zueinander angeordnet sind, dass eine vorgegebene maximale Entfernung zwischen Sender und Empfänger unterschritten wird. Weiterhin kann zum Beispiel der Aktivierungsschalter des medizinischen Gerätes, welcher von einem Aktivierungselement des externen Gerätes aktiviert wird, nur dann ein Anschalt- oder Freigabesignal ausgeben, wenn das medizinische Gerät und ein externes Gerät eine vorgegebene Orientierung zueinander haben, also zum Beispiel Sende- und Empfangseinheiten oder Sende- und Empfangselemente etwa einander gegenüber liegen.

Somit kann der Energiebedarf des medizinischen Gerätes verringert werden, da nur dann elektrische oder elektronische Komponenten zur Übertragung von Daten aktiviert werden, wenn ein entsprechender Sender oder Empfänger eines externen Geräts in Reichweite ist, wobei die Sende- und Empfangseinheiten so dimensioniert oder ausgelegt werden können, dass eine Datenübertragung nur über eine relativ kurze Strecke, wie zum Beispiel 5 cm oder weniger, sichergestellt werden muss, was beispielsweise ausreicht, um Daten von einem externen Gerät, welche auf die Kleidung eines Benutzers aufgelegt wurde, durch diese Kleidung hindurch zu einem darunter auf der Haut des Patienten angebrachten oder implantierten medizinischen Gerätes zu übertragen oder von diesem medizinischen Gerät zu empfangen. Da die Datenübertragungseinheit erfindungsgemäß nur eine relativ geringe Leistungsfähigkeit aufweisen muss, kann diese im Vergleich zu zum Beispiel Datenübertragungseinheiten, welche für Entfernungen im Meterbereich ausgelegt sind, relativ klein ausgestaltet werden, wobei Sende- und Empfangs-Elemente, wie zum Beispiel Antennen, Induktionsspulen, oder andere elektromagnetische Wellen aussendende oder empfangende Elemente, wie zum Beispiel Lampen- oder Fotodioden oder Lautsprecher und Mikrophone nur eine geringe Reichweite und Leistungsfähigkeit besitzen müssen.

Der Aktivierungsschalter kann zum Beispiel auch ein Element oder Bauteil sein, mit welchem eine zum Beispiel von dem externen Gerät zur Verfügung gestellte Energie empfangen oder aufgenommen werden kann, um zum Beispiel mit dem externen Gerät kommunizieren zu können oder um eine zum Beispiel von dem externen Gerät vorgegebene Aktion auszuführen, so dass das medizinische Gerät in diesem Fall keine eigene Energieversorgung aufweisen muss, da diesem die benötigte Energie von dem externen Gerät zur Verfügung gestellt wird. Beispielsweise kann eine Induktionsspule als Aktivierungsschalter vorgesehen sein, wobei ein sich in der Nähe der Induktionsspule befindendes externes Gerät zum Beispiel ebenfalls eine Induktionsspule aufweisen kann, um über die induktive Kopplung der Induktionsspulen Energie an das medizinische Gerät zu übertragen, wodurch dieses aktiviert werden und zum Beispiel eine Messung durchführen kann.

Alternativ oder ergänzend kann ein Aktivierungsschalter auch als Magnetschalter, zum Beispiel als Reed-Kontakt ausgebildet sein, welcher von einem externen Magnetfeld, also

zum Beispiel einem an dem externen Gerät vorgesehenen Permanent-Magneten oder Elektro-Magneten aktiviert wird und zum Beispiel eine Verbindung der in dem medizinischen Gerät vorhandenen elektrischen oder elektronischen Komponenten, wie zum Beispiel der Sende- / Empfangseinheit mit einer ebenfalls in dem medizinischen Gerät vorhandenen Energiequelle zum Beispiel in Form einer Batterie oder eines Akkumulators herstellt. Weiterhin können andere Sensoren, welche zum Beispiel elektromagnetische Felder, Schall oder Licht detektieren können, oder magnetische oder kapazitive Effekte nutzen, als Aktivierungsschalter verwendet werden, wie zum Beispiel eine Fotodiode oder ein Mikrophon.

Dabei kann der Aktivierungsschalter so ausgebildet sein, dass eine nach der Aktivierung durch ein externes Gerät hergestellte Kommunikationsverbindung wieder unterbrochen wird, wenn kein Aktivierungssignal mehr anliegt, also zum Beispiel wenn ein vorgegebener Mindestabstand zum externen Gerät wieder überschritten wird. Alternativ oder ergänzend kann die Aktivierung des medizinischen Gerätes auch nur für einen vorgegebenen Zeitraum erfolgen, welcher zum Beispiel benötigt wird, um Daten zu übertragen oder eine vorgegebene Aktion, wie zum Beispiel das Abgeben eines Bolus und/oder das Aussenden eines Bestätigungssignals, auszuführen.

Ebenso kann auch ein mechanischer Schalter als Aktivierungsschalter zum Beispiel unter einem gummiartigen Oberflächenelement vorgesehen sein, welcher zum Beispiel die Stromversorgung oder eine Sende-/Empfangseinheit des medizinischen Gerätes aktiviert, nachdem ein mechanischer Schaltvorgang, also zum Beispiel ein Druck auf den mechanischen Schalter, durch ein auf das medizinische Gerät aufgelegtes externes Gerät ausgelöst wurde. Dabei kann das medizinische Gerät beispielsweise ein Oberflächenprofil aufweisen, welches einem Gegenprofil des externen Gerätes entspricht, sodass das externe Gerät zum Beispiel in einer durch das Oberflächenprofil bestimmten Orientierung auf das medizinische Gerät aufgelegt werden muss, um dieses zu aktivieren oder um eine Datenverbindung herzustellen. Im Falle eines direkten Kontaktes zwischen dem medizinischen Gerät und dem externen Gerät kann eine Datenverbindung oder auch eine Energieübertragung zum Beispiel auch über eine elektrische Leitung erfolgen, wenn sich

einander entsprechende Kontaktelemente des medizinischen Geräts und des externen Gerätes berühren.

Die Erfindung bezieht sich weiterhin auf ein Steuergerät, wie zum Beispiel eine Fernbedienung oder ein Blutglukose-Messgerät zum Ansteuern eines wie oben beschriebenen medizinischen Gerätes, wobei das Steuergerät als externes Gerät eine Aktivierungseinheit aufweist, mit welcher ein oder mehrere Aktivierungsschalter des medizinischen Gerätes aktiviert oder getätigt werden können. Als Aktivierungseinheit kann am externen Gerät zum Beispiel ein Magnet, insbesondere ein Permanentmagnet oder ein Elektromagnet, eine Induktionsspule zum Übertragen von Energie zu dem medizinischen Gerät, ein Lautsprecher, eine Lampe oder ein bestimmtes Oberflächenprofil zur Betätigung eines mechanischen Schalters vorgesehen sein. Weiterhin weist das Steuergerät eine Sende- und/oder Empfangseinheit auf, um eine Datenverbindung mit dem medizinischen Gerät herstellen zu können, wobei die Sende-/Empfangseinheit zum Beispiel aktiviert werden kann, nachdem ein Aktivierungssignal von der Aktivierungseinheit des Steuergerätes ausgesandt wurde oder vom Steuergerät detektiert wurde, dass eine Verbindung, wie zum Beispiel ein mechanischer Kontakt, eine Funkverbindung und/oder eine induktive Kopplung, mit dem medizinischen Gerät hergestellt wurde, oder besteht.

Das externe Gerät kann eine Eingabeeinheit, zum Beispiel eine Tastatur oder einen Touch-Screen, aufweisen, um es einem Benutzer zu ermöglichen Steuersignale in das Steuergerät einzugeben, welche von diesem an das medizinische Gerät übertragen werden können, um zum Beispiel die Arbeitsweise einer implantierten Insulinpumpe zu steuern, wie zum Beispiel die Basalrate oder einen Bolus einzustellen. Vorzugsweise weist das Steuergerät eine Anzeigeeinheit oder ein Display auf, an welchem zum Beispiel zu übertragende Steuerdaten, von einem Benutzer eingegebene Befehle oder Parameter, oder von dem medizinischen Gerät empfangene Daten, wie zum Beispiel Messdaten eines Sensors, dargestellt werden können.

Bevorzugt weist das Steuergerät eine Schnittstelle für die Kommunikation mit einem anderen elektrischen Gerät auf, wie zum Beispiel eine USB-Schnittstelle, eine Infrarot-Schnittstelle oder eine Bluetooth-Schnittstelle, um Daten zum Beispiel mit einem

Computer, einem Mobiltelefon oder einem PDA austauschen zu können, also eine so genannte „Long-Range" Kommunikation durchführen zu können.

Weiterhin bezieht sich die Erfindung auf ein System zum Übertragen von Daten mit einem wie oben beschriebenen bevorzugt am oder im Körper eines Patienten tragbaren medizinischen Gerät und einem wie oben beschriebenen externen Steuergerät, wobei diese Geräte nach dem Aktivieren der Sende- und/oder Empfangseinheit auch synchronisiert werden können.

Gemäß einem weiteren Aspekt bezieht sich die Erfindung auf ein Verfahren zum Übertragen von Daten zwischen einem medizinischen Gerät und einem externen Gerät, wobei das sich im Ruhezustand befindende medizinische Gerät von dem externen Gerät vor der Datenübertragung aktiviert wird. Somit kann das medizinische Gerät zum Beispiel in einem wenige oder keine Energie verbrauchenden Ruhezustand bleiben, wenn kein externes Gerät vorhanden oder aktiviert ist, um eine Datenverbindung herzustellen, sodass das medizinische Gerät nur dann Energie für die Datenkommunikation verbraucht, wenn es vorher von einem externen oder Steuergerät aktiviert wurde, welches zur Datenübertragung bereit ist.

Vorzugsweise wird das medizinische Gerät berührungslos zum Beispiel durch ein elektrisches, magnetisches oder elektromagnetisches Feld, Schall und/oder Licht aktiviert. Ebenso ist es auch möglich, das medizinische Gerät durch einen direkten physikalischen Kontakt mit dem Steuergerät zu aktivieren. Vorzugsweise erfolgt die Aktivierung des medizinischen Gerätes nur dann, wenn ein vorgegebener Abstand von zum Beispiel 2 bis 10cm, also zum Beispiel 5 cm unterschritten wurde, wobei es möglich ist, dass zum Beispiel ein Aktivierungsschalter des medizinischen Gerätes eine Kommunikation zwischen diesem und einem externen Gerät wieder abbricht, wenn ein vorgegebener Abstand wieder überschritten wird. Die Aktivierung des medizinischen Gerätes kann auch zeitlich begrenzt sein oder mit der Ausführung einer Aktion des medizinischen Gerätes beendet werden, wie zum Beispiel nach dem Transfer von Messdaten aus dem Speicher eines Sensor über die Sende- und Empfangseinheiten zu dem externen Steuergerät, wobei diese Messdaten nach dem Senden an das externe Gerät oder nach dem Empfang eines

Bestätigungssignals über den richtigen Empfang der gesendeten Daten im Speicher des medizinischen Gerätes gelöscht werden können. Bei einer solchen Datenübertragung können zum Beispiel alle Daten, die seit dem letzten Datenaustausch gewonnen wurden, wie zum Beispiel Messwerte mit zugehörigem Erfassungszeitpunkt, übertragen und zum Beispiel gelöscht werden, damit der Speicher des medizinischen Gerätes zur Speicherung neuer Daten zur Verfügung steht.

Vorzugsweise können von dem medizinischen Gerät und/oder dem externen Steuergerät Identifikationscodes gesendet werden, um zu verhindern, dass Daten versehentlich zwischen unterschiedlichen nicht zugeordneten Systemen ausgetauscht werden. Der Identifikationscode kann zum Beispiel Teil eines Funkprotokolls sein und zum Beispiel in einer Systemkomponente fest einprogrammiert sein. Ebenso ist es möglich, dass der Identifikationscode zum Beispiel beim Systemstart frei programmierbar ist und zum Beispiel zwei Komponenten nach Aktivierung durch einen Benutzer miteinander gekoppelt werden können. Weiterhin können bekannte RFID tags zum Beispiel am medizinischen Gerät zusammen mit RFID-Transpondern am Steuergerät zur Identifikation verwendet werden.

Die Erfindung wird nachfolgend anhand bevorzugter Ausführungsbeispiele beschrieben. Es zeigen:

Figur 1 eine erste Ausführungsform eines erfindungsgemäßen Systems zur Aktivierung eines medizinischen Gerätes durch eine Energieübertragung von einem Steuergerät;

Figur 2 eine zweite Ausführungsform eines erfindungsgemäßen Systems zur Aktivierung eines medizinischen Geräts über einen Permanent-Magneten;

Figur 3 eine dritte Ausführungsform eines erfindungsgemäßen Systems mit der Fähigkeit zur „Long-Range“ Kommunikation;

Figur 4 eine vierte Ausführungsform eines erfindungsgemäßen Systems, welches die Übertragung einfacher Signale über größere Entfernungen ermöglicht;

Figur 5 eine fünfte Ausführungsform eines erfindungsgemäßen Systems, welche einen Datenaustausch zwischen einem medizinischen Gerät und einem Steuergerät ermöglicht; und

Figur 6 die Ausführungsform aus Figur 5 während des Datenaustauschs zwischen einem medizinischen Gerät und einem Steuergerät.

Figur 1 zeigt eine erste Ausführungsform eines erfindungsgemäßen Systems mit einem ambulant auf der Haut 3 eines Anwenders tragbaren medizinischen Gerät 1, welches auf der Haut 3 angebracht oder implantiert sein kann und zum Beispiel eine Pumpe oder ein Sensor ist. Das medizinische Gerät 1 weist eine Induktionsspule 6 zum Aufnehmen einer von einer korrespondierenden Induktionsspule 6' eines externen Steuergeräts 2 durch induktive Kopplung übertragenen Energie auf, wobei die Induktionsspule 6 des medizinischen Gerätes 1 als Aktivierungsschalter für die Sende-/Empfangseinheit 5 und den Prozessor 7 des Gerätes 1 dient, welche von der Induktionsspule 6 mit Strom versorgt werden. Der Prozessor 7 ist mit einem Speicher 8 gekoppelt und kann nach der Aktivierung auch die Sende-/Empfangseinheit 5 ansteuern, um zum Beispiel Mess- oder Konfigurationsdaten aus dem Speicher 8 über die Einheit 5 an die korrespondierende Sende-/Empfangseinheit 5' des externen Steuergeräts 2 zu übertragen oder in Gegenrichtung empfangene Daten, wie zum Beispiel Konfigurationsdaten für das medizinische Gerät 1, zu verarbeiten und/oder in dem Speicher 8 zu speichern. Weiterhin kann in dem medizinischen Gerät 1 optional auch eine Batterie 11 vorgesehen sein, welche zum Beispiel nur die für eine Sensor- oder Pump-Funktion des medizinischen Gerätes 1 erforderliche Energie zur Verfügung stellt, so dass zum Beispiel für die Datenkommunikation keine Energieversorgung im medizinischen Gerät 1 benötigt wird.

Das externe Steuergerät 2, wie zum Beispiel ein Blutglukosemessgerät, weist ebenso wie das medizinische Gerät 1 einen Prozessor 7' und einen Speicher 8' auf, um zum Beispiel von einem Benutzer über einen Touch-Screen 10 eingegebene Daten und/oder vom

medizinischen Gerät 1 erhaltene Daten abzuspeichern oder Daten über die Sende-/Empfangseinheiten 5, 5' an das medizinische Gerät zu übertragen. Weiterhin ist eine Batterie oder ein Akkumulator 9 zur Energieversorgung des externen Steuergerätes 2 vorgesehen. Somit kann eine Kommunikation zwischen dem medizinischen Gerät 1 und dem externen Steuergerät 2 nach der Aktivierung über einen Energietransfer durch die Induktionsspulen 6, 6' hergestellt werden, wobei zum Beispiel nach erfolgter Datenübertragung zwischen diesen Geräten der Speicher des Steuergerätes 2 von einem weiteren Gerät, wie zum Beispiel unter Bezugnahme auf die Figuren 3 und 4 beschrieben, ausgelesen werden kann.

Die elektronischen Baugruppen 5 bis 9 und 11 sind in dem gezeigten Beispiel auf einer Platine 4 angeordnet.

Figur 2 zeigt eine zweite Ausführungsform eines erfindungsgemäßen Systems, wobei im Unterschied zur ersten in Figur 1 gezeigten Ausführungsform ein Permanentmagnet 6' im Steuergerät 2 vorgesehen ist, um einen Magnetschalter 12, wie zum Beispiel einen Reed-Kontakt, des medizinischen Gerätes 1 zu aktivieren, so dass der als Aktivierungsschalter dienende Magnetschalter 12 zum Beispiel die Sende-/Empfangseinheit 5 und/oder den Prozessor 7 des medizinischen Gerätes 1 aktivieren und für eine Datenübertragung freigeben kann.

Figur 3 zeigt eine dritte Ausführungsform eines erfindungsgemäßen Systems, wobei eine Aktivierung oder Datenübertragung des medizinischen Gerätes 1 durch das externe Steuergerät 2 zum Beispiel durch eine Induktionsspule 6' oder einen Permanentmagneten 6'' erfolgen kann, welche mit einer Induktionsspule 6 oder einem Magnetschalter 12 des medizinischen Gerätes 1 zusammenwirken. Weiterhin ist das externe Steuergerät 2 so ausgelegt, dass eine Datenverbindung mit einem weiteren externen Gerät 13, wie zum Beispiel mit einem PC, einem Mobiltelefon oder einem PDA, hergestellt werden kann, um Daten von dem Steuergerät 2, welche zum Beispiel an dieses von dem medizinischen Gerät 1 übertragen wurden, an die externe Einheit 13 zu übertragen oder in Gegenrichtung von dieser zu empfangen.

Figur 4 zeigt eine vierte Ausführungsform eines erfindungsgemäßen Systems, wobei zusätzlich zu der in Figur 3 gezeigten dritten Ausführungsform eine Datenkommunikation auch über eine größere Entfernung zwischen dem medizinischen Gerät 1 und dem Steuergerät 2 für bestimmte Signale, wie zum Beispiel kurze Statussignale, möglich ist. Hierzu kann die Sende-/Empfangseinheit 5 des medizinischen Gerätes 1 so ausgelegt sein, dass kurzzeitig unter Einsatz größerer Energie ein zum Beispiel mehrere Meter reichendes Status- oder Requestsignal ausgesandt wird, welches zum Beispiel auch über eine größere Entfernung an das Steuergerät 2 übertragen werden kann, um zum Beispiel einem Benutzer des Steuergerätes 2 zu signalisieren, dass eine Kommunikation mit dem medizinischen Gerät 1 hergestellt werden soll.

Die Figuren 5 und 6 zeigen eine fünfte Ausführungsform eines erfindungsgemäßen Systems, welches einen Datenaustausch zwischen einem ambulant auf der Haut 3 eines Anwenders tragbaren medizinischen Gerät 1, wie einem Sensor oder einer Pumpe oder Infusionspumpe oder einem so genannten Patch Module, und einem externen, insbesondere von einem Anwender tragbaren oder mobilen, Steuergerät 2, wie einem Blutzucker-Messgerät, ermöglicht. Das medizinische Gerät 1, welches auf der Haut 3 angebracht oder implantiert sein kann, weist zum Beispiel eine Nadel 15 auf, mittels welcher geringe Blutmengen des Anwenders abgenommen werden können. Auch kann das medizinische Gerät 1 subkutan oder unter der Haut 3 des Anwenders angeordnet sein oder kann minimal-invasiv geringe Blutmengen des Anwenders abnehmen. Das medizinische Gerät 1 umfasst eine Recheneinheit, wie einen Prozessor oder Mikroprozessor, einen Speicher, eine Sende-/Empfangseinheit, eine Energiequelle, wie eine Batterie und/oder eine zuvor beschriebene Induktionsspule und/oder einen zuvor beschriebenen Magnetschalter, und eine Messeinheit, wie eine elektronische Schaltung, zum Messen oder Ermitteln mindestens eines physiologischen Parameters des Anwenders, insbesondere des Blutzuckerwerts oder Blutglukosespiegels, anhand der abgenommenen Blutmenge. Die Messeinheit kann optisch arbeiten, so dass das abgenommene Blut mit verschiedenen chemischen Stoffen reagiert, was zu einer Farbänderung eines Testfeldes führt. Diese Farbänderung kann von der Messeinheit erfasst werden und es aus der Dauer und Stärke der Änderung kann der Blutzuckerwert bestimmt werden. Auch kann die Messeinheit amperometrisch arbeiten, so

dass durch Messung eines Stromstärke-Verlaufs durch das Blut der Blutzuckerwert bestimmt werden kann.

Das externe Steuergerät 2, wie ein Blutglukosemessgerät oder Datenlogger, weist eine Anzeigevorrichtung 10, insbesondere einen Bildsschirm oder ein Display oder einen Touch-Screen, eine Sende-/Empfangseinheit, einen Speicher, eine Energiequelle, wie eine Batterie, und zumindest eine Recheneinheit, insbesondere einen Prozessor oder Mikroprozessor auf. Weiter kann das externe Steuergerät 2 einen in Bezug auf die Figuren 1 bis 4 beschriebenen Aktivierungsschalter, insbesondere eine Induktionsspule oder einen Permanentmagneten, aufweisen. Das Steuergerät 2 kann so ausgebildet sein, dass es anhand von Messdaten den Blutzuckerwert oder den Blutzuckerwertverlauf des Anwenders ermitteln kann, welcher zum Beispiel durch Ausgabe von Zahlenwerten oder eines grafischen Verlaufs oder Diagrams auf der Anzeigevorrichtung 10 dargestellt werden kann.

Wie in Figur 6 gezeigt, kann das externe Steuergerät 2, wie das Blutzucker-Messgerät, in die Nähe oder in Reichweite des medizinischen Geräts 1, wie dem Patch Module, gebracht werden, um einen Datenaustausch oder eine Datenübertragung zwischen dem Steuergerät 2 und dem medizinischen Gerät 1 zu ermöglichen. Vorzugsweise aktiviert dabei der Aktivierungsschalter des Steuergeräts 2 den Aktivierungsschalter des medizinischen Geräts 1, so dass von dem Aktivierungsschalter des Steuergeräts 2 Energie auf den Aktivierungsschalter des medizinischen Geräts 1 übertragen werden kann, mittels welcher das medizinische Gerät 1 mit Strom versorgt werden kann. Auch kann beispielsweise der Aktivierungsschalter des Steuergeräts 2 die Energiequelle oder Energieversorgung des medizinischen Geräts 1 aktivieren, so dass das medizinische Gerät 1 nach Aktivierung der Energiequelle mit Strom versorgt werden kann.

Mit dem medizinischen Gerät 1 kann aus dem Blut eines Anwenders ein Blutwert bestimmt werden. Dieser Wert kann beispielsweise mit Seiteninformationen, wie der Uhrzeit der Blutabnahme, von der Sende-/Empfangseinheit des medizinischen Geräts 1 an die Send-/Empfangseinheit des Steuergeräts 2 gesendet werden, wenn sich das Steuergerät 2 in ausreichender Nähe des medizinischen Geräts 1 befindet, welche eine Datenübertragung ermöglicht. Aus diesem Blutwert kann in dem Steuergerät 2 von der Recheneinheit des

Steuergeräts 2 der Blutzuckerwert oder Glukosegehalt des Anwenders ermittelt werden und beispielsweise mit den Seiteninformationen in dem Speicher abgespeichert oder auf der Anzeigevorrichtung 10 dargestellt werden.

Auch kann in dem medizinischen Gerät 1 aus dem abgenommenen Blut des Anwenders mittels der Recheneinheit der Blutzuckerwert oder Glukosespiegel des Anwenders ermittelt werden und beispielsweise in der in Figur 6 gezeigten Position oder Anordnung an das Steuergerät 2 beispielsweise mit den Seiteninformationen übertragen werden. Auch können zu verschiedenen Zeitpunkten aufgenommene Blutzuckerwerte mit dem Zeitpunkt oder der Uhrzeit der Abnahme in dem Speicher des medizinischen Geräts 1 gespeichert werden und bei Bedarf von dem externen Steuergerät 2 abgerufen werden. Daten über den ermittelten Blutzuckerspiegel und gegebenenfalls die Seiteninformationen können von der Sende-/Empfangseinheit des medizinischen Geräts 1 an die Sende-/Empfangseinheit des Steuergeräts 2 übertragen werden und können in dem Speicher des Steuergeräts 2 abgespeichert werden oder auf der Anzeigevorrichtung 10 des Steuergeräts 2 als Zahlenwerte oder als Diagram dargestellt werden. Beispielsweise können in dem Steuergerät 2 mehrere zu verschiedenen Zeitpunkten gewonnene Blutzuckerwerte gespeichert und bei Bedarf beispielsweise über der Zeit grafisch dargestellt werden, um ein Blutzuckerspiegel-Diagramm eines Anwenders zu erhalten. Einzelwerte in dem Blutzuckerspiegel-Diagramm können zum Beispiel von dem Anwender mittels des Touch-Screens oder mittels einer anderen Eingabeeinheit ausgewählt werden, welche dann als Zahlenwerte ausgegeben werden können. Insbesondere kann auch unmittelbar nach dem Empfang des von dem medizinischen Gerät ermittelten Blutzuckerwerts der Blutzuckerwert auf der Anzeigevorrichtung 10 des Steuergeräts 2 ausgegeben werden. Auch kann das Steuergerät 2 in Aktivierungs-Reichweite des medizinischen Geräts 1 gehalten werden, so dass die Sende-/Empfangseinheit des Steuergeräts 2 beispielsweise ein Aktivierungssignal an das medizinische Gerät 1 senden kann, worauf das medizinische Gerät 1 aktiviert wird und zum Beispiel eine Blutzuckermessung durchführt und/oder einen ermittelten Blutzuckerwert an das Steuergerät 2 sendet, welcher auf der Anzeigevorrichtung 10 des Steuergeräts 2 ausgegeben werden kann.

Die ermittelten Daten über den Glukosespiegel oder den Glukosespiegelverlauf des Anwenders können über eine an dem Steuergerät 2 angeordnete Schnittstelle, wie einer Infrarot- oder Bluetooth- oder FireWire-Schnittstelle, auf eine externe Recheneinheit, wie einen Computer, übertragen werden und in der Recheneinheit weiterverarbeitet oder ausgegeben oder mit einer Darstellungs- oder Auswertungs-Software dargestellt und/oder ausgewertet werden.

Anwaltsakte: 55 551 XX
Anmelder: Disetronic Licensing AG

Patentansprüche 1 bis 7

1. Medizinisches System umfassend:
   a) ein medizinisches Gerät (1) zum Einsatz am und/oder im Körper eines Benutzers mit einer Sendeeinheit und/oder Empfangseinheit (5) und einem Aktivierungsschalter (6), welcher mit der Sendeeinheit und/oder Empfangseinheit (5) verbunden ist und die Sendeeinheit und/oder Empfangseinheit (5) aktivieren kann, wenn ein Aktivierungssignal vom Aktivierungsschalter (6) empfangen wurde; und
   b) eine Fernbedienung (2) mit einer Dateneingabeeinheit, einer Aktivierungseinheit (6', 6") zum Aktivieren des Aktivierungsschalters (6) des medizinischen Geräts (1) und einer Sende- und/oder Empfangseinheit (5'), welche mit der Sendeeinheit und/oder Empfangseinheit (5) des medizinischen Geräts (1) Daten austauschen kann.

2. Medizinisches System nach Anspruch 1, wobei das medizinische Gerät (1) ein Sensor, ein Glukosesensor, ein Infusionssystem, eine Pumpe, eine Insulin-Pumpe, oder ein Pen ist.

3. Medizinisches System nach Anspruch 1 oder 2, wobei die Fernbedienung (2) ein Glucosemessgerät ist.

4. Medizinisches Gerät nach einem der vorhergehenden Ansprüche, wobei der Aktivierungsschalter (6) eine Induktionsspule, ein Magnetschalter (12), ein Reed-Kontakt, ein Mikrofon oder ein lichtempfindlicher Schalter, eine Fotodiode, oder ein mechanischer Schalter ist.

5. Medizinisches System nach einem der vorhergehenden Ansprüche, wobei die Aktivierungseinheit (6', 6") eine Induktionsspule (6') und/oder ein Permanentmagnet (6") ist.

6. Medizinisches System nach einem der vorhergehenden Ansprüche, wobei die Fernbedienung (2) eine Datenausgabeeinheit (10) aufweist.

7. Medizinisches System nach einem der vorhergehenden Ansprüche, wobei die Fernbedienung (2) eine Schnittstelle zur Kommunikation mit einem elektronischen Gerät, einem PC, Mobiltelefon oder PDA aufweist.

FIG. 1

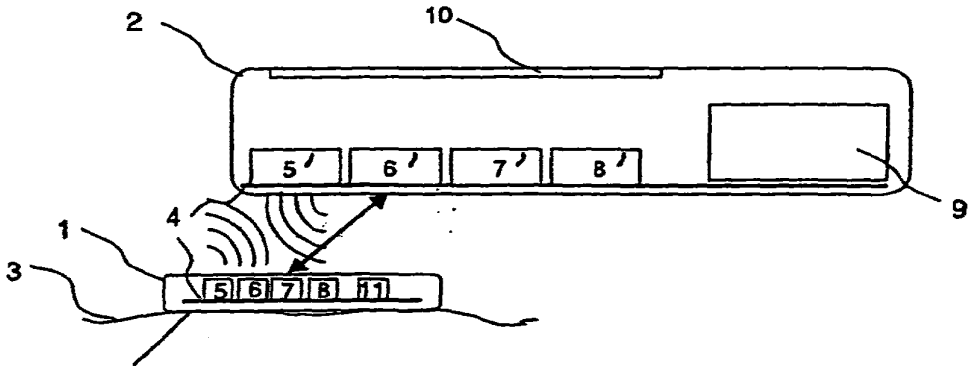


FIG. 2

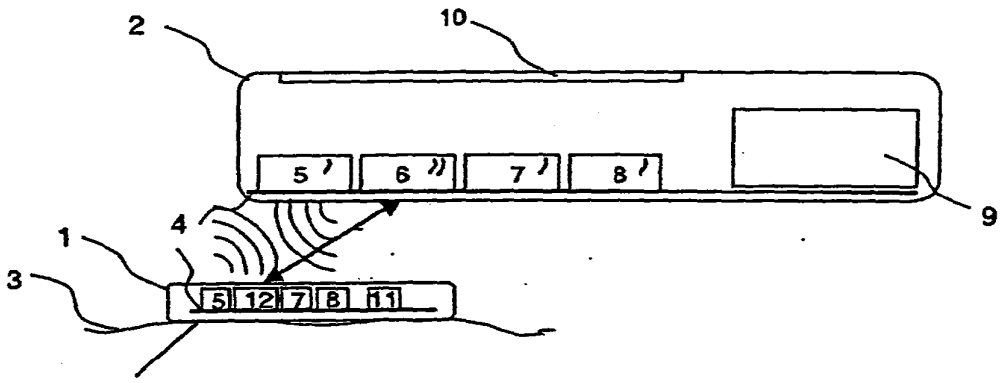


FIG. 3

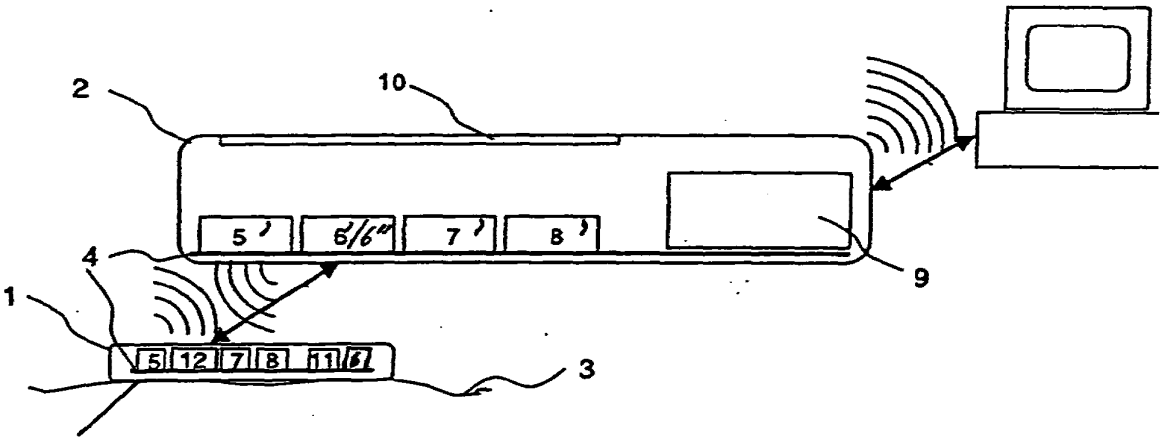
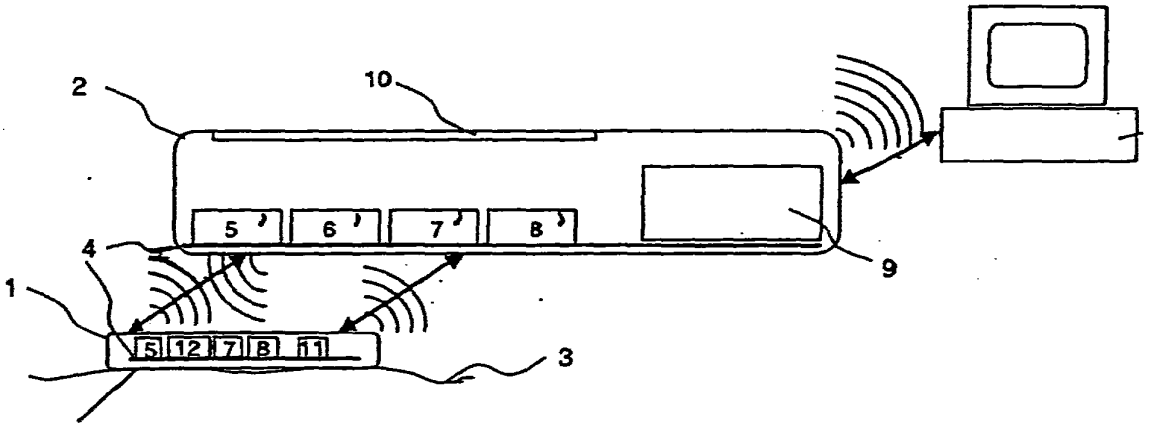


FIG. 4



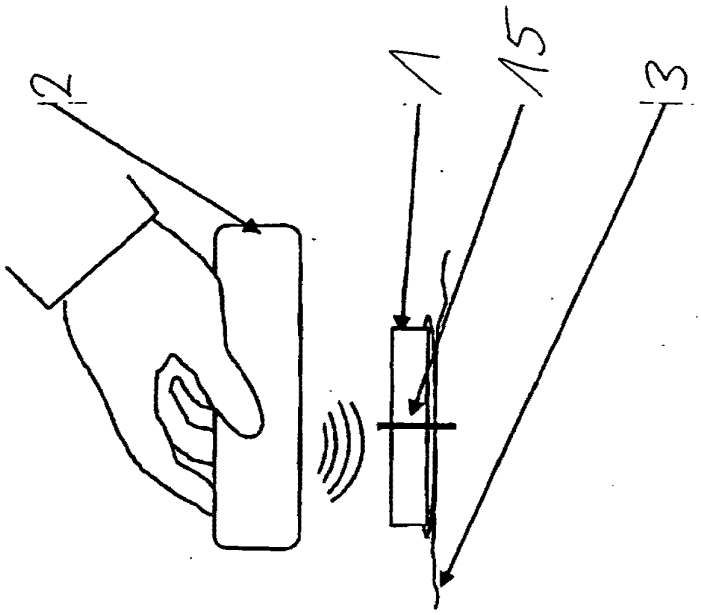


Fig. 6

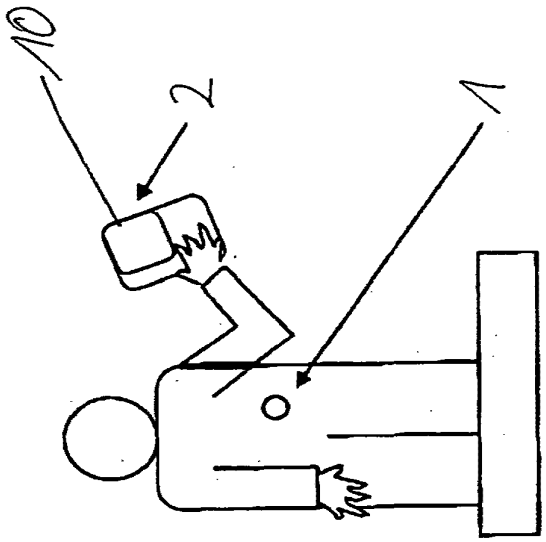


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2006/003869

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61M5/00 A61B5/00

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)
A61M A61B

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/204744 A1 (PENNER AVI ET AL) 14 October 2004 (2004-10-14) figures 1-6 paragraph [0034] - paragraph [0068]	1,2,4-7
X	EP 1 343 112 A (ENDOART S.A) 10 September 2003 (2003-09-10) paragraph [0022] - paragraph [0027]; claim 12; figures 1-4	1,2,4-6
X	US 2002/072784 A1 (SHEPPARD NORMAN F ET AL) 13 June 2002 (2002-06-13) paragraph [0031] - paragraph [0032]; figures 1-3	1,2,4-6

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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
11 July 2006	02/08/2006

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Reinbold, S

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/065464 A1 (TALBOT CARY D ET AL) 24 March 2005 (2005-03-24) figures 1-7 paragraph [0044] - paragraph [0049]	1,3
X	US 6 239 724 B1 (DORON EYAL ET AL) 29 May 2001 (2001-05-29) figures 1-13 column 8, line 54 - column 11, line 3	1,2,4-6

2

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Information on patent family members

International application No
PCT/EP2006/003869

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INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2006/003869

A. KLASSIFIZIERUNG DES ANMELDUNGSGEGENSTANDES
INV. A61M5/00 A61B5/00

Nach der Internationalen Patentklassifikation (IPC) oder nach der nationalen Klassifikation und der IPC

B. RECHERCHIERTE GEBIETE

Recherchierter Mindestprüfstoff (Klassifikationssystem und Klassifikationssymbole)
A61M A61B

Recherchierte, aber nicht zum Mindestprüfstoff gehörende Veröffentlichungen, soweit diese unter die recherchierten Gebiete fallen

Während der internationalen Recherche konsultierte elektronische Datenbank (Name der Datenbank und evtl. verwendete Suchbegriffe)
EPO-Internal, WPI Data

C. ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	US 2004/204744 A1 (PENNER AVI ET AL) 14. Oktober 2004 (2004-10-14) Abbildungen 1-6 Absatz [0034] - Absatz [0068]	1,2,4-7
X	EP 1 343 112 A (ENDOART S.A) 10. September 2003 (2003-09-10) Absatz [0022] - Absatz [0027]; Anspruch 12; Abbildungen 1-4	1,2,4-6
X	US 2002/072784 A1 (SHEPPARD NORMAN F ET AL) 13. Juni 2002 (2002-06-13) Absatz [0031] - Absatz [0032]; Abbildungen 1-3	1,2,4-6

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[X] Weitere Veröffentlichungen sind der Fortsetzung von Feld C zu entnehmen [X] Siehe Anhang Patentfamilie

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Datum des Abschlusses der internationalen Recherche	Absendedatum des internationalen Recherchenberichts
11. Juli 2006	02/08/2006

Name und Postanschrift der Internationalen Recherchenbehörde	Bevollmächtigter Bediensteter
Europäisches Patentamt, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Reinbold, S

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INTERNATIONALER RECHERCHENBERICHT

Internationales Aktenzeichen
PCT/EP2006/003869

C. (Fortsetzung) ALS WESENTLICH ANGESEHENE UNTERLAGEN

Kategorie*	Bezeichnung der Veröffentlichung, soweit erforderlich unter Angabe der in Betracht kommenden Teile	Betr. Anspruch Nr.
X	US 2005/065464 A1 (TALBOT CARY D ET AL) 24. März 2005 (2005-03-24) Abbildungen 1-7 Absatz [0044] - Absatz [0049]	1,3
X	US 6 239 724 B1 (DORON EYAL ET AL) 29. Mai 2001 (2001-05-29) Abbildungen 1-13 Spalte 8, Zeile 54 - Spalte 11, Zeile 3	1,2,4-6

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INTERNATIONALER RECHERCHENBERICHT

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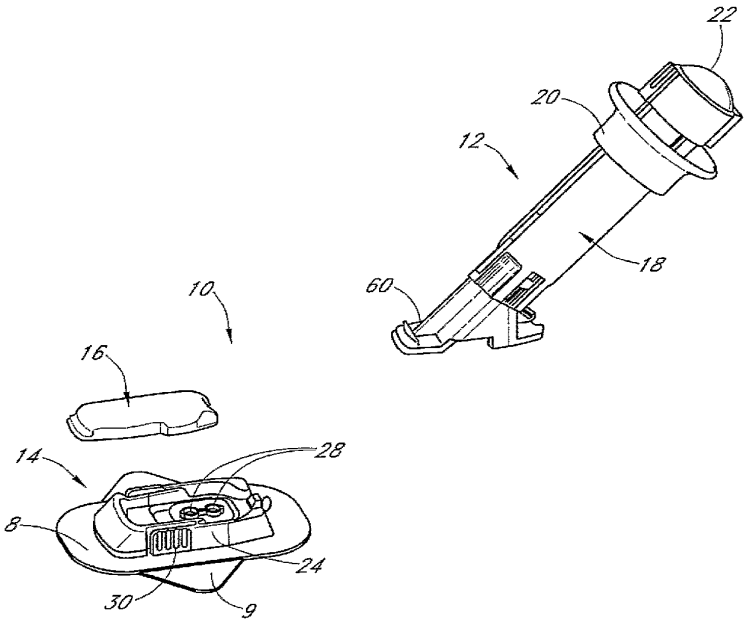
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(54) Title: ANALYTE SENSOR



(57) Abstract: The present invention relates generally to systems and methods for measuring an analyte in a host. More particularly, the present invention relates to systems and methods for transcutaneous measurement of glucose in a host using a transcutaneous analyte sensor system including an applicator (12), a mounting unit (14), an electronics unit (16), a base (24), a sensor (32), and one or more contacts (28) configured to provide secure electrical contact between the sensor and the electronics unit (16).

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ANALYTE SENSOR

FIELD OF THE INVENTION

[0001] The present invention relates generally to systems and methods for measuring an analyte in a host. More particularly, the present invention relates to systems and methods for transcutaneous measurement of glucose in a host.

BACKGROUND OF THE INVENTION

[0002] Diabetes mellitus is a disorder in which the pancreas cannot create sufficient insulin (Type I or insulin dependent) and/or in which insulin is not effective (Type 2 or non–insulin dependent). In the diabetic state, the victim suffers from high blood sugar, which can cause an array of physiological derangements associated with the deterioration of small blood vessels, for example, kidney failure, skin ulcers, or bleeding into the vitreous of the eye. A hypoglycemic reaction (low blood sugar) can be induced by an inadvertent overdose of insulin, or after a normal dose of insulin or glucose-lowering agent accompanied by extraordinary exercise or insufficient food intake.

[0003] Conventionally, a person with diabetes carries a self-monitoring blood glucose (SMBG) monitor, which typically requires uncomfortable finger pricking methods. Due to the lack of comfort and convenience, a person with diabetes normally only measures his or her glucose levels two to four times per day. Unfortunately, such time intervals are so far spread apart that the person with diabetes likely finds out too late of a hyperglycemic or hypoglycemic condition, sometimes incurring dangerous side effects. It is not only unlikely that a person with diabetes will take a timely SMBG value, it is also likely that he or she will not know if his or her blood glucose value is going up (higher) or down (lower) based on conventional method. This inhibits the ability to make educated insulin therapy decisions.

[0004] A variety of sensors are known that use an electrochemical cell to provide output signals by which the presence or absence of an analyte, such as glucose, in a sample can be determined. For example, in an electrochemical cell, an analyte (or a species derived from it) that is electro-active generates a detectable signal at an electrode, and this signal can be used to detect or measure the presence and/or amount within a biological sample. In some conventional sensors, an enzyme is provided that reacts with the analyte to be measured, and

the byproduct of the reaction is qualified or quantified at the electrode. An enzyme has the advantage that it can be very specific to an analyte and also, when the analyte itself is not sufficiently electro-active, can be used to interact with the analyte to generate another species which is electro-active and to which the sensor can produce a desired output. In one conventional amperometric glucose oxidase-based glucose sensor, immobilized glucose oxidase catalyses the oxidation of glucose to form hydrogen peroxide, which is then quantified by amperometric measurement (for example, change in electrical current) through a polarized electrode.

SUMMARY OF THE INVENTION

[0005] In a first aspect, a sensor for transcutaneous measurement of an analyte in a host is provided, the sensor comprising at least one electrode formed from a conductive material; and a membrane disposed on an electroactive portion of the electrode, wherein the membrane is configured to control an influx of the analyte therethrough, and wherein the membrane comprises a substantially non-smooth outer surface.

[0006] In an embodiment of the first aspect, the substantially non-smooth surface appears under magnification to resemble a super-positioning of disc shaped objects.

[0007] In an embodiment of the first aspect, the disc shaped objects comprise a rounded shape.

[0008] In an embodiment of the first aspect, the disc shaped objects have an average diameter of from about 5 microns to about 250 microns.

[0009] In an embodiment of the first aspect, the membrane further comprises an enzyme domain.

[0010] In an embodiment of the first aspect, the membrane further comprises an interference domain.

[0011] In an embodiment of the first aspect, the membrane further comprises an electrode domain.

[0012] In an embodiment of the first aspect, the membrane is at least partially formed by a vapor deposition coating process.

[0013] In an embodiment of the first aspect, the vapor deposition coating process comprises a physical vapor deposition coating process, e.g., ultrasonic vapor deposition.

[0014] In an embodiment of the first aspect, the membrane substantially resists ascorbate flux therethrough.

[0015] In an embodiment of the first aspect, the electrode comprises a wire comprising a conductive material, and wherein the sensor is configured for substantially continuous measurement of glucose in a host.

[0016] In a second aspect, a method for manufacturing a transcutaneous analyte sensor is provided, the method comprising the steps of providing at least one electrode comprising an electroactive portion; and applying a membrane to the electroactive port ion, wherein at least one layer of the membrane is applied by vapor deposition.

[0017] In an embodiment of the second aspect, the vapor deposition comprises physical vapor deposition.

[0018] In an embodiment of the second aspect, the physical vapor deposition comprises ultrasonic vapor deposition.

[0019] In an embodiment of the second aspect, the layer of the membrane is deposited in a vacuum chamber. The layer can be configured to resist flow of the analyte therethrough.

[0020] In an embodiment of the second aspect, at least one layer of the membrane is applied using an ultrasonic nozzle. The layer can be configured to resist flow of the analyte therethrough.

[0021] In an embodiment of the second aspect, the step of applying a membrane comprises applying an enzyme domain. The enzyme domain can be applied by dip coating.

[0022] In an embodiment of the second aspect, the step of applying a membrane comprises applying an electrode domain. The electrode domain can be applied by dip coating.

[0023] In an embodiment of the second aspect, the electrode comprises a wire comprising a conductive material, and wherein the sensor is configured for substantially continuous measurement of glucose in a host.

[0024] In a third aspect, a method for manufacturing a plurality of transcutaneous analyte sensors is provided, the method comprising providing a plurality of electrodes, each

electrode comprising an electroactive portion; placing the plurality of electrodes into a vacuum chamber; and vapor depositing at least one membrane layer thereon.

[0025] In an embodiment of the third aspect, the membrane layer is configured to control influx of an analyte therethrough.

[0026] In an embodiment of the third aspect, wherein an *in vitro* sensitivity of the plurality of sensors deviates from a median *in vitro* sensitivity by less about 20%.

[0027] In an embodiment of the third aspect, an *in vitro* sensitivity of the plurality of sensors deviates from a median *in vitro* sensitivity by less about 16%.

[0028] In an embodiment of the third aspect, an *in vitro* sensitivity of the plurality of sensors deviates from a median *in vitro* sensitivity by less about 12%.

[0029] In an embodiment of the third aspect, the method further comprises curing the membrane layer. The curing step can include placing a plurality of electrodes, each comprising the membrane layer, into a vacuum oven, a convection oven, or a variable frequency microwave oven.

[0030] In an embodiment of the third aspect, each electrode comprises a wire comprising a conductive material, and wherein each sensor is configured for substantially continuous measurement of glucose in a host.

[0031] In a fourth aspect, a method for limiting use of an analyte sensor to a predetermined time period is provided, the method comprising providing a key associated with an analyte sensor, wherein the key is configured to control an amount of time over which information is obtained from the analyte sensor.

[0032] In an embodiment of the fourth aspect, the analyte sensor is a transcutaneous glucose sensor.

[0033] In an embodiment of the fourth aspect, the sensor is operatively connected to a receiver, wherein the receiver is configured to display sensor data.

[0034] In an embodiment of the fourth aspect, the receiver is configured to receive the key.

[0035] In an embodiment of the fourth aspect, the receiver is configured to control an amount of time over which information is displayed on the receiver from the sensor in response to the key.

[0036] In an embodiment of the fourth aspect, the key is a software key.

[0037] In an embodiment of the fourth aspect, the key is a unique code.

[0038] In an embodiment of the fourth aspect, the key is selected from the group consisting of a unique number, a receiver ID, a sensor duration, a number of sensor systems, and combinations thereof.

[0039] In an embodiment of the fourth aspect, the key is configured for use with a plurality of sensors.

[0040] In an embodiment of the fourth aspect, the key is provided by an information tag.

[0041] In a fifth aspect, a method for distributing and controlling use of implantable sensor systems comprising reusable and disposable parts, the method comprising providing a single-use device associated with the sensor system, wherein the single-use device is configured to be inserted into a host's tissue; providing a key associated with the single-use device; and providing a reusable device associated with a sensor system, wherein the reusable device is configured to provide sensor information responsive to receipt of the key.

[0042] In an embodiment of the fifth aspect, the reusable device comprises a receiver configured to receive sensor information.

[0043] In an embodiment of the fifth aspect, the reusable device further comprises an electronics unit configured to releasably mate with the single-use device.

[0044] In an embodiment of the fifth aspect, the method further comprises obtaining a package containing a plurality of single-use devices.

[0045] In an embodiment of the fifth aspect, the single-use device is a transcutaneous analyte sensor configured for insertion into a subcutaneous tissue of a host.

[0046] In an embodiment of the fifth aspect, the key comprises a written license code packaged with the single-use device.

[0047] In an embodiment of the fifth aspect, the step of providing the key comprises providing a license code via at least one communication selected from the group consisting of written communication, voice communication, and electronic communication.

[0048] In an embodiment of the fifth aspect, the reusable device is configured to receive the key via manual entry.

[0049] In an embodiment of the fifth aspect, the reusable device is configured to wirelessly receive the key.

[0050] In an embodiment of the fifth aspect, key comprises sensor duration information configured to enable the sensor system to control an amount of time over which information is obtained from the single-use device or is displayed by the reusable device.

[0051] In an embodiment of the fifth aspect, the single-use device comprises a transcutaneous analyte sensor configured for insertion in a subcutaneous tissue of a host, and wherein the key comprises sensor insertion information configured to enable the sensor system to control a number of sensor insertions.

[0052] In an embodiment of the fifth aspect, the single-use device comprises a transcutaneous analyte sensor configured for insertion in a subcutaneous tissue of a host, and wherein the step of inserting the single-use device into a host comprises using an applicator to insert the sensor into the host.

[0053] In an embodiment of the fifth aspect, the step of obtaining sensor information from the sensor system comprises at least one step selected from the group consisting of measurement of analyte information, digitalizing of sensor information, transmission of sensor information, receiving of sensor information, storing of sensor information, processing of sensor information, and displaying of sensor information.

[0054] In a sixth aspect, a method for limiting use of a glucose sensor system to a predetermined time period is provided, the method comprising inputting a key into a receiver, wherein the key is configured to control an amount of time over which information is obtained from a sensor system, after which time the sensor system is disabled such that glucose information cannot be obtained, wherein the sensor system is a transcutaneous glucose sensor system comprising a sensor configured for insertion into a tissue of a host and an electronics unit operatively connected to the sensor and configured to provide a signal representative of a glucose concentration in the host, and wherein the receiver is configured to receive the signal representative of a glucose concentration in the host and to display corresponding glucose information; and obtaining glucose information from the sensor.

[0055] In an embodiment of the sixth aspect, the step of inputting the key into the receiver is performed before the step of obtaining glucose information from the sensor.

[0056] In a seventh aspect, a device for measuring an analyte in a host is provided, the device comprising a sensor operably connected to sensor electronics, the sensor electronics configured for measuring an analyte in a host; at least one electrical contact configured to connect the sensor to the sensor electronics; and a sealing member, wherein the sealing member at least partially surrounds at least one of the sensor and the electrical contact, wherein the sealing member comprises a material having a durometer hardness of from about 5 Shore A to about 80 Shore A.

[0057] In an embodiment of the seventh aspect, the durometer hardness is from about 10 Shore A to about 50 Shore A.

[0058] In an embodiment of the seventh aspect, the durometer hardness is about 20 Shore A.

[0059] In an embodiment of the seventh aspect, the durometer hardness is about 50 Shore A

[0060] In an embodiment of the seventh aspect, the sensor comprises a wire.

[0061] In an embodiment of the seventh aspect, the sensor comprises a planar substrate.

[0062] In an embodiment of the seventh aspect, the sealing material comprises a silicone.

[0063] In an embodiment of the seventh aspect, the device further comprises a sealant adjacent to the sealing member.

[0064] In an embodiment of the seventh aspect, the sensor electronics are housed within an electronics unit configured to mate with the electrical contact.

[0065] In an embodiment of the seventh aspect, the electronics unit and the sealing member are configured to mate to provide a compression force therebetween.

[0066] In an embodiment of the seventh aspect, the device further comprises at least one raised portion configured to provide a compression force to the sealing member when the electrical contact is connected to the sensor electronics.

[0067] In an eighth embodiment, a device for use in measuring an analyte in a host is provided, the device comprising a sensor operably connected to sensor electronics, the sensor electronics configured for measuring an analyte in a host; at least one electrical contact configured to operably connect the sensor to the sensor electronics; and a sealing member at least partially surrounding at least one of the sensor and the electrical contact, wherein the sealing member is configured to seal the electrical contact from moisture when the sensor is operably connected to the sensor electronics.

[0068] In an embodiment of the eighth aspect, the sealing member comprises a material having a durometer hardness of from about 5 Shore A to about 80 Shore A.

[0069] In an embodiment of the eighth aspect, the device further comprises a sealant adjacent to the sealing member.

[0070] In an embodiment of the eighth aspect, the device further comprises a housing on which the sealing member is disposed, wherein the housing is configured to mechanically or chemically hold the sealing member thereon.

[0071] In an embodiment of the eighth aspect, the device further comprises an adhesive configured to hold the sealing member on the housing.

[0072] In an embodiment of the eighth aspect, the device further comprises at least one protrusion configured to substantially mate with at least one depression, whereby the sealing member is held on the housing.

[0073] In an embodiment of the eighth aspect, the sealing member comprises at least one gap that is maintained when the electrical contact is operably connected to the sensor electronics.

[0074] In an embodiment of the eighth aspect, the sensor at least partially extends through the gap.

[0075] In an embodiment of the eighth aspect, the gap is filled with a sealant.

[0076] In an embodiment of the eighth aspect, the device further comprises at least one channel communicating between a first side of the sealing member and a second side of the sealing member.

[0077] In an embodiment of the eighth aspect, the channel is filled with a sealant.

[0078] In an embodiment of the eighth aspect, substantially no air gaps are adjacent to the electrical contact when the electrical contact is operably connected to the sensor electronics.

[0079] In an embodiment of the eighth aspect, the sealing member comprises a material selected from the group consisting of silicone, silicone/polyurethane hybrid, polyurethane, polysulfide, and mixtures thereof.

[0080] In an embodiment of the eighth aspect, the sealing member is self-lubricating.

[0081] In an embodiment of the eighth aspect, the sealing member comprises a sealant sandwiched between an upper portion of the sealing member and a lower portion of the sealing member.

[0082] In an embodiment of the eighth aspect, the device further comprises a guide tube configured to maintain an opening in the sealing member prior to sensor insertion into the host.

[0083] In an embodiment of the eighth aspect, the device further comprises a lubricant between the sealing member and the guide tube.

[0084] In a ninth aspect, a device for use in measuring an analyte in a host is provided, the device comprising a sensor operably connected to sensor electronics, the sensor electronics configured for measuring an analyte in a host; at least one electrical contact configured to connect the sensor to the sensor electronics, wherein the electrical contact comprises a material having a durometer hardness of from about 5 Shore A to about 80 Shore A; and a sealing member at least partially surrounding at least one of the sensor and the electrical contact, wherein the sealing member comprises a material having a durometer hardness of from about 5 Shore A to about 80 Shore A.

[0085] In an embodiment of the ninth aspect, the durometer hardness of the electrical contact is higher than the durometer hardness of the sealing member.

[0086] In an embodiment of the ninth aspect, the durometer hardness of the electrical contact is about 50 Shore A.

[0087] In an embodiment of the ninth aspect, the durometer hardness of the sealing member is higher than the durometer hardness of the contact.

[0088] In an embodiment of the ninth aspect, the durometer hardness of the sealing member is about 50 Shore A.

[0089] In an embodiment of the ninth aspect, the sealing member comprises a filler material.

[0090] In an embodiment of the ninth aspect, the filler material is configured to stiffen the sealing member.

[0091] In a tenth aspect, a sensor system for measuring an analyte concentration in a host is provided, the system comprising at least one electrode configured for implantation in a host and configured to measure an analyte concentration in a tissue of the host; sensor electronics operably connected to the electrode and configured to provide analyte data representative of an analyte concentration in the host; and an information tag comprising sensor information.

[0092] In an embodiment of the tenth aspect, the information tag comprises a memory.

[0093] In an embodiment of the tenth aspect, the information tag transmits information using at least one connection selected from the group consisting of a serial connection, a radio frequency connection, an acoustic frequency connection, an infrared frequency connection, and a magnetic induction connection.

[0094] In an embodiment of the tenth aspect, the system further comprises a mounting unit configured to maintain the sensor positioned transcutaneously within the tissue of the host.

[0095] In an embodiment of the tenth aspect, the information tag is embedded within the mounting unit.

[0096] In an embodiment of the tenth aspect, the system further comprises a receiver configured to receive the analyte data from the sensor electronics.

[0097] In an embodiment of the tenth aspect, the receiver is configured to read sensor information from the information tag.

[0098] In an embodiment of the tenth aspect, the system further comprises packaging configured to contain at least a portion of a sensor system during transport.

[0099] In an embodiment of the tenth aspect, the information tag is in or on the packaging.

[0100] In an embodiment of the tenth aspect, the sensor information comprises at least one item selected from the group consisting of manufacturing information, calibration information, identification information, expiration information, sensor duration information, and archived data.

[0101] In an embodiment of the tenth aspect, the sensor information comprises a license code.

[0102] In an eleventh aspect, a transcutaneous analyte sensor assembly is provided, the assembly comprising a mounting unit adapted for mounting on a skin of a host; an electronics unit configured to releasably mate with the mounting unit; a sensor configured to measure a concentration of an analyte in the host, wherein the sensor is operably connected to the electronics unit when the electronics unit is mated to the mounting unit; and an information tag comprising sensor information.

[0103] In an embodiment of the eleventh aspect, the sensor information is embedded in an information tag within the mounting unit.

[0104] In an embodiment of the eleventh aspect, the assembly further comprises a receiver, wherein the receiver is configured to read sensor information from the information tag.

[0105] In an embodiment of the eleventh aspect, the information tag comprises a memory.

[0106] In an embodiment of the eleventh aspect, the information tag transmits information using at least one connection selected from the group consisting of a serial connection, a radio frequency connection, an acoustic frequency connection, an infrared frequency connection, and a magnetic induction connection.

[0107] In an embodiment of the eleventh aspect, the sensor information is embedded within the electronics unit.

[0108] In an embodiment of the eleventh aspect, the assembly further comprises packaging configured to contain the sensor assembly during transport, wherein the information tag is provided in or on the packaging.

[0109] In an embodiment of the eleventh aspect, the assembly further comprises a receiver, wherein the receiver is configured to read the sensor information from the information tag.

[0110] In an embodiment of the eleventh aspect, the sensor information comprises information configured to trigger initialization of the sensor.

[0111] In a twelfth aspect, a transcutaneous glucose sensor system is provided, the sensor system comprising a mounting unit adapted for mounting on a skin of a host; a sensor configured to measure an analyte concentration in the host; sensor electronics operably connected to the sensor, wherein the sensor is configured to provide data representative of an analyte concentration in the host; a receiver remote from the mounting unit and configured to receive sensor data from the electronics unit representative of a measured analyte concentration; and an information tag configured to provide sensor information selected from the group consisting of manufacturing information, calibration information, identification information, expiration information, sensor duration information, archived data, license code information, and combinations thereof.

[0112] In an embodiment of the twelfth aspect, the receiver is configured to read sensor information from the information tag.

[0113] In an embodiment of the twelfth aspect, the electronics unit is configured to releasably mate with the mounting unit, and wherein the electronics unit is operably connected to the sensor when the electronics unit is mated to the mounting unit.

[0114] In a thirteenth aspect, a device configured for placement on a skin surface of a host is provided, the device comprising a sensor configured for transcutaneous insertion into a host and operatively connected to sensor electronics for processing data obtained from the sensor; and a housing adapted for placement on a skin surface of the host and coupled to the sensor electronics, wherein at least one of the housing and the sensor electronics comprises a user interface configured to communicate information responsive to processed sensor data.

[0115] In an embodiment of the thirteenth aspect, the user interface comprises a screen configured to display at least one numerical value.

[0116] In an embodiment of the thirteenth aspect, the user interface comprises a screen configured to display trend information.

[0117] In an embodiment of the thirteenth aspect, the user interface comprises a screen configured to display graphical information.

[0118] In an embodiment of the thirteenth aspect, the user interface is configured to communicate information audibly.

[0119] In an embodiment of the thirteenth aspect, the user interface is configured to communicate information tactilely.

[0120] In an embodiment of the thirteenth aspect, the user interface is configured to provide information to the host in response to activation of a button.

[0121] In an embodiment of the thirteenth aspect, the sensor electronics are configured to alert the host when the sensor data is outside a predetermined boundary.

[0122] In an embodiment of the thirteenth aspect, the sensor electronics are configured to filter the sensor data.

[0123] In an embodiment of the thirteenth aspect, the sensor electronics are configured to calibrate the sensor data.

[0124] In an embodiment of the thirteenth aspect, the device further comprises a receiver, wherein the receiver is configured to communicate with the sensor electronics.

[0125] In an embodiment of the thirteenth aspect, the receiver is configured to request information from the sensor electronics.

[0126] In an embodiment of the thirteenth aspect, the sensor electronics are configured to transmit sensor data responsive to a request by the receiver.

[0127] In an embodiment of the thirteenth aspect, the receiver and the sensor electronics are operatively connected by at least one connection selected from the group consisting of a cable, a radio frequency connection, an optical connection, an inductive coupling connection, an infrared connection, and a microwave connection.

[0128] In an embodiment of the thirteenth aspect, the sensor electronics are releasably attachable to the housing.

[0129] In a fourteenth aspect, a transcutaneous glucose sensing device is provided, the device comprising a glucose sensor configured for transcutaneous insertion

through a skin of a host; and an on-skin housing coupled to the sensor, wherein the on-skin housing is adhered to the skin, and wherein the on-skin housing comprises sensor electronics configured to process sensor data and to provide sensor data to the host via a user interface.

[0130] In an embodiment of the fourteenth aspect, the user interface is configured to provide sensor data by at least method selected from the group consisting of visually, audibly, and tactilely.

[0131] In an embodiment of the fourteenth aspect, the user interface is housed on or in the on-skin housing.

[0132] In an embodiment of the fourteenth aspect, the user interface is operatively connected to the on-skin housing via at least one wire.

[0133] In an embodiment of the fourteenth aspect, the user interface is configured to be worn on the host at a location remote from the on-skin housing.

[0134] In an embodiment of the fourteenth aspect, the user interface is configured to be worn on clothing of the host, and wherein the on-skin housing in configured to be worn on the skin of the host.

[0135] In an embodiment of the fourteenth aspect, the user interface is directly wired to the on-skin housing.

[0136] In an embodiment of the fourteenth aspect, the sensor electronics are releasably attachable to the on-skin housing.

[0137] In a fifteenth aspect, a transcutaneous glucose sensor system is provided, the system comprising a glucose sensor configured for transcutaneous insertion through skin of a host; an on-skin device coupled to the sensor and comprising electronics configured to process data obtained from the sensor; and a receiver remote from the on-skin device configured to request information from the on-skin device.

[0138] In an embodiment of the fifteenth aspect, the on-skin device is configured to provide sensor information indicative of a glucose value of the host by at least one method selected from the group consisting of visual, audible, and tactile.

[0139] In an embodiment of the fifteenth aspect, the on-skin device is configured to provide filtered sensor data by at least one method selected from the group consisting of visual, audible, and tactile.

[0140] In an embodiment of the fifteenth aspect, the on-skin device is configured to provide calibrated sensor data by at least one method selected from the group consisting of visual, audible, and tactile.

BRIEF DESCRIPTION OF THE DRAWINGS

[0141] Fig. 1 is a perspective view of a transcutaneous analyte sensor system, including an applicator, a mounting unit, and an electronics unit.

[0142] Fig. 2 is a perspective view of a mounting unit, including the electronics unit in its functional position.

[0143] Fig. 3 is an exploded perspective view of a mounting unit, showing its individual components.

[0144] Fig. 4A is an exploded perspective view of a contact subassembly, showing its individual components.

[0145] Fig. 4B is a perspective view of an alternative contact configuration.

[0146] Fig. 4C is a perspective view of another alternative contact configuration.

[0147] Figs. 4D to 4H are schematic cross-sectional views of a portion of the contact subassembly; namely, a variety of embodiments illustrating alternative sealing member configurations.

[0148] Fig. 5A is an expanded cutaway view of a proximal portion of a sensor.

[0149] Fig. 5B is an expanded cutaway view of a distal portion of a sensor.

[0150] Fig. 5C is a cross-sectional view through the sensor of Fig. 5B on line C-C, showing an exposed electroactive surface of a working electrode surrounded by a membrane system.

[0151] Fig. 6 is an exploded side view of an applicator, showing the components that facilitate sensor insertion and subsequent needle retraction.

[0152] Figs. 7A to 7D are schematic side cross-sectional views that illustrate applicator components and their cooperating relationships.

[0153] Fig. 8A is a perspective view of an applicator and mounting unit in one embodiment including a safety latch mechanism.

[0154] Fig. 8B is a side view of an applicator matingly engaged to a mounting unit in one embodiment, prior to sensor insertion.

[0155] Fig. 8C is a side view of a mounting unit and applicator depicted in the embodiment of Fig. 8B, after the plunger subassembly has been pushed, extending the needle and sensor from the mounting unit.

[0156] Fig. 8D is a side view of a mounting unit and applicator depicted in the embodiment of Fig. 8B, after the guide tube subassembly has been retracted, retracting the needle back into the applicator.

[0157] Fig. 8E is a perspective view of an applicator, in an alternative embodiment, matingly engaged to the mounting unit after to sensor insertion.

[0158] Fig. 8F is a perspective view of the mounting unit and applicator, as depicted in the alternative embodiment of Fig. 8E, matingly engaged while the electronics unit is slidingly inserted into the mounting unit.

[0159] Fig. 8G is a perspective view of the electronics unit, as depicted in the alternative embodiment of Fig. 8E, matingly engaged to the mounting unit after the applicator has been released.

[0160] Figs. 8H and 8I are comparative top views of the sensor system shown in the alternative embodiment illustrated in Figs. 8E to 8G as compared to the embodiments illustrated in Figs. 8B to 8D.

[0161] Figs. 9A to 9C are side views of an applicator and mounting unit, showing stages of sensor insertion.

[0162] Figs. 10A and 10B are perspective and side cross-sectional views, respectively, of a sensor system showing the mounting unit immediately following sensor insertion and release of the applicator from the mounting unit.

[0163] Figs. 11A and 11B are perspective and side cross-sectional views, respectively, of a sensor system showing the mounting unit after pivoting the contact subassembly to its functional position.

[0164] Figs. 12A to 12C are perspective and side views, respectively, of the sensor system showing the sensor, mounting unit, and electronics unit in their functional positions.

[0165] Fig. 13 is an exploded perspective view of one exemplary embodiment of a continuous glucose sensor

[0166] Fig.14A is a block diagram that illustrates electronics associated with a sensor system.

[0167] Fig. 14B is a perspective view of an alternative embodiment, wherein the electronics unit and/or mounting unit, hereinafter referred to as the "on-skin device," is configured to communicate sensor information directly to the user (e.g., host).

[0168] Fig. 15 is a perspective view of a sensor system wirelessly communicating with a receiver.

[0169] Fig. 16A illustrates a first embodiment wherein the receiver shows a numeric representation of the estimated analyte value on its user interface, which is described in more detail elsewhere herein.

[0170] Fig. 16B illustrates a second embodiment wherein the receiver shows an estimated glucose value and one hour of historical trend data on its user interface, which is described in more detail elsewhere herein.

[0171] Fig. 16C illustrates a third embodiment wherein the receiver shows an estimated glucose value and three hours of historical trend data on its user interface, which is described in more detail elsewhere herein.

[0172] Fig. 16D illustrates a fourth embodiment wherein the receiver shows an estimated glucose value and nine hours of historical trend data on its user interface, which is described in more detail elsewhere herein.

[0173] Fig. 17A is a block diagram that illustrates a configuration of a medical device including a continuous analyte sensor, a receiver, and an external device.

[0174] Figs. 17B to 17D are illustrations of receiver liquid crystal displays showing embodiments of screen displays.

[0175] Fig. 18A is a flow chart that illustrates the initial calibration and data output of sensor data.

[0176] Fig. 18B is a graph that illustrates one example of using prior information for slope and baseline. Figs. 18C-G disclose integrated receiver housing **1892** and stylus **1998**.

[0177] Fig. 19A is a flow chart that illustrates evaluation of reference and/or sensor data for statistical, clinical, and/or physiological acceptability.

[0178] Fig. 19B is a graph of two data pairs on a Clarke Error Grid to illustrate the evaluation of clinical acceptability in one exemplary embodiment.

[0179] Fig. 20 is a flow chart that illustrates evaluation of calibrated sensor data for aberrant values.

[0180] Fig. 21 is a flow chart that illustrates self-diagnostics of sensor data.

[0181] Figs. 22A and 22B are graphical representations of glucose sensor data in a human obtained over approximately three days.

[0182] Fig. 23A is a graphical representation of glucose sensor data in a human obtained over approximately seven days.

[0183] Fig. 23B is a flow chart that illustrates a method for distributing and controlling use of sensor systems with disposable and single-use parts.

[0184] Fig. 24A is a bar graph that illustrates the ability of sensors to resist uric acid pre- and post-electron beam exposure in one *in vitro* experiment.

[0185] Fig. 24B is a bar graph that illustrates the ability of sensors to resist ascorbic acid pre- and post-electron beam exposure in one *in vitro* experiment.

[0186] Fig. 24C is a bar graph that illustrates the ability of sensors to resist acetaminophen pre- and post-electron beam exposure in one *in vitro* experiment.

[0187] Fig. 25A is a graphical representation that illustrates the acetaminophen blocking ability of a glucose sensor including a cellulose acetate interference domain that has been treated using electron beam radiation and tested *in vivo*.

[0188] Fig. 25B is a graphical representation that illustrates the acetaminophen blocking ability of a glucose sensor including a cellulose acetate/Nafion® interference domain that has been treated using electron beam radiation and tested *in vivo*.

[0189] Fig. 25C is a graphical representation that illustrates the lack of acetaminophen blocking ability of a control glucose sensor without an interference domain and tested *in vivo*.

[0190] Fig. 26A is a bar graph that represents the break-in time of the test sensors vs. the control sensors.

[0191] Fig. 26B is a graph that represents the response of glucose sensors to a variety of interferents.

[0192] Fig. 26C is a graph that represents an "equivalent glucose signal" caused by the interferents tested.

[0193] Fig. 27 is a photomicrograph obtained by Scanning Electron Microscopy (SEM) at 350X magnification of a sensor including a vapor deposited resistance domain on an outer surface.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0194] The following description and examples illustrate some exemplary embodiments of the disclosed invention in detail. Those of skill in the art will recognize that there are numerous variations and modifications of this invention that are encompassed by its scope. Accordingly, the description of a certain exemplary embodiment should not be deemed to limit the scope of the present invention.

Definitions

[0195] In order to facilitate an understanding of the preferred embodiments, a number of terms are defined below.

[0196] The term "analyte" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to a substance or chemical constituent in a biological fluid (for example, blood, interstitial fluid, cerebral spinal fluid, lymph fluid or urine) that can be analyzed. Analytes can include naturally occurring substances, artificial substances, metabolites, and/or reaction products. In some embodiments, the analyte for measurement by the sensing regions, devices, and methods is glucose. However, other analytes are contemplated as well, including but not limited to acarboxyprothrombin; acylcarnitine; adenine phosphoribosyl transferase; adenosine deaminase; albumin; alpha-fetoprotein; amino acid profiles (arginine (Krebs cycle), histidine/urocanic acid, homocysteine, phenylalanine/tyrosine, tryptophan); andrenostenedione; antipyrine; arabinitol enantiomers; arginase; benzoylecgonine (cocaine); biotinidase; biopterin; c-reactive protein; carnitine; carnosinase; CD4; ceruloplasmin; chenodeoxycholic acid; chloroquine; cholesterol; cholinesterase; conjugated 1-ß hydroxy-cholic acid; cortisol; creatine kinase; creatine kinase MM isoenzyme; cyclosporin A; d-penicillamine; de-ethylchloroquine; dehydroepiandrosterone sulfate; DNA (acetylator

polymorphism, alcohol dehydrogenase, alpha 1-antitrypsin, cystic fibrosis, Duchenne/Becker muscular dystrophy, glucose-6-phosphate dehydrogenase, hemoglobin A, hemoglobin S, hemoglobin C, hemoglobin D, hemoglobin E, hemoglobin F, D-Punjab, beta-thalassemia, hepatitis B virus, HCMV, HIV-1, HTLV-1, Leber hereditary optic neuropathy, MCAD, RNA, PKU, Plasmodium vivax, sexual differentiation, 21-deoxycortisol); desbutylhalofantrine; dihydropteridine reductase; diptheria/tetanus antitoxin; erythrocyte arginase; erythrocyte protoporphyrin; esterase D; fatty acids/acylglycines; free ß-human chorionic gonadotropin; free erythrocyte porphyrin; free thyroxine (FT4); free tri-iodothyronine (FT3); fumarylacetoacetase; galactose/gal-1-phosphate; galactose-1-phosphate uridyltransferase; gentamicin; glucose-6-phosphate dehydrogenase; glutathione; glutathione perioxidase; glycocholic acid; glycosylated hemoglobin; halofantrine; hemoglobin variants; hexosaminidase A; human erythrocyte carbonic anhydrase I; 17-alpha-hydroxyprogesterone; hypoxanthine phosphoribosyl transferase; immunoreactive trypsin; lactate; lead; lipoproteins ((a), B/A-1, ß); lysozyme; mefloquine; netilmicin; phenobarbitone; phenytoin; phytanic/pristanic acid; progesterone; prolactin; prolidase; purine nucleoside phosphorylase; quinine; reverse tri-iodothyronine (rT3); selenium; serum pancreatic lipase; sissomicin; somatomedin C; specific antibodies (adenovirus, anti-nuclear antibody, anti-zeta antibody, arbovirus, Aujeszky's disease virus, dengue virus, Dracunculus medinensis, Echinococcus granulosus, Entamoeba histolytica, enterovirus, Giardia duodenalisa, Helicobacter pylori, hepatitis B virus, herpes virus, HIV-1, IgE (atopic disease), influenza virus, Leishmania donovani, leptospira, measles/mumps/rubella, Mycobacterium leprae, Mycoplasma pneumoniae, Myoglobin, Onchocerca volvulus, parainfluenza virus, Plasmodium falciparum, poliovirus, Pseudomonas aeruginosa, respiratory syncytial virus, rickettsia (scrub typhus), Schistosoma mansoni, Toxoplasma gondii, Trepenoma pallidium, Trypanosoma cruzi/rangeli, vesicular stomatis virus, Wuchereria bancrofti, yellow fever virus); specific antigens (hepatitis B virus, HIV-1); succinylacetone; sulfadoxine; theophylline; thyrotropin (TSH); thyroxine (T4); thyroxine-binding globulin; trace elements; transferrin; UDP-galactose-4-epimerase; urea; uroporphyrinogen I synthase; vitamin A; white blood cells; and zinc protoporphyrin. Salts, sugar, protein, fat, vitamins, and hormones naturally occurring in blood or interstitial fluids can also constitute analytes in certain embodiments. The analyte

can be naturally present in the biological fluid, for example, a metabolic product, a hormone, an antigen, an antibody, and the like. Alternatively, the analyte can be introduced into the body, for example, a contrast agent for imaging, a radioisotope, a chemical agent, a fluorocarbon-based synthetic blood, or a drug or pharmaceutical composition, including but not limited to insulin; ethanol; cannabis (marijuana, tetrahydrocannabinol, hashish); inhalants (nitrous oxide, amyl nitrite, butyl nitrite, chlorohydrocarbons, hydrocarbons); cocaine (crack cocaine); stimulants (amphetamines, methamphetamines, Ritalin, Cylert, Preludin, Didrex, PreState, Voranil, Sandrex, Plegine); depressants (barbituates, methaqualone, tranquilizers such as Valium, Librium, Miltown, Serax, Equanil, Tranxene); hallucinogens (phencyclidine, lysergic acid, mescaline, peyote, psilocybin); narcotics (heroin, codeine, morphine, opium, meperidine, Percocet, Percodan, Tussionex, Fentanyl, Darvon, Talwin, Lomotil); designer drugs (analogs of fentanyl, meperidine, amphetamines, methamphetamines, and phencyclidine, for example, Ecstasy); anabolic steroids; and nicotine. The metabolic products of drugs and pharmaceutical compositions are also contemplated analytes. Analytes such as neurochemicals and other chemicals generated within the body can also be analyzed, such as, for example, ascorbic acid, uric acid, dopamine, noradrenaline, 3-methoxytyramine (3MT), 3,4-dihydroxyphenylacetic acid (DOPAC), homovanillic acid (HVA), 5-hydroxytryptamine (5HT), histamine, Advanced Glycation End Products (AGEs) and 5-hydroxyindoleacetic acid (FHIAA).

[0197] The term "host" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to mammals, particularly humans.

[0198] The term "exit-site" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to the area where a medical device (for example, a sensor and/or needle) exits from the host's body.

[0199] The term "continuous (or continual) analyte sensing" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers

without limitation to the period in which monitoring of analyte concentration is continuously, continually, and or intermittently (regularly or irregularly) performed, for example, about every 5 to 10 minutes.

[0200] The term "electrochemically reactive surface" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to the surface of an electrode where an electrochemical reaction takes place. For example, a working electrode measures hydrogen peroxide produced by the enzyme-catalyzed reaction of the analyte detected, which reacts to create an electric current. Glucose analyte can be detected utilizing glucose oxidase, which produces H_2O_2 as a byproduct. H_2O_2 reacts with the surface of the working electrode, producing two protons ($2H^+$), two electrons ($2e^-$) and one molecule of oxygen (O_2), which produces the electronic current being detected.

[0201] The term "electronic connection" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to any electronic connection known to those in the art that can be utilized to interface the sensing region electrodes with the electronic circuitry of a device, such as mechanical (for example, pin and socket) or soldered electronic connections.

[0202] The term "sensing region" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to the region of a monitoring device responsible for the detection of a particular analyte. The sensing region generally comprises a non-conductive body, a working electrode (anode), a reference electrode (optional), and/or a counter electrode (cathode) passing through and secured within the body forming electrochemically reactive surfaces on the body and an electronic connective means at another location on the body, and a multi-domain membrane affixed to the body and covering the electrochemically reactive surface.

[0203] The term "high oxygen solubility domain" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to

a domain composed of a material that has higher oxygen solubility than aqueous media such that it concentrates oxygen from the biological fluid surrounding the membrane system. The domain can act as an oxygen reservoir during times of minimal oxygen need and has the capacity to provide, on demand, a higher oxygen gradient to facilitate oxygen transport across the membrane. Thus, the ability of the high oxygen solubility domain to supply a higher flux of oxygen to critical domains when needed can improve overall sensor function.

[0204] The term "domain" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to a region of the membrane system that can be a layer, a uniform or non-uniform gradient (for example, an anisotropic region of a membrane), or a portion of a membrane.

[0205] The term "distal to" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to the spatial relationship between various elements in comparison to a particular point of reference. In general, the term indicates an element is located relatively far from the reference point than another element.

[0206] The term "proximal to" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to the spatial relationship between various elements in comparison to a particular point of reference. In general, the term indicates an element is located relatively near to the reference point than another element.

[0207] The term "*in vivo* portion" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to the portion of the device (for example, a sensor) adapted for insertion into and/or existence within a living body of a host.

[0208] The term "*ex vivo* portion" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to

be limited to a special or customized meaning), and refers without limitation to the portion of the device (for example, a sensor) adapted to remain and/or exist outside of a living body of a host.

[0209] The terms "raw data stream", "raw data signal", and "data stream" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to an analog or digital signal from the analyte sensor directly related to the measured analyte. For example, the raw data stream is digital data in "counts" converted by an A/D converter from an analog signal (for example, voltage or amps) representative of an analyte concentration. The terms broadly encompass a plurality of time spaced data points from a substantially continuous analyte sensor, each of which comprises individual measurements taken at time intervals ranging from fractions of a second up to, for example, 1, 2, or 5 minutes or longer.

[0210] The term "count" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to a unit of measurement of a digital signal. For example, a raw data stream or raw data signal measured in counts is directly related to a voltage (for example, converted by an A/D converter), which is directly related to current from the working electrode.

[0211] The term "physiologically feasible" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to one or more physiological parameters obtained from continuous studies of glucose data in humans and/or animals. For example, a maximal sustained rate of change of glucose in humans of about 4 mg/dL/min to about 6 mg/dL/min and a maximum acceleration of the rate of change of about 0.1 mg/dL/min/min to about 0.2 mg/dL/min/min are deemed physiologically feasible limits. Values outside of these limits are considered non-physiological and are likely a result of, *e.g.*, signal error.

[0212] The term "ischemia" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be

limited to a special or customized meaning), and refers without limitation to local and temporary deficiency of blood supply due to obstruction of circulation to a part (for example, a sensor). Ischemia can be caused, for example, by mechanical obstruction (for example, arterial narrowing or disruption) of the blood supply.

[0213] The term "matched data pairs" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to reference data (for example, one or more reference analyte data points) matched with substantially time corresponding sensor data (for example, one or more sensor data points).

[0214] The term "Clarke Error Grid" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to an error grid analysis, for example, an error grid analysis used to evaluate the clinical significance of the difference between a reference glucose value and a sensor generated glucose value, taking into account 1) the value of the reference glucose measurement, 2) the value of the sensor glucose measurement, 3) the relative difference between the two values, and 4) the clinical significance of this difference. See Clarke *et al.*, "Evaluating Clinical Accuracy of Systems for Self-Monitoring of Blood Glucose" Diabetes Care, Volume 10, Number 5, September-October 1987.

[0215] The term "Consensus Error Grid" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to an error grid analysis that assigns a specific level of clinical risk to any possible error between two time corresponding measurements, *e.g.*, glucose measurements. The Consensus Error Grid is divided into zones signifying the degree of risk posed by the deviation. See Parkes *et al.*, "A New Consensus Error Grid to Evaluate the Clinical Significance of Inaccuracies in the Measurement of Blood Glucose" Diabetes Care, Volume 23, Number 8, August 2000.

[0216] The term "clinical acceptability" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to

determination of the risk of an inaccuracy to a patient. Clinical acceptability considers a deviation between time corresponding analyte measurements (for example, data from a glucose sensor and data from a reference glucose monitor) and the risk (for example, to the decision making of a person with diabetes) associated with that deviation based on the analyte value indicated by the sensor and/or reference data. An example of clinical acceptability can be 85% of a given set of measured analyte values within the "A" and "B" region of a standard Clarke Error Grid when the sensor measurements are compared to a standard reference measurement.

[0217] The terms "sensor" and "sensor system" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to the component or region of a device by which an analyte can be quantified.

[0218] The term "needle" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to a slender hollow instrument for introducing material into or removing material from the body.

[0219] The terms "operatively connected," "operatively linked," "operably connected," and "operably linked" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to one or more components linked to one or more other components. The terms can refer to a mechanical connection, an electrical connection, or a connection that allows transmission of signals between the components. For example, one or more electrodes can be used to detect the amount of analyte in a sample and to convert that information into a signal; the signal can then be transmitted to a circuit. In such an example, the electrode is "operably linked" to the electronic circuitry.

[0220] The term "baseline" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to the component of an analyte sensor signal that is not related to the analyte concentration. In one example of

a glucose sensor, the baseline is composed substantially of signal contribution due to factors other than glucose (for example, interfering species, non-reaction-related hydrogen peroxide, or other electroactive species with an oxidation potential that overlaps with hydrogen peroxide). In some embodiments wherein a calibration is defined by solving for the equation $y=mx+b$, the value of b represents the baseline of the signal.

[0221] The terms "sensitivity" and "slope" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to an amount of electrical current produced by a predetermined amount (unit) of the measured analyte. For example, in one preferred embodiment, a sensor has a sensitivity (or slope) of about 3.5 to about 7.5 picoAmps of current for every 1 mg/dL of glucose analyte.

[0222] The term "membrane system" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to a permeable or semi-permeable membrane that can be comprised of two or more domains and is typically constructed of materials of one or more microns in thickness, which is permeable to oxygen and is optionally permeable to, *e.g.*, glucose or another analyte. In one example, the membrane system comprises an immobilized glucose oxidase enzyme, which enables a reaction to occur between glucose and oxygen whereby a concentration of glucose can be measured.

[0223] The terms "processor module" and "microprocessor" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to a computer system, state machine, processor, or the like designed to perform arithmetic or logic operations using logic circuitry that responds to and processes the basic instructions that drive a computer.

[0224] The terms "smoothing" and "filtering" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to modification of a set of data to make it smoother and more continuous or to remove or

diminish outlying points, for example, by performing a moving average of the raw data stream.

[0225] The term "algorithm" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to a computational process (for example, programs) involved in transforming information from one state to another, for example, by using computer processing.

[0226] The term "regression" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to finding a line for which a set of data has a minimal measurement (for example, deviation) from that line. Regression can be linear, non-linear, first order, second order, or the like. One example of regression is least squares regression.

[0227] The term "calibration" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to the process of determining the relationship between the sensor data and the corresponding reference data, which can be used to convert sensor data into meaningful values substantially equivalent to the reference data. In some embodiments, namely, in continuous analyte sensors, calibration can be updated or recalibrated over time as changes in the relationship between the sensor data and reference data occur, for example, due to changes in sensitivity, baseline, transport, metabolism, or the like.

[0228] The terms "interferents" and "interfering species" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to effects and/or species that interfere with the measurement of an analyte of interest in a sensor to produce a signal that does not accurately represent the analyte concentration. In one example of an electrochemical sensor, interfering species are compounds with an oxidation potential that overlap that of the analyte to be measured, thereby producing a false positive signal.

[0229] The terms "chloridization" and "chloridizing" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to treatment or preparation with chloride. The term "chloride" as used herein, is a broad term and is used in its ordinary sense, including, without limitation, to refer to Cl^- ions, sources of Cl^- ions, and salts of hydrochloric acid. Chloridization and chloridizing methods include, but are not limited to, chemical and electrochemical methods.

[0230] The term "R-value" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to one conventional way of summarizing the correlation of data; that is, a statement of what residuals (*e.g.*, root mean square deviations) are to be expected if the data are fitted to a straight line by the a regression.

[0231] The terms "data association" and "data association function" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to a statistical analysis of data and particularly its correlation to, or deviation from, from a particular curve. A data association function is used to show data association. For example, the data that forms that calibration set as described herein can be analyzed mathematically to determine its correlation to, or deviation from, a curve (*e.g.*, line or set of lines) that defines the conversion function; this correlation or deviation is the data association. A data association function is used to determine data association. Examples of data association functions include, but are not limited to, linear regression, non-linear mapping/regression, rank (*e.g.*, non-parametric) correlation, least mean square fit, mean absolute deviation (MAD), mean absolute relative difference. In one such example, the correlation coefficient of linear regression is indicative of the amount of data association of the calibration set that forms the conversion function, and thus the quality of the calibration.

[0232] The term "quality of calibration" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to the

statistical association of matched data pairs in the calibration set used to create the conversion function. For example, an R-value can be calculated for a calibration set to determine its statistical data association, wherein an R-value greater than 0.79 determines a statistically acceptable calibration quality, while an R-value less than 0.79 determines statistically unacceptable calibration quality.

[0233] The term "congruence" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to the quality or state of agreeing, coinciding, or being concordant. In one example, congruence can be determined using rank correlation.

[0234] The term "concordant" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to being in agreement or harmony, and/or free from discord.

[0235] The phrase "continuous glucose sensing" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to the period in which monitoring of plasma glucose concentration is continuously or continually performed, for example, at time intervals ranging from fractions of a second up to, for example, 1, 2, or 5 minutes, or longer.

[0236] The term "single point glucose monitor" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to a device that can be used to measure a glucose concentration within a host at a single point in time, for example, some embodiments utilize a small volume in vitro glucose monitor that includes an enzyme membrane such as described with reference to U.S. Patent 4,994,167 and U.S. Patent 4,757,022. It should be understood that single point glucose monitors can measure multiple samples (for example, blood or interstitial fluid); however only one sample is measured at a time and typically requires some user initiation and/or interaction.

[0237] The term "biological sample" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to sample of a host body, for example blood, interstitial fluid, spinal fluid, saliva, urine, tears, sweat, or the like.

[0238] The terms "substantial" and "substantially" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to a sufficient amount that provides a desired function. For example, the interference domain of the preferred embodiments is configured to resist a sufficient amount of interfering species such that tracking of glucose levels can be achieved, which may include an amount greater than 50 percent, an amount greater than 60 percent, an amount greater than 70 percent, an amount greater than 80 percent, and an amount greater than 90 percent of interfering species.

[0239] The terms "cellulosic derivatives" and "cellulosic polymers" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to derivatives of cellulose formed by reaction with carboxylic acid anhydrides. Examples of cellulosic derivatives include cellulose acetate, 2-hydroxyethyl cellulose, cellulose acetate phthalate, cellulose acetate propionate, cellulose acetate butyrate, cellulose acetate trimellitate, and the like.

[0240] The term "cellulose acetate" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to any of several compounds obtained by treating cellulose with acetic anhydride.

[0241] The term "cellulose acetate butyrate" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to any of several compounds obtained by treating cellulose with acetic anhydride and butyric anhydride.

[0242] The term "Nafion®" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to DuPont's trademark of a sulfonated tetrafluorethylene polymer modified from Teflon® developed in the late 1960s. In general, Nafion® is a perfluorinated polymer that contains small proportions of sulfonic or carboxylic ionic functional groups.

[0243] The terms "crosslink" and "crosslinking" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to joining (adjacent chains of a polymer or protein) by creating covalent bonds. Crosslinking can be accomplished by techniques such as thermal reaction, chemical reaction or by providing ionizing radiation (for example, electron beam radiation, UV radiation, or gamma radiation). In preferred embodiments, crosslinking utilizes a technique that forms free radicals, for example, electron beam exposure.

[0244] The term "ionizing radiation" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to radiation consisting of particles, X-ray beams, electron beams, UV beams, or gamma ray beams, which produce ions in the medium through which it passes.

[0245] The term "casting" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to a process where a fluid material is applied to a surface or surfaces and allowed to cure or dry. The term is broad enough to encompass a variety of coating techniques, for example, using a draw-down machine (*i.e.*, drawing-down), dip coating, spray coating, spin coating, or the like.

[0246] The term "dip coating" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to coating which involves dipping an object or material into a liquid coating substance.

[0247] The term "spray coating" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to coating which involves spraying a liquid coating substance onto an object or material.

[0248] The term "spin coating" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to a coating process in which a thin film is created by dropping a raw material solution onto a substrate while it is rotating.

[0249] The terms "solvent" and "solvent systems" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to substances (e.g., liquids) capable of dissolving or dispersing one or more other substances. Solvents and solvent systems can include compounds and/or solutions that include components in addition to the solvent itself.

[0250] The term "baseline" as used herein is a broad term, and is to be given its ordinary and customary meaning to a person of ordinary skill in the art (and is not to be limited to a special or customized meaning), and refers without limitation to the component of an analyte sensor signal that is not related to the analyte concentration. In one example of a glucose sensor, the baseline is composed substantially of signal contribution due to factors other than glucose (for example, interfering species, non-reaction-related hydrogen peroxide, or other electroactive species with an oxidation potential that overlaps with hydrogen peroxide). In some embodiments wherein a calibration is defined by solving for the equation $y=mx+b$, the value of b represents the baseline of the signal.

[0251] The terms "sensitivity" and "slope" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to an amount of electrical current produced by a predetermined amount (unit) of the measured analyte. For example, in one preferred embodiment, a sensor has a sensitivity (or slope) of about 3.5 to about 7.5 picoAmps of current for every 1 mg/dL of glucose analyte.

[0252] The terms "baseline and/or sensitivity shift," "baseline and/or sensitivity drift," "shift," and "drift" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to a change in the baseline and/or sensitivity of the sensor signal over time. While the term "shift" generally refers to a substantially distinct change over a relatively short time period, and the term "drift" generally refers to a substantially gradual change over a relatively longer time period, the terms can be used interchangeably and can also be generally referred to as "change" in baseline and/or sensitivity.

[0253] The terms "sealant" and "lubricant" as used herein are broad terms, and are to be given their ordinary and customary meaning to a person of ordinary skill in the art (and are not to be limited to a special or customized meaning), and refer without limitation to a material with a low surface tension that repels and/or blocks moisture, for example, oil, grease, or gel. Sealants or lubricants can be used to fill gaps and/or to repel or block water. One exemplary sealant is petroleum jelly.

Sensor System

[0254] The preferred embodiments relate to the use of an analyte sensor that measures a concentration of analyte of interest or a substance indicative of the concentration or presence of the analyte. In some embodiments, the sensor is a continuous device, for example a subcutaneous, transdermal (*e.g.*, transcutaneous), or intravascular device. In some embodiments, the device can analyze a plurality of intermittent blood samples. The analyte sensor can use any method of analyte-sensing, including enzymatic, chemical, physical, electrochemical, spectrophotometric, polarimetric, calorimetric, radiometric, or the like.

[0255] The analyte sensor uses any method, including invasive, minimally invasive, and non-invasive sensing techniques, to provide an output signal indicative of the concentration of the analyte of interest. The output signal is typically a raw signal that is used to provide a useful value of the analyte of interest to a user, such as a patient or physician, who can be using the device. Accordingly, appropriate smoothing, calibration, and evaluation methods can be applied to the raw signal and/or system as a whole to provide relevant and acceptable estimated analyte data to the user.

[0256] The methods and devices of preferred embodiments can be employed in a continuous glucose sensor that measures a concentration of glucose or a substance indicative of a concentration or a presence of glucose. However, certain methods and devices of preferred embodiments are also suitable for use in connection with non-continuous (e.g., single point measurement or finger stick) monitors, such as the OneTouch® system manufactured by LifeScan, Inc., or monitors as disclosed in U.S. Pat. Nos. 5,418,142; 5,515,170; 5,526,120; 5,922,530; 5,968,836; and 6,335,203. In some embodiments, the glucose sensor is an invasive, minimally-invasive, or non-invasive device, for example a subcutaneous, transdermal, or intravascular device. In some embodiments, the device can analyze a plurality of intermittent biological samples, such as blood, interstitial fluid, or the like. The glucose sensor can use any method of glucose-measurement, including colorimetric, enzymatic, chemical, physical, electrochemical, spectrophotometric, polarimetric, calorimetric, radiometric, or the like. In alternative embodiments, the sensor can be any sensor capable of determining the level of an analyte in the body, for example oxygen, lactase, hormones, cholesterol, medicaments, viruses, or the like.

[0257] The glucose sensor uses any method to provide an output signal indicative of the concentration of the glucose. The output signal is typically a raw data stream that is used to provide a value indicative of the measured glucose concentration to a patient or doctor, for example.

[0258] One exemplary embodiment described in detail below utilizes an implantable glucose sensor. Another exemplary embodiment described in detail below utilizes a transcutaneous glucose sensor.

[0259] In one alternative embodiment, the continuous glucose sensor comprises a transcutaneous sensor such as described in U.S. Patent 6,565,509 to Say *et al.* In another alternative embodiment, the continuous glucose sensor comprises a subcutaneous sensor such as described with reference to U.S. Patent 6,579,690 to Bonnecaze *et al.* or U.S. Patent 6,484,046 to Say *et al.* In another alternative embodiment, the continuous glucose sensor comprises a refillable subcutaneous sensor such as described with reference to U.S. Patent 6,512,939 to Colvin *et al.* In another alternative embodiment, the continuous glucose sensor comprises an intravascular sensor such as described with reference to U.S. Patent 6,477,395

to Schulman *et al.* In another alternative embodiment, the continuous glucose sensor comprises an intravascular sensor such as described with reference to U.S. Patent 6,424,847 to Mastrototaro *et al.* All of the above patents are incorporated in their entirety herein by reference.

[0260] Although a few exemplary embodiments of continuous glucose sensors are illustrated and described herein, it should be understood that the disclosed embodiments are applicable to any device capable of single analyte, substantially continual or substantially continuous measurement of a concentration of analyte of interest and providing an output signal that represents the concentration of that analyte.

[0261] In a first exemplary embodiment, a transcutaneous analyte sensor system is provided that includes an applicator for inserting the transdermal analyte sensor under a host's skin. The sensor system includes a sensor for sensing the analyte, wherein the sensor is associated with a mounting unit adapted for mounting on the skin of the host. The mounting unit houses the electronics unit associated with the sensor and is adapted for fastening to the host's skin. In certain embodiments, the system further includes a receiver for receiving and/or processing sensor data.

[0262] Fig. 1 is a perspective view of a transcutaneous analyte sensor system **10.** In the preferred embodiment of a system as depicted in Fig. 1, the sensor includes an applicator **12**, a mounting unit **14**, and an electronics unit **16**. The system can further include a receiver **158**, such as is described in more detail with reference to Fig. 15.

[0263] The mounting unit (housing) **14** includes a base **24** adapted for mounting on the skin of a host, a sensor adapted for transdermal insertion through the skin of a host (see Fig. 4A), and one or more contacts **28** configured to provide secure electrical contact between the sensor and the electronics unit **16**. The mounting unit **14** is designed to maintain the integrity of the sensor in the host so as to reduce or eliminate translation of motion between the mounting unit, the host, and/or the sensor.

[0264] In one embodiment, an applicator **12** is provided for inserting the sensor **32** through the host's skin at the appropriate insertion angle with the aid of a needle (see Figs. 6 through 8), and for subsequent removal of the needle using a continuous push-pull action. Preferably, the applicator comprises an applicator body **18** that guides the applicator

components (see Figs. 6 through 8) and includes an applicator body base **60** configured to mate with the mounting unit **14** during insertion of the sensor into the host. The mate between the applicator body base **60** and the mounting unit **14** can use any known mating configuration, for example, a snap-fit, a press-fit, an interference-fit, or the like, to discourage separation during use. One or more release latches **30** enable release of the applicator body base **60**, for example, when the applicator body base **60** is snap fit into the mounting unit **14**.

[0265] The electronics unit **16** includes hardware, firmware, and/or software that enable measurement of levels of the analyte via the sensor. For example, the electronics unit **16** can comprise a potentiostat, a power source for providing power to the sensor, other components useful for signal processing, and preferably an RF module for transmitting data from the electronics unit **16** to a receiver (see Figs. 14 to 16). Electronics can be affixed to a printed circuit board (PCB), or the like, and can take a variety of forms. For example, the electronics can take the form of an integrated circuit (IC), such as an Application-Specific Integrated Circuit (ASIC), a microcontroller, or a processor. Preferably, electronics unit **16** houses the sensor electronics, which comprise systems and methods for processing sensor analyte data. Examples of systems and methods for processing sensor analyte data are described in more detail in U.S. Publication No. US-2005-0027463-A1.

[0266] After insertion of the sensor using the applicator **12**, and subsequent release of the applicator **12** from the mounting unit **14** (see Figs. 8B to 8D), the electronics unit **16** is configured to releasably mate with the mounting unit **14** in a manner similar to that described above with reference to the applicator body base **60**. The electronics unit **16** includes contacts on its backside (not shown) configured to electrically connect with the contacts **28**, such as are described in more detail with reference to Figs. 2 through 4. In one embodiment, the electronics unit **16** is configured with programming, for example initialization, calibration reset, failure testing, or the like, each time it is initially inserted into the mounting unit **14** and/or each time it initially communicates with the sensor **32**.

Mounting Unit

[0267] Fig. 2 is a perspective view of a sensor system of a preferred embodiment, shown in its functional position, including a mounting unit and an electronics unit matingly

engaged therein. Figs. 12A to 12C illustrate the sensor is its functional position for measurement of an analyte concentration in a host.

[0268] In preferred embodiments, the mounting unit **14**, also referred to as a housing, comprises a base **24** adapted for fastening to a host's skin. The base can be formed from a variety of hard or soft materials, and preferably comprises a low profile for minimizing protrusion of the device from the host during use. In some embodiments, the base **24** is formed at least partially from a flexible material, which is believed to provide numerous advantages over conventional transcutaneous sensors, which, unfortunately, can suffer from motion-related artifacts associated with the host's movement when the host is using the device. For example, when a transcutaneous analyte sensor is inserted into the host, various movements of the sensor (for example, relative movement between the *in vivo* portion and the *ex vivo* portion, movement of the skin, and/or movement within the host (dermis or subcutaneous)) create stresses on the device and can produce noise in the sensor signal. It is believed that even small movements of the skin can translate to discomfort and/or motion-related artifact, which can be reduced or obviated by a flexible or articulated base. Thus, by providing flexibility and/or articulation of the device against the host's skin, better conformity of the sensor system **10** to the regular use and movements of the host can be achieved. Flexibility or articulation is believed to increase adhesion (with the use of an adhesive pad) of the mounting unit **14** onto the skin, thereby decreasing motion-related artifact that can otherwise translate from the host's movements and reduced sensor performance.

[0269] Fig. 3 is an exploded perspective view of a sensor system of a preferred embodiment, showing a mounting unit, an associated contact subassembly, and an electronics unit. In some embodiments, the contacts **28** are mounted on or in a subassembly hereinafter referred to as a contact subassembly **26** (see Fig. 4A), which includes a contact holder **34** configured to fit within the base **24** of the mounting unit **14** and a hinge **38** that allows the contact subassembly **26** to pivot between a first position (for insertion) and a second position (for use) relative to the mounting unit **14**, which is described in more detail with reference to Figs. 10 and 11. The term "hinge" as used herein is a broad term and is used in its ordinary sense, including, without limitation, to refer to any of a variety of pivoting, articulating,

and/or hinging mechanisms, such as an adhesive hinge, a sliding joint, and the like; the term hinge does not necessarily imply a fulcrum or fixed point about which the articulation occurs.

[0270] In certain embodiments, the mounting unit **14** is provided with an adhesive pad **8**, preferably disposed on the mounting unit's back surface and preferably including a releasable backing layer **9**. Thus, removing the backing layer **9** and pressing the base portion **24** of the mounting unit onto the host's skin adheres the mounting unit **14** to the host's skin. Additionally or alternatively, an adhesive pad can be placed over some or all of the sensor system after sensor insertion is complete to ensure adhesion, and optionally to ensure an airtight seal or watertight seal around the wound exit-site (or sensor insertion site) (not shown). Appropriate adhesive pads can be chosen and designed to stretch, elongate, conform to, and/or aerate the region (*e.g.*, host's skin).

[0271] In preferred embodiments, the adhesive pad **8** is formed from spun-laced, open- or closed-cell foam, and/or non-woven fibers, and includes an adhesive disposed thereon, however a variety of adhesive pads appropriate for adhesion to the host's skin can be used, as is appreciated by one skilled in the art of medical adhesive pads. In some embodiments, a double-sided adhesive pad is used to adhere the mounting unit to the host's skin. In other embodiments, the adhesive pad includes a foam layer, for example, a layer wherein the foam is disposed between the adhesive pad's side edges and acts as a shock absorber.

[0272] In some embodiments, the surface area of the adhesive pad **8** is greater than the surface area of the mounting unit's back surface. Alternatively, the adhesive pad can be sized with substantially the same surface area as the back surface of the base portion. Preferably, the adhesive pad has a surface area on the side to be mounted on the host's skin that is greater than about 1, 1.25, 1.5, 1.75, 2, 2.25, or 2.5, times the surface area of the back surface **25** of the mounting unit base **24**. Such a greater surface area can increase adhesion between the mounting unit and the host's skin, minimize movement between the mounting unit and the host's skin, and/or protect the wound exit-site (sensor insertion site) from environmental and/or biological contamination. In some alternative embodiments, however, the adhesive pad can be smaller in surface area than the back surface assuming a sufficient adhesion can be accomplished.

[0273] In some embodiments, the adhesive pad **8** is substantially the same shape as the back surface **25** of the base **24**, although other shapes can also be advantageously employed, for example, butterfly-shaped, round, square, or rectangular. The adhesive pad backing can be designed for two-step release, for example, a primary release wherein only a portion of the adhesive pad is initially exposed to allow adjustable positioning of the device, and a secondary release wherein the remaining adhesive pad is later exposed to firmly and securely adhere the device to the host's skin once appropriately positioned. The adhesive pad is preferably waterproof. Preferably, a stretch-release adhesive pad is provided on the back surface of the base portion to enable easy release from the host's skin at the end of the useable life of the sensor, as is described in more detail with reference to Figs. 9A to 9C.

[0274] In some circumstances, it has been found that a conventional bond between the adhesive pad and the mounting unit may not be sufficient, for example, due to humidity that can cause release of the adhesive pad from the mounting unit. Accordingly, in some embodiments, the adhesive pad can be bonded using a bonding agent activated by or accelerated by an ultraviolet, acoustic, radio frequency, or humidity cure. In some embodiments, a eutectic bond of first and second composite materials can form a strong adhesion. In some embodiments, the surface of the mounting unit can be pretreated utilizing ozone, plasma, chemicals, or the like, in order to enhance the bondability of the surface.

[0275] A bioactive agent is preferably applied locally at the insertion site (exit-site) prior to or during sensor insertion. Suitable bioactive agents include those which are known to discourage or prevent bacterial growth and infection, for example, anti-inflammatory agents, antimicrobials, antibiotics, or the like. It is believed that the diffusion or presence of a bioactive agent can aid in prevention or elimination of bacteria adjacent to the exit-site. Additionally or alternatively, the bioactive agent can be integral with or coated on the adhesive pad, or no bioactive agent at all is employed.

[0276] Fig. 4A is an exploded perspective view of the contact subassembly **26** in one embodiment, showing its individual components. Preferably, a watertight (waterproof or water-resistant) sealing member **36**, also referred to as a sealing material or seal, fits within a contact holder **34** and provides a watertight seal configured to surround the electrical connection at the electrode terminals within the mounting unit in order to protect the

electrodes (and the respective operable connection with the contacts of the electronics unit **16**) from damage due to moisture, humidity, dirt, and other external environmental factors. In one embodiment, the sealing member **36** is formed from an elastomeric material, such as silicone; however, a variety of other elastomeric or sealing materials can also be used, for example, silicone-polyurethane hybrids, polyurethanes, and polysulfides. Preferably, the sealing member is configured to compress within the contact subassembly when the electronics unit is mated to the mounting unit. In some embodiments, the sealing member **36** comprises a self-lubricating material, for example, self-lubricating silicone or other materials impregnated with or otherwise comprising a lubricant configured to be released during use. In some embodiments, the sealing member **36** includes a self-sealing material, for example, one that leaches out a sealant such as a silicone oil. In some embodiments, bumps, ridges, or other raised portions (not shown), can be added to a component of the sensor system, such as to the contact subassembly **26** (e.g., housing adjacent to the sealing member), electronics unit **16** and/or sealing member **36** to provide additional compression and improve the seal formed around the contacts **28** and/or sensor **32** when the contacts **28** are mated to the sensor electronics.

[0277] Preferably, the sealing member is selected using a durometer. A durometer is an instrument used for measuring the indentation hardness of rubber, plastics, and other materials. Durometers are built to various standards from ASTM, DIN, JIS, and ISO. The hardness of plastics is most commonly measured by the Shore (Durometer) test or Rockwell hardness test. Both methods measure the resistance of plastics toward indentation and provide an empirical hardness value. Shore Hardness, using either the Shore A or Shore D scale, is the preferred method for rubbers/elastomers and is also commonly used for softer plastics such as polyolefins, fluoropolymers, and vinyls. The Shore A scale is used for softer rubbers while the Shore D scale is used for harder ones. In preferred embodiments, the Shore A scale is employed in connection with selection of a sealing member.

[0278] The Shore hardness is measured with a Durometer and sometimes referred to as "Durometer hardness." The hardness value is determined by the penetration of the Durometer indenter foot into the sample. Because of the resilience of rubbers and plastics, the indentation reading may change over time, so the indentation time is sometimes reported

along with the hardness number. The ASTM test method designation for the Shore Durometer hardness test is ASTM D2240. The results obtained from this test are a useful measure of relative resistance to indentation of various grades of polymers.

[0279] Using a durometer in the selection of a sealing member enables selection of a material with optimal durometer hardness that balances the advantages of a lower durometer hardness with the advantages of a higher durometer hardness. For example, when a guide tube (e.g., cannula) is utilized to maintain an opening in a silicone sealing member prior to sensor insertion, a compression set (e.g., some retention of a compressed shape caused by compression of the material over time) within the silicone can result due to compression over time of the sealing member by the guide tube. Compression set can also result from certain sterilization procedures (e.g., radiation sterilization such as electron beam or gamma radiation). Unfortunately, in some circumstances, the compression set of the sealing member may cause gaps or incompleteness of contact between the sealing member and the contacts and/or sensor. In general, a lower durometer hardness provides a better conformation (e.g., seal) surrounding the contacts and/or sensor as compared to a higher durometer hardness. Additionally, a lower durometer hardness enables a design wherein less force is required to create the seal (e.g., to snap the electronics unit into the mounting unit, for example, as in the embodiment illustrated in Fig. 4A) as compared to a higher durometer hardness, thereby increasing the ease of use of the device. However, the benefits of a lower durometer hardness silicone material must be balanced with potential disadvantages in manufacturing. For example, lower durometer hardness silicones are often produced by compounding with a silicone oil. In some circumstances, it is believed that some silicone oil may leach or migrate during manufacture and/or sterilization, which may corrupt aspects of the manufacturing process (e.g., adhesion of glues and/or effectiveness of coating processes). Additionally, a higher durometer hardness material generally provides greater stability of the material, which may reduce or avoid damage to the sealing member cause by pressure or other forces.

[0280] It is generally preferred that a sealing member **36** with a durometer hardness of from about 5 to about 80 Shore A is employed, more preferably a durometer hardness of from about 10 to about 50 Shore A, and even more preferably from about 20 to

about 50 Shore A. In one embodiment, of a transcutaneous analyte sensor, the sealing member is fabricated using a silicone of about 20 Shore A to maximize the conformance of the seal around the contacts and/or sensor while minimizing the force required to compress the silicone for that conformance. In another embodiment, the sealing member is formed from a silicone of about 50 Shore A so as to provide increased strength of the sealing member (e.g., its resistance to compression). While a few representative examples have been provided above, one skilled in the art appreciates that higher or lower durometer hardness sealing material may also be suitable for use.

[0281] In one alternative embodiment, a sealing member **36** with a durometer hardness of about 10 Shore A is used. In this embodiment, the sealing material tends to "weep" out, further increasing conformance of the seal against the adjacent parts. In another alternative embodiment, a sealing material with a durometer hardness of about 0 (zero) Shore A is used as a sealant and/or in combination with a sealant, also referred to as a lubricant, which in some embodiments is a hydrophobic fluid filling material such as a grease, silicone, petroleum jelly, or the like. Preferably, the sensor and/or contacts are encased in a housing that contains the sealant, causing the material to "squeeze" around contacts and/or sensor. Any suitable hydrophobic fluid filling material can be employed. Especially preferred are synthetic or petroleum hydrocarbon-based materials, silicone-based materials, ester-based greases, and other pharmaceutical-grade materials.

[0282] In some embodiments, the sealing member can comprise a material that has been modified to enhance the desirable properties of the sealing member **36**. For example, one or more filler materials or stiffening agents such as glass beads, polymer beads, composite beads, beads comprising various inert materials, carbon black, talc, titanium oxide, silicone dioxide, and the like. In some embodiments, the filler material is incorporated into the sealing member material to mechanically stiffen the sealing member. In general, however, use of a filler material or stiffening agent in the sealing member material can provide a variety of enhanced properties including increased modulus of elasticity, crosslink density, hardness, and stiffness, and decreased creep, for example. In some alternative embodiments, gases are chemically (or otherwise) injected into the sealing member material. For example, the sealing material can comprise a polymeric foam (e.g., a polyurethane foam,

a latex foam, a styrene-butadiene foam, and the like), or a dispersion of gas bubbles in a grease or jelly.

[0283] In alternative embodiments, the seal **36** is designed to form an interference fit with the electronics unit and can be formed from a variety of materials, for example, flexible plastics, or noble metals. One of ordinary skill in the art appreciates that a variety of designs can be employed to provide a seal surrounding electrical contacts such as described herein. For example, the contact holder **34** can be integrally designed as a part of the mounting unit, rather than as a separate piece thereof. Additionally or alternatively, a sealant can be provided in or around the sensor (*e.g.*, within or on the contact subassembly or sealing member), such as is described in more detail with reference to Figs 11A and 11B. In general, sealing materials with durometer hardnesses in the described ranges can provide improved sealing in a variety of sensor applications. For example, a sealing member as described in the preferred embodiments (e.g., selected using a durometer to ensure optimal durometer hardness, and the like) can be implemented adjacent to and/or to at least partially surrounding the sensor in a variety of sensor designs, including, for example, the sensor designs of the preferred embodiments, as well as a planar substrate such as described in U.S. Patent Number 6,175,752.

[0284] In the illustrated embodiment of Fig. 4A, the sealing member **36** is formed with a raised portion **37** surrounding the contacts **28**. The raised portion **37** enhances the interference fit surrounding the contacts **28** when the electronics unit **16** is mated to the mounting unit **14**. Namely, the raised portion surrounds each contact and presses against the electronics unit **16** to form a tight seal around the electronics unit. However, a variety of alternative sealing member configurations are described with reference to Figs. 4D to 4H, below.

[0285] Contacts **28** fit within the seal **36** and provide for electrical connection between the sensor **32** and the electronics unit **16**. In general, the contacts are designed to ensure a stable mechanical and electrical connection of the electrodes that form the sensor **32** (see Fig. 5A to 5C) to mutually engaging contacts **28** thereon. A stable connection can be provided using a variety of known methods, for example, domed metallic contacts, cantilevered fingers, pogo pins, or the like, as is appreciated by one skilled in the art.

[0286] In preferred embodiments, the contacts **28** are formed from a conductive elastomeric material, such as a carbon black elastomer, through which the sensor **32** extends (see Figs. 10B and 11B). Conductive elastomers are advantageously employed because their resilient properties create a natural compression against mutually engaging contacts, forming a secure press fit therewith. In some embodiments, conductive elastomers can be molded in such a way that pressing the elastomer against the adjacent contact performs a wiping action on the surface of the contact, thereby creating a cleaning action during initial connection. Additionally, in preferred embodiments, the sensor **32** extends through the contacts **28** wherein the sensor is electrically and mechanically secure by the relaxation of elastomer around the sensor (see Figs. 7A to 7D).

[0287] In an alternative embodiment, a conductive, stiff plastic forms the contacts, which are shaped to comply upon application of pressure (for example, a leaf-spring shape). Contacts of such a configuration can be used instead of a metallic spring, for example, and advantageously avoid the need for crimping or soldering through compliant materials; additionally, a wiping action can be incorporated into the design to remove contaminants from the surfaces during connection. Non-metallic contacts can be advantageous because of their seamless manufacturability, robustness to thermal compression, non-corrosive surfaces, and native resistance to electrostatic discharge (ESD) damage due to their higher-than-metal resistance.

[0288] Figs. 4B and 4C are perspective views of alternative contact configurations. Fig. 4B is an illustration of a narrow contact configuration. Fig. 4C is an illustration of a wide contact configuration. One skilled in the art appreciates that a variety of configurations are suitable for the contacts of the preferred embodiments, whether elastomeric, stiff plastic or other materials are used. In some circumstances, it can be advantageous to provide multiple contact configurations (such as illustrated in Figs. 4A to 4C) to differentiate sensors from each other. In other words, the architecture of the contacts can include one or more configurations each designed (keyed) to fit with a particular electronics unit. See section entitled "Differentiation of Sensor Systems" below, which describes systems and methods for differentiating (keying) sensor systems.

[0289] Figs. 4D to 4H are schematic cross-sectional views of a portion of the contact subassembly; namely, a variety of alternative embodiments of the sealing member **36** are illustrated. In each of these embodiments (e.g., Figs. 4D to 4H), a sensor **32** is shown, which is configured for operable connection to sensor electronics for measuring an analyte in a host such as described in more detail elsewhere herein. Additionally, two electrical contacts **28**, as described in more detail elsewhere herein, are configured to operably connect the sensor to the sensor electronics. Thus, the sealing member **36** in each of these alternative configurations (e.g., Figs. 4D to 4H) at least partially surrounds the sensor and/or the electrical contacts to seal the electrical contacts from moisture when the sensor is operably connected to the sensor electronics.

[0290] Fig. 4D is a schematic cross-sectional view of the sealing member **36** in an embodiment similar to Fig. 4A, including gaps **400** that are maintained when the one or more electrical contacts are operably connected to the sensor electronics. Preferably, these air gaps provide for some flexibility of the sealing member **36** to deform or compress to seal the electrical contacts **28** from moisture or other environmental effects.

[0291] In certain circumstances, such as during sensor insertion or needle/guide tube retraction (see Figs. 7A to 7D), a sealing member with a certain elasticity can be compressed or deformed by the insertion and/or retraction forces applied thereto. Accordingly in some embodiments, the sealing member is configured to be maintained (e.g., held substantially in place) on the housing (e.g., contact subassembly **26** or base **34**) without substantial translation, deformation, and/or compression (e.g., during sensor insertion). Fig. 4D illustrates one such implementation, wherein one or more depressions **402** are configured to receive mating protrusions (e.g., on the base **34** of the contact subassembly **26**, not shown). A variety of male-female or other such mechanical structures can be implemented to hold the sealing member in place, as is appreciated by one skilled in the art. In one alternative embodiment, an adhesive (not shown) is configured to adhere the sealing member **36** to the housing (e.g., base **34** of the contact subassembly **26**) to provide substantially the same benefit of holding the sealing member during sensor insertion/retraction without substantial deformation, as described in more detail, above. In another embodiment, the base **34** of the contact subassembly **26** (or equivalent structure) comprises reinforcing mechanical supports

configured to hold the sealing member as described above. One skilled in the art appreciates a variety of mechanical and/or chemical methods that can be implemented to maintain a sealing member substantially stationary (e.g., without substantial translation, deformation and/or compression) when compression and/or deformation forces are applied thereto. Although one exemplary embodiment is illustrated with reference to Fig. 4D, a wide variety of systems and methods for holding the sealing member can be implemented with a sealing member of any particular design.

[0292] Fig. 4E is a schematic cross-sectional view of the sealing member **36** in an alternative embodiment without gaps. In certain circumstances, full contact between mating members may be preferred.

[0293] In certain circumstances moisture may "wick" along the length of the sensor (e.g., from an exposed end) through the sealing member **36** to the contacts **28**. Fig. 4F is a schematic cross-sectional view of a sealing member **36** in an alternative embodiment wherein one or more gaps **400** are provided. In this embodiment, the gaps **400** extend into the sealing member and encompass at least a portion of the sensor **32**. The gaps **400** or "deep wells" of Fig. 4F are designed to interrupt the path that moisture may take, avoiding contact of the moisture at the contacts **28**. If moisture is able to travel along the path of the sensor, the abrupt change of surface tension at the opening **404** of the gap **400** in the sealing member **36** substantially deters the moisture from traveling to the contacts **28**.

[0294] Fig. 4G is a schematic cross-sectional view of the sealing member **36** in another alternative embodiment wherein one or more gaps **400** are provided. In this embodiment, the gaps extend from the bottom side of the sealing member **36**, which can be helpful in maintaining a stable position of the contacts **28** and/or reduces "pumping" of air gaps in some situations.

[0295] In some embodiments, gaps **400** can be filled by a sealant, which also may be referred to as a lubricant, for example, oil, grease, or gel. In one exemplary embodiment, the sealant includes petroleum jelly and is used to provide a moisture barrier surrounding the sensor. Referring to Fig. 4F, filling the gaps **400** with a sealant provides an additional moisture barrier to reduce or avoid moisture from traveling to the contacts **28**. Sealant can be used to fill gaps or crevices in any sealing member configuration.

[0296] In some sealing member configurations, it can be advantageous to provide a channel **406** through the sealing member **36** in order to create an additional pathway for sealant (e.g. lubricant) in order to expel air and/or to provide a path for excess sealant to escape. In some embodiments, more than one channel is provided.

[0297] Fig. 4H is a schematic cross-sectional view of a sealing member **36** in an alternative embodiment wherein a large gap **400** is provided between the sealing member upper portion **408** and the sealing member lower portion **410**. These portions **408**, **410** may or may not be connected; however, they are configured to sandwich the sensor and sealant (e.g., grease) therebetween. The sealing member **36** illustrated with reference to Fig. 4H can provide ease of manufacture and/or product assembly with a comprehensive sealing ability. Additional gaps (with or without sealant) can be provided in a variety of locations throughout the sealing member **36**; these additional gaps, for example, provide space for excess sealant.

Sensor

[0298] Preferably, the sensor **32** includes a distal portion **42**, also referred to as the *in vivo* portion, adapted to extend out of the mounting unit for insertion under the host's skin, and a proximal portion **40**, also referred to as an *ex vivo* portion, adapted to remain above the host's skin after sensor insertion and to operably connect to the electronics unit **16** via contacts **28**. Preferably, the sensor **32** includes two or more electrodes: a working electrode **44** and at least one additional electrode, which can function as a counter electrode and/or reference electrode, hereinafter referred to as the reference electrode **46**. A membrane system is preferably deposited over the electrodes, such as described in more detail with reference to Figs. 5A to 5C, below.

[0299] Fig. 5A is an expanded cutaway view of a proximal portion **40** of the sensor in one embodiment, showing working and reference electrodes. In the illustrated embodiments, the working and reference electrodes **44**, **46** extend through the contacts **28** to form electrical connection therewith (see Figs. 10B and 11B). Namely, the working electrode **44** is in electrical contact with one of the contacts **28** and the reference electrode **46** is in electrical contact with the other contact **28**, which in turn provides for electrical connection with the electronics unit **16** when it is mated with the mounting unit **14**. Mutually engaging electrical contacts permit operable connection of the sensor **32** to the electronics unit **16** when