(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 July 2013 (04.07.2013)

WIPO | PCT

(10) International Publication Number
WO 2013/098564 Al

(51) **International Patent Classification:**
G01N 27/327 (2006.01)

(21) **International Application Number:**
PCT/GB20 12/053277

(22) **International Filing Date:**
28 December 2012 (28. 12.2012)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**

61/581,087	29 December 201 1 (29. 12.201 1)	US
61/581,089	29 December 201 1 (29. 12.201 1)	US
61/581,099	29 December 201 1 (29. 12.201 1)	US
61/581,100	29 December 201 1 (29. 12.201 1)	US
61/654,013	31 May 2012 (31.05.2012)	US

(71) **Applicant: LIFESCAN SCOTLAND LIMITED** [GB/GB]; Beechwood Park North, Inverness, Inverness-shire I72 3ED (GB).

(72) **Inventor: MALECHA, Michael;** An Caorann, Corry Road, Muir of Ord, Inverness-shire I7 6 7TL (GB).

(74) **Agents: BRUNNER, John Michael Owen** et al; Carpmaels & Ransford, One Southampton Row, London WC1B 5HA (GB).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available):* AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available):* ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,

[Continued on nextpage]

(54) **Title:** ACCURATE ANALYTE MEASUREMENTS FOR ELECTROCHEMICAL TEST STRIP BASED ON MULTIPLE DISCRETE MEASUREMENTS DEFINED BY SENSED PHYSICAL CHARACTERISTIC(S) OF THE SAMPLE CONTAINING THE ANALYTE

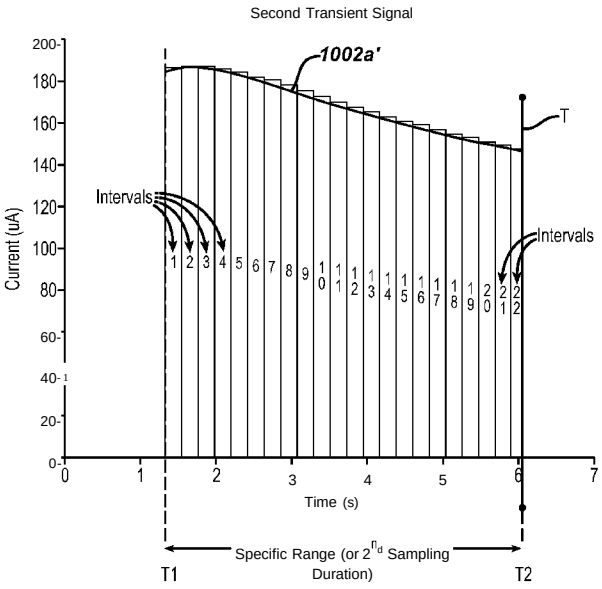

FIG. 7D

(57) **Abstract:** Various embodiments that allow for a more accurate analyte concentration by determining at least one physical characteristic, particularly hematocrit, of the blood sample containing the analyte, particularly glucose, and deriving a specific sampling time based on a relationship between the physical characteristic and sampling time so that the analyte concentration can be determined with greater accuracy with the specific sampling time point.

WO 2013/098564 A1

TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

Accurate Analyte Measurements for Electrochemical Test Strip Based on Multiple Discrete Measurements Defined by Sensed Physical Characteristic(s) of the Sample Containing the Analyte

PRIORITY

[0001] This application claims the benefits of priority of prior filed US Provisional Patent Application Serial Nos. 61/581,087 (Attorney Docket No. DDI5220USPSP); 61/581,089 (Attorney Docket No. DDI5220USPSP1); 61/581,099 (Attorney Docket No. DDI5220USPSP2); and 61/581,100 (Attorney Docket No. DDI5221USPSP), all filed on the same day of December 29, 2011, and US Provisional Patent Application Serial No. 61/654,013 (Attorney Docket No. DDI5228USPSP), filed on 31st May 2012, and all the prior applications are hereby incorporated by reference as if fully set forth herein.

BACKGROUND

[0002] Electrochemical glucose biosensors, such as those used in the OneTouch® Ultra® whole blood testing kit, which is available from LifeScan, Inc., are designed to measure the concentration of glucose in a blood sample from patients with diabetes. The measurement of glucose can be based on the selective oxidation of glucose by the enzyme glucose oxidase (GO). The reactions that can occur in a glucose biosensor are summarized below in Equations 1 and 2.

Eq. 1 $\text{Glucose} + GO_{(ox)} \rightarrow \text{Gluconic Acid} + GO_{(red)}$

Eq. 2 $GO_{(red)} + 2\,Fe(CN)_6^{3-} \rightarrow GO_{(ox)} + 2\,Fe(CN)_6^{4-}$

[0003] As illustrated in Equation 1, glucose is oxidized to gluconic acid by the oxidized form of glucose oxidase ($GO_{(ox)}$). It should be noted that $GO_{(ox)}$ may also be referred to as an "oxidized enzyme." During the reaction in Equation 1, the oxidized enzyme $GO_{(ox)}$ is converted to its reduced state, which is denoted as $GO_{(red)}$ (i.e., "reduced enzyme"). Next, the reduced enzyme $GO_{(red)}$ is re-oxidized back to $GO_{(ox)}$ by reaction with $Fe(CN)_6^{3-}$

(referred to as either the oxidized mediator or ferricyanide) as illustrated in Equation 2. During the re-generation of $GO_{(red)}$ back to its oxidized state $GO_{(ox)}$, $Fe(CN)_6^{3-}$ is reduced to $Fe(CN)_6^{4-}$ (referred to as either reduced mediator or ferrocyanide).

[0004] When the reactions set forth above are conducted with a test signal applied between two electrodes, a test current can be created by the electrochemical re-oxidation of the reduced mediator at the electrode surface. Thus, since, in an ideal environment, the amount of ferrocyanide created during the chemical reaction described above is directly proportional to the amount of glucose in the sample positioned between the electrodes, the test current generated would be proportional to the glucose content of the sample. A mediator, such as ferricyanide, is a compound that accepts electrons from an enzyme such as glucose oxidase and then donates the electrons to an electrode. As the concentration of glucose in the sample increases, the amount of reduced mediator formed also increases; hence, there is a direct relationship between the test current, resulting from the re-oxidation of reduced mediator, and glucose concentration. In particular, the transfer of electrons across the electrical interface results in the flow of a test current (2 moles of electrons for every mole of glucose that is oxidized). The test current resulting from the introduction of glucose can, therefore, be referred to as a glucose current.

[0005] Electrochemical biosensors may be adversely affected by the presence of certain blood components that may undesirably affect the measurement and lead to inaccuracies in the detected signal. This inaccuracy may result in an inaccurate glucose reading, leaving the patient unaware of a potentially dangerous blood sugar level, for example. As one example, the blood hematocrit level (i.e. the percentage of the amount of blood that is occupied by red blood cells) can erroneously affect a resulting analyte concentration measurement.

[0006] Variations in a volume of red blood cells within blood can cause variations in glucose readings measured with disposable electrochemical biosensors. Typically, a negative bias (i.e., lower calculated analyte concentration) is observed at high hematocrit, while a positive bias (i.e., higher calculated analyte concentration) is observed at low hematocrit. At high hematocrit, for example, the red blood cells may impede the reaction of enzymes and electrochemical mediators, reduce the rate of chemistry dissolution since there is less plasma volume to solvate the chemical reactants, and slow diffusion of the

mediator. These factors can result in a lower than expected glucose reading as less current is produced during the electrochemical process. Conversely, at low hematocrit, fewer red blood cells may affect the electrochemical reaction than expected, and a higher measured current can result. In addition, the blood sample resistance is also hematocrit dependent, which can affect voltage and/or current measurements.

[0007] Several strategies have been used to reduce or avoid hematocrit based variations on blood glucose. For example, biosensors have been designed to incorporate meshes to remove red blood cells from the samples, or have included various compounds or formulations designed to increase the viscosity of red blood cells and attenuate the effect of low hematocrit on concentration determinations. Other test strips have included lysis agents and systems configured to determine hemoglobin concentration in an attempt to correct for the effects of hematocrit. Further, biosensors have been configured to measure hematocrit by measuring an electrical response of the fluid sample via alternating current signals or change in optical variations after irradiating the blood sample with light, or measuring hematocrit based on a function of sample chamber fill time. A common technique of the strategies involving detection of hematocrit is to use the measured hematocrit value to correct or change the measured analyte concentration, which technique is generally shown and described in the following respective US Patent Application Publication Nos. 2010/0283488; 2010/0206749; 2009/0236237; 2010/0276303; 2010/0206749; 2009/0223834; 2008/0083618; 2004/0079652; 2010/0283488; 2010/0206749; 2009/0194432; or US Patent Nos., 7,972,861 and 7,258,769, all of which are incorporated by reference herein to this application.

SUMMARY OF THE DISCLOSURE

[0008] Applicant has provided various embodiments of a technique to allow for improved glucose measurement using a relationship between sampling time point and hematocrit to derive or calculate a specific sampling time point that can be used to calculate a more accurate analyte concentration from an electrochemical biosensor. This newly provided technique does not rely on correction(s) or modification(s) to be made to an analyte measurement, thereby reducing test time while at the same time improving accuracy.

[0009] In a first aspect, a method of determining an analyte concentration from a physiological sample with a biosensor is provided. The biosensor has at least two electrodes and a reagent disposed on at least one electrode of the electrodes. The method can be achieved by: depositing a physiological sample on any one of the at least two electrodes to start an analyte test sequence; applying a first signal to the sample to derive a physical characteristic of the sample; driving a second signal to the sample for a first sampling time duration that overlaps with the test sequence to obtain a first transient signal output from the sample, the first transient signal correlated to both time and magnitude during the first sampling time duration; extracting a specific sampling time during the test sequence in the first sampling time duration based on the physical characteristic of the sample; defining a second sampling time duration based on the specific sampling time such that the second sampling time duration overlaps the first sampling time duration; obtaining from the first transient signal a second transient signal referenced with respect to the second sampling time duration; dividing the second transient signal into discrete intervals with respect to the second sampling time duration; deriving respective magnitudes of the second transient signal at discrete selected intervals in the second sampling time duration; and determining an analyte concentration based on respective magnitudes of the second transient signal at the discrete selected time intervals.

[0010] In a second aspect, a method of determining an analyte concentration from a physiological sample with a biosensor is provided. The biosensor has at least two electrodes and a reagent disposed on at least one electrode of the electrodes. The method can be achieved by: depositing a physiological sample on any one of the at least two electrodes to start an analyte test sequence; applying a first signal to the sample to derive a physical characteristic of the sample; driving a second signal to the sample for a first sampling time duration that overlaps with the test sequence to obtain a first transient signal output from the sample, the first transient signal correlated to both time and magnitude during the first sampling time duration; extracting a specific sampling time during the test sequence in the first sampling time duration based on the physical characteristic of the sample; obtaining from the first transient signal a second transient signal over a second sampling time duration; deriving respective magnitudes of the second transient signal at selected intervals in the second sampling time duration; and determining an analyte

concentration based on respective magnitudes of the second transient signal at the selected time intervals.

[0011] In a third aspect, a method of determining an analyte concentration from a physiological sample with a biosensor is provided. The biosensor has at least two electrodes and a reagent disposed on at least one electrode of the electrodes. The method can be achieved by: depositing a physiological sample on any one of the at least two electrodes to start an analyte test sequence; applying a first signal to the sample to derive a physical characteristic of the sample; extracting a specific sampling time in a first sampling time duration; driving a second signal into the sample for the first sampling time duration; measuring or sampling a first transient signal output from the sample for the duration of the first sampling time duration; defining a specific range of time that includes the specific sampling time in the first sampling time duration; obtaining plural magnitudes of the first transient signal at respective discrete intervals within the specific range of time, and determining the analyte concentration based on the magnitudes of the first transient signal from the obtaining step.

[0012] In a fourth aspect, a method of determining an analyte concentration from a physiological sample with a biosensor is provided. The biosensor has at least two electrodes and a reagent disposed on at least one electrode of the electrodes. The method can be achieved by: depositing a physiological sample on any one of the at least two electrodes to start an analyte test sequence; applying a first signal to the sample to derive a physical characteristic of the sample; extracting a specific sampling time in a first sampling time duration; driving a second signal into the sample for the first sampling time duration; measuring or sampling a first transient signal output from the sample for the duration of the first sampling time duration; obtaining plural magnitudes of the first transient signal output at time intervals other than at about the specific sampling time; and deterring the analyte concentration based on the plural magnitudes of the first transient signal from the obtaining step.

[0013] In a fifth aspect, a method of determining an analyte concentration from a physiological sample with a biosensor is provided. The biosensor has at least two electrodes and a reagent disposed on at least one electrode of the electrodes. The method can be achieved by: depositing a physiological sample on any one of the at least two

electrodes to start an analyte test sequence for each of a plurality of the biosensors; applying a first signal to the sample to derive a physical characteristic of the sample for each of a plurality of the biosensors; extracting a specific sampling time in a first sampling time duration for each of a plurality of the biosensors; driving a second signal into the sample for the first sampling time duration for each of a plurality of the biosensors; measuring or sampling a first transient signal output from the sample for the duration of the first sampling time duration for each of a plurality of the biosensors; defining a specific range of time that includes the specific sampling time in the first sampling time duration for each of a plurality of the biosensors; obtaining plural magnitudes of the first transient signal at respective discrete intervals within the specific range of time for each of a plurality of the biosensors, and determining the analyte concentration for each of the plurality of the biosensors based on the magnitudes of the first transient signal from the obtaining step such that an error between a plurality of analyte concentrations determined by the determining step for each of the plurality of the biosensors is less than ± 15% as compared to referential value at each of 30%, 42%, and 55% hematocrits.

[0014] For these aspects, the following features may also be utilized in various combinations. For example, the specific range of time may include magnitudes of first transient signal measured before the specific sampling time; the step of extracting the specific sampling time may include calculating a defined specific sampling time in the first sampling time duration based on the physical characteristic of the sample; the calculating step for the defined specific sampling time may include utilizing an equation of the form:

$$SpecificSamplingTime = x_1 H^{x_2} + x_3$$

where

"SpecificSamplingTime" is designated as a time point from the start of the test sequence at which to sample the output signal of the biosensor,

H represents physical characteristic of the sample;

x_i is about 4.3e5, or is equal to 4.3e5, or is equal to 4.3e5 +/- 10%, 5% or 1% of the numerical value provided hereof;

x_2 is about (—)3.9, or is equal to -3.9, or is equal to -3.9 +/- 10%, 5% or 1% of the numerical value provided hereof; and

x_3 is about 4.8, or is equal to 4.8, or is equal to 4.8 +/- 10%, 5% or 1% of the numerical value provided herein.

[0015] With reference to these aspects, the following features may also be utilized in various combinations with these aspects. For example, the step of defining the second sampling time duration may include obtaining an absolute value of a difference between the defined specific sampling time and a predetermined time point to define a start time (Tl) and an end time (T2) approximately equal to the specific sampling time point, and the first sampling time duration may include about 10 seconds or less from the step of depositing the sample; the step of obtaining further may include defining a second sampling time duration that overlaps the first sampling time duration and includes a portion of the first transient signal and its magnitudes with respect to time of the second sampling time duration, wherein the portion is designated as a second transient signal; the step of obtaining the second transient signal may include extracting from the first transient signal a portion of the first transient signal that is designated as a second transient signal that is within the second sampling time duration; the deriving of respective magnitudes of the second transient signal at discrete selected time intervals may include calculating a magnitude of the second transient signal during each selected time intervals; the dividing may include dividing the second transient signal into at least 22 intervals in sequence starting from interval one at about the start time to interval twenty-two at about the end time.

[0016] As with other features, the following features may also be utilized in combination with these aforementioned aspects. For example, the determination of analyte concentration may be obtained by utilizing an equation of the form:

$$G = \frac{\left(\frac{|I_3|}{|I_4|}\right)^{x_1} \times \left(\frac{|I_2|+x_4|I_5|-x_5|I_1|}{|I_2|+x_4|I_5|}|I_5|\right)-x_2}{x_3}$$

where:

G is representative of analyte concentration;

I_1 ≈ magnitude of second transient signal at interval 17, or I_1 = magnitude of second transient signal at interval 17, or I_1 = magnitude of second transient signal at interval 17, +/- 10%, 5% or 1%;

I_2 ≈ magnitude of second transient signal at interval 13, or I_2 = magnitude of second transient signal at interval 13, or I_2 = magnitude of second transient signal at interval 13, +/- 10%, 5% or 1%;

I_3 ≈ magnitude of second transient signal at interval 5, or I_3 = magnitude of second transient signal at interval 5, or I_3 = magnitude of second transient signal at interval 5, +/- 10%, 5% or 1%;

I_4 ≈ magnitude of second transient signal at interval 3, I_4 = magnitude of second transient signal at interval 3, or I_4 = magnitude of second transient signal at interval 3, +/- 10%, 5% or 1%;

I_5 ≈ magnitude of second transient signal at interval 22; I_5 = magnitude of second transient signal at interval 22, or I_5 = magnitude of second transient signal at interval 22, +/- 10%, 5% or 1%

x_i «0.75, x_i =0.75, or x_i =0.75 +/- 10%, 5% or 1%;

x_2 «337.27, x_2 =337.27, or x_2 =337.27 +/- 10%, 5% or 1%;

x_3 ≈ (—) 16.81, x_3 = (—) 16.81, or x_3 = (—) 16.81 +/- 10%, 5% or 1%;

x_4 «1.41, x_4 =1.41, or x_4 =1.41 +/- 10%, 5% or 1%; and

x_5 ~2.67, x_5 =2.67, or x_5 =2.67 +/- 10%, 5% or 1%;

or the determination of analyte concentration may be obtained by utilizing an equation of the form:

$$G = \frac{x_1(|I_1|)^{\left(x_2 - \frac{x_3}{|I_2|}\right)} - x_4}{x_5}$$

where:

G is representative of analyte concentration;

I_i ≈ magnitude of second transient signal at interval 11, I_1 = magnitude of second

transient signal at interval 11, or I_1 = magnitude of second transient signal at interval 11, +/- 10%, 5% or 1%;

$I_2 \approx$ magnitude of second transient signal at interval 7, I_2 = magnitude of second transient signal at interval 7, or I_2 = magnitude of second transient signal at interval 7, +/- 10%, 5% or 1%;

x_i-0.59, x_i=0.59, or x_i=0.59 +/- 10%, 5% or 1%;

x_2~2.51, x_2=2.51, orx_2=2.51 +/- 10%, 5% or 1%;

x_3~{—)12.74, x_3={—)12.74, or x_3=(—)12.74 +/- 10%, 5% or 1%;

x_4~ {—) 188.31, x_4= (—) 188.31, or x_4= {—) 188.31 +/- 10%, 5% or 1%; and

x_5~9.2, x_5=9.2, or x_5=9.2 +/- 10%, 5% or 1%;

or the determination of analyte concentration may be obtained by utilizing an equation of the form:

$$G = \frac{x_1 ln\left(x_2 \frac{|I_1|}{|I_2|}\right)^{x_3} |I_3|^{x_4} - x_5}{x_6}$$

where

G is representative of analyte concentration;

$Ii \approx$ magnitude of second transient signal at interval 20, Ii = magnitude of second transient signal at interval 20, or I_1 = magnitude of second transient signal at interval 20, +/- 10%, 5% or 1%;

$I_2 \approx$ magnitude of second transient signal at interval 22, I_2 = magnitude of second transient signal at interval 22, or I_2 = magnitude of second transient signal at interval 22, +/- 10%, 5% or 1%;

$I_3 \approx$ magnitude of second transient signal at interval 19, I_3 = magnitude of second transient signal at interval 19, or $I3$ = magnitude of second transient signal at interval 19, +/- 10%, 5% or 1%;

x,~20.15, x,=20.15, orx,=20.15 +/- 10%, 5% or 1%;

x^l.0446, x_2=1.0446, or x_2=1.0446 +/- 10%, 5% or 1%;

x_3~0.95, x_3=0.95, orx $_3$=0.95 +/- 10%, 5% or 1%;

x_4-1.39, x_4=\39, orx $_4$=1.39 +/- 10%, 5% or 1%;

x_5≈(—)0.71, x_5=(—)0.71, orx $_5$=(—)0.71 +/- 10%, 5% or 1%; and

x_6~0.11, x_6=0.1 1, orx $_6$=0.1 1 +/- 10%, 5% or 1%;

or the determination of analyte concentration may be obtained by utilizing an equation of the form:

$$G = \frac{x_3 \left|\frac{I_1}{I_2}\right|^{\left(x_1 - x_2\left|\frac{I_3}{I_4}\right|\right)} \times |I_5| - x_5}{x_4}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 5, *Ii* = magnitude of second transient signal at interval 5, or *Ii* = magnitude of second transient signal at interval 5, +/- 10%, 5% or 1%;

I_2 ≈ magnitude of second transient signal at interval 1, 1_2 = magnitude of second transient signal at interval 1, or I_2 = magnitude of second transient signal at interval 1, +/- 10%, 5% or 1%;

I_3 ≈ magnitude of second transient signal at interval 2, 1_3 = magnitude of second transient signal at interval 2, or I_3 = magnitude of second transient signal at interval 2, +/- 10%, 5% or 1%;

I_4 ≈ magnitude of second transient signal at interval 10, I_4 = magnitude of second transient signal at interval 10, or I_4 = magnitude of second transient signal at interval 10, +/- 10%, 5% or 1%;

I_5 ≈ magnitude of second transient signal at interval 22, 1_5 = magnitude of second transient signal at interval 22, 1_5 = magnitude of second transient signal at interval 22, +/- 10%, 5% or 1%;

x_i-0.70, x,=0.70, or $x_{i=}$0.70 +/- 10%, 5% or 1%,

x_2≈0.49, x_2=0A9, or x_2=0.49 +/- 10%, 5% or 1%,

x_3-28.59, x_3=28.59, orx_3=28.59 +/- 10%, 5% or 1%,

x_4≈0.7, x_4=0.7, or x_4=0.7 +/- 10%, 5% or 1%, and

x_5~15.51, x_5=15.51, orx_5=15.51 +/- 10%, 5% or 1%;

or the determination of analyte concentration may be obtained by utilizing an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^2+x_3|I_3|+x_4}{x_5|I_4|+x_6}\right)-x_7}{x_8}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 19, *Ii* = magnitude of second transient signal at interval 19, or I_1 = magnitude of second transient signal at interval 19, +/- 10%, 5% or 1%;

I_2 ≈ magnitude of second transient signal at interval 16, I_2 = magnitude of second transient signal at interval 16, I_2 = magnitude of second transient signal at interval 16, +/- 10%, 5% or 1%;

1_3 ≈ magnitude of second transient signal at interval 11, *I*? = magnitude of second transient signal at interval 11, or I_3 = magnitude of second transient signal at interval 11, +/- 10%, 5% or 1%;

1_4 ≈ magnitude of second transient signal at interval 5, 1_4 = magnitude of second transient signal at interval 5, or I_4 = magnitude of second transient signal at interval 5, +/- 10%, 5% or 1%;

$x_{i\sim(—}$)1.68, $x_{i=(—}$)1.68, orXi=(—)1.68 +/- 10%, 5% or 1%;

x_2~0.95, x_2=0.95, orx_2=0.95 +/- 10%, 5% or 1%;

x_3≈(—)4.97, $x_{3=(—}$)4.97, or x_3=(—)4.97 +/- 10%, 5% or 1%;

x_4~6.29, x_4=6.29, or x_4=6.29 +/- 10%, 5% or 1%;

x_5~3.08, x_5=3.08, or x_5=3.08 +/- 10%, 5% or 1%;

x_6~(—)5.84, x_6=(—)5.84, or x_6=(—)5.84 +/- 10%, 5% or 1%;

x_7~(—)0.47, x_7=(—)0.47, or x_7={—)0.47 +/- 10%, 5% or 1%;

xs~0.01, xs=0.01, orx_s=0.01 +/- 10%, 5% or 1%;

or the determination of analyte concentration may be obtained by utilizing an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^3 + x_3|I_3|^2 + x_4|I_3| + x_5}{x_6|I_4|^2 + x_7|I_4| + x_8}\right) - x_9}{x_{10}}$$

where:

G is representative of analyte concentration;

11 ≈ magnitude of second transient signal at interval 16, *Ii* = magnitude of second transient signal at interval 16, or I_1 = magnitude of second transient signal at interval 16, +/- 10%, 5% or 1%;

12 ≈ magnitude of second transient signal at interval 5, *12* = magnitude of second transient signal at interval 5, or *I2* = magnitude of second transient signal at interval 5, +/- 10%, 5% or 1%;

13 ≈ magnitude of second transient signal at interval 12, *I3* = magnitude of second transient signal at interval 12, or I_{13} = magnitude of second transient signal at interval 12, +/- 10%, 5% or 1%;

I_4 ≈ magnitude of second transient signal at interval 14, I_4 = magnitude of second transient signal at interval 14, or I_4 = magnitude of second transient signal at interval 14, +/- 10%, 5% or 1%;

Xi~1.18, Xi=1.18, orXi=1.18 +/- 10%, 5% or 1%;

x_2-0.97, x_2=0.97, or x_2=0.97 +/- 10%, 5% or 1%;

*x3~(—)*11.32, *x3=(—)*11.32, orx3=(—)11.32 +/- 10%, 5% or 1%;

x_4~38.76, x_4=38.76, orx_4=38.76 +/- 10%, 5% or 1%;

x_5~(—)39.32, x_5=(—)39.32, or x_5=(—)39.32 +/- 10%, 5% or 1%;

x_6~0.0928, x_6=0.0928, or x_6=0.0928 +/- 10%, 5% or 1%;

x_7~(—)0.85, x_7=(—)0.85, or x_7=(—)0.85 +/- 10%, 5% or 1%;

xs~1.75, xs=1.75, or x_s=1.75 +/- 10%, 5% or 1%;

x_9~(—)9.38, x_9=(—)9.38, or x_9=(—)9.38 +/- 10%, 5% or 1%; and

Xio-0.25, x_{i0}=0.25, or x_{i0}=0.25 +/- 10%, 5% or 1%.

[0017] In any of these features, the magnitude of the second transient signal at each of the plurality of discrete intervals may include an average magnitude of the signal sampled throughout each interval; the applying of the first signal and the driving of the second signal may be in sequential order; the applying of the first signal may overlap with the driving of the second signal; the applying of the first signal may include directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal; the applying of the first signal may include directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal; the physical characteristic may include hematocrit and the analyte may include glucose; the physical characteristic may include at least one of viscosity, hematocrit, temperature, or density of the sample; the directing may include driving first and second alternating signal at different respective frequencies in which a first frequency may include a frequency than the second frequency; the first frequency may be at least one order of magnitude lower than the second frequency; the first frequency may include any frequency in the range of about 10kHz to about 250kHz, or about lOkHz to about 90kHz; the obtaining may include extracting from the first transient signal a second transient signal referenced with respect to the second sampling time duration; the obtaining may include removing signals from the first transient signals that are outside of the second sampling time duration to leave the second transient signal within the second sampling time duration; the deriving may include storing magnitudes of the second transient signal for each discrete intervals in the second sampling time duration.

[0018] In a fifth aspect, an analyte measurement system is provided that includes a biosensor and an analyte meter. The biosensor includes a substrate, a plurality of electrodes connected to respective electrode connectors. The analyte meter includes a

housing, a biosensor port connector configured to connect to the respective electrode connectors of the biosensor. The meter also includes a microprocessor in electrical communication with the biosensor port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence. The microprocessor is configured to: (a) apply a first signal to the plurality of electrodes so that a physical characteristic of the sample is derived to provide a specific sampling time, (b) apply a second signal to the plurality of electrodes, (c) measure a first transient output signal from the plurality of electrodes; (d) extract a second transient output signal from the first output signal; (e) determine a magnitude of the second transient output signal over a plurality of discrete time intervals; and (f) calculate the analyte concentration from the magnitudes of the second transient output signal at selected intervals of the plurality of discrete time intervals.

[0019] In a sixth aspect, an analyte measurement system is provided that includes a test strip and an analyte meter. The test strip includes a substrate, a plurality of electrodes disposed on the substrate and connected to respective electrode connectors. The analyte meter includes a housing, a test strip port connector configured to connect to the respective electrode connectors of the test strip. The meter also includes a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence. The microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence, the microprocessor is configured to: (a) apply a first signal to the plurality of electrodes so that a physical characteristic of the sample is derived to provide a specific sampling time, (b) apply a second signal to the plurality of electrodes, (c) measure a first transient output signal from the plurality of electrodes; (d) extract a second transient output signal from the first output signal; (e) determine a magnitude of the second transient output signal over a plurality of discrete time intervals; and (f) calculate the analyte concentration from the magnitudes of the second transient output signal at selected intervals of the plurality of discrete time intervals to annunciate the analyte concentration within about 10 seconds of a start of the test sequence.

[0020] In a seventh aspect, an analyte meter is provided that includes a housing and a test strip port connector configured to connect to respective electrode connectors of a test strip. The meter also includes a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from a plurality of electrodes of the test strip during a test sequence. The microprocessor is configured to: (a) apply a first signal to the plurality of electrodes so that a physical characteristic of the sample is derived to provide a specific sampling time, (b) apply a second signal to the plurality of electrodes, (c) measure a first transient output signal from the plurality of electrodes; (d) extract a second transient output signal from the first output signal; (e) determine a magnitude of the second transient output signal over a plurality of discrete time intervals; and (f) calculate the analyte concentration from the magnitudes of the second transient output signal at selected intervals of the plurality of discrete time intervals.

[0021] In any of the fifth, sixth and seventh aspects, the following features can also be utilized in combination with the aforementioned aspects. For example, the plurality of electrodes may include at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration; the at least two electrodes and the at least two other electrodes may be disposed in the same chamber provided on the substrate; the at least two electrodes and the at least two other electrodes may be disposed in different chambers provided on the substrate; the at least two electrodes may comprise two electrodes to measure the physical characteristic and the analyte concentration; the plurality of electrodes may include two electrodes to measure the physical characteristic and the analyte concentration; all of the electrodes may be disposed on the same plane defined by the substrate; a reagent may be disposed proximate the at least two other electrodes and no reagent disposed on the at least two electrodes; the plurality of discrete time intervals may comprise at least 22 discrete time intervals, the specific sampling time may be calculated using an equation of the form:

$$SpecificSamplingTime = x_1 H^{x_2} + x_3$$

where

"SpecificSamplingTime" is designated as a time point from the start of the test sequence at which to sample the output signal of the biosensor,

H represents physical characteristic of the sample;

x_1 represents about 4.3e5, or is equal to 4.3e5, or is equal to 4.3e5 +/- 10%, 5% or 1% of the numerical value provided hereof;

x_2 represents about (—)3.9, or is equal to -3.9, or is equal to -3.9 +/- 10%, 5% or 1% of the numerical value provided hereof; and

x_3 represents about 4.8, or is equal to -3.9, or is equal to -3.9 +/- 10%, 5% or 1% of the numerical value provided hereof.

[0022] As indicated earlier, other features can also be used with the fifth, sixth and seventh aspects. For example, the microprocessor may calculate the analyte concentration with an equation of the form:

$$G = \frac{\left(\frac{|I_3|}{|I_4|}\right)^{x_1} \times \left(\frac{|I_2|+x_4|I_5|-x_5|I_1|}{|I_2|+x_4|I_5|}|I_5|\right)-x_2}{x_3}$$

where:

G is representative of analyte concentration;

$I_1 \simeq$ magnitude of second transient signal at interval 17, or I_1 = magnitude of second transient signal at interval 17, or I_1 = magnitude of second transient signal at interval 17, +/- 10%, 5% or 1%;

$I_2 \simeq$ magnitude of second transient signal at interval 13, or I_2 = magnitude of second transient signal at interval 13, or I_2 = magnitude of second transient signal at interval 13, +/- 10%, 5% or 1%;

$I_3 \approx$ magnitude of second transient signal at interval 5, or I_3 = magnitude of second transient signal at interval 5, or I_3 = magnitude of second transient signal at interval 5, +/- 10%, 5% or 1%;

$I_4 \approx$ magnitude of second transient signal at interval 3, I_4 = magnitude of second transient signal at interval 3, or I_4 = magnitude of second transient signal at interval 3, +/- 10%, 5% or 1%;

$I_5 \simeq$ magnitude of second transient signal at interval 22; I_5 = magnitude of second

transient signal at interval 22, or I_5 = magnitude of second transient signal at interval 22, +/- 10%, 5% or 1%

x_1«0.75, x_1=0.75, or x_1=0.75 +/- 10%, 5% or 1%;

x_2«337.27, x_2=337.27, or x_2=337.27 +/- 10%, 5% or 1%;

x_3≈ (—) 16.81, x_3= (—) 16.81, or x_3= (—) 16.81 +/- 10%, 5% or 1%;

x_4«1.41, x_4=1.41, or x_4=1.41 +/- 10%, 5% or 1%; and

x_5-2.67, x_5=2.67, or x_5=2.67 +/- 10%, 5% or 1%;

[0023] As another example, the microprocessor may also calculate the analyte concentration with an equation of the form:

$$G = \frac{x_1(|I_1|)^{\left(x_2-\frac{x_3}{|I_2|}\right)}-x_4}{x_5}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 11, /; = magnitude of second transient signal at interval 11, or $/_1$ = magnitude of second transient signal at interval 11, +/- 10%, 5% or 1%;

I_2 ≈ magnitude of second transient signal at interval 7, I_2 = magnitude of second transient signal at interval 7, or I_2 = magnitude of second transient signal at interval 7, +/- 10%, 5% or 1%;

x_1-0.59, x_1=0.59, or x_1=0.59 +/- 10%, 5% or 1%;

x_2~2.51 , x_2=2.51, orx_2=2.51 +/- 10%, 5% or 1%;

x_3~{—)12.74, x_3={—)12.74, or x_3=(—)12.74 +/- 10%, 5% or 1%;

x_4~ {—) 188.31, x_4= (—) 188.31, or x_4= {—) 188.31 +/- 10%, 5% or 1%; and

x_5~9.2, x_5=9.2, or x_5=9.2 +/- 10%, 5% or 1%

[0024] In an alternative example, the microprocessor may calculate the analyte concentration with an equation of the form:

$$G = \frac{x_1 ln\left(x_2 \frac{|I_1|}{|I_2|}\right)^{x_3} |I_3|^{x_4} - x_5}{x_6}$$

where G is representative of analyte concentration;

$Ii \approx$ magnitude of second transient signal at interval 20, Ii = magnitude of second transient signal at interval 20, or I_1 = magnitude of second transient signal at interval 20, +/- 10%, 5% or 1%;

$I_2 \approx$ magnitude of second transient signal at interval 22, I_2 = magnitude of second transient signal at interval 22, or I_2 = magnitude of second transient signal at interval 22, +/- 10%, 5% or 1%;

$I_3 \sim$ magnitude of second transient signal at interval 19, I_3 = magnitude of second transient signal at interval 19, or I_3 = magnitude of second transient signal at interval 19, +/- 10%, 5% or 1%;

x,~20.15, x_i=20.15, orx_i=20.15 +/- 10%, 5% or 1%;

x^l.0446, x_2=1.0446, or x_2=1.0446 +/- 10%, 5% or 1%;

x_3~0.95, x_3=0.95, orx_3=0.95 +/- 10%, 5% or 1%;

x_4~1.39, x_4=*l.39*, orx_4=1.39 +/- 10%, 5% or 1%;

x_5≈(—)0.71, x_5=(—)0.71, orx_5=(—)0.71 +/- 10%, 5% or 1%; and

x_6~0. 11, x_6=0. 11, or x_6=0. 11 +/- 10%, 5% or 1%;

[0025] Alternatively, the microprocessor may calculate the analyte concentration with an equation of the form:

$$G = \frac{x_3 \left|\frac{I_1}{I_2}\right|^{\left(x_1 - x_2 \left|\frac{I_3}{I_4}\right|\right)} \times |I_5| - x_5}{x_4}$$

where:

G is representative of analyte concentration

$Ii \approx$ magnitude of second transient signal at interval 5, Ii = magnitude of second transient signal at interval 5, or Ii = magnitude of second transient signal at interval 5, +/- 10%, 5% or 1%;

$I_2 \approx$ magnitude of second transient signal at interval 1, $I_2 =$ magnitude of second transient signal at interval 1, or I_2 = magnitude of second transient signal at interval 1, +/- 10%, 5% or 1%;

$I_3 \approx$ magnitude of second transient signal at interval 2, $I_3 =$ magnitude of second transient signal at interval 2, or $I_3 =$ magnitude of second transient signal at interval 2, +/- 10%, 5% or 1%;

$I_4 \simeq$ magnitude of second transient signal at interval 10, $I_4 =$ magnitude of second transient signal at interval 10, or $I_4 =$ magnitude of second transient signal at interval 10, +/- 10%, 5% or 1%;

$I_5 \approx$ magnitude of second transient signal at interval 22, $I_5 =$ magnitude of second transient signal at interval 22, $I_5 =$ magnitude of second transient signal at interval 22, +/- 10%, 5% or 1%;

x_i-0.70, x_i=0.70, or x_i=0.70 +/- 10%, 5% or 1%,

x_2-0.49, x_2=0.49, or x_2=0.49 +/- 10%, 5% or 1%,

x_3-28.59, x_3=28.59, or x_3=28.59 +/- 10%, 5% or 1%,

x_4~0.1, x_4=0.7, or x_4=0.7 +/- 10%, 5% or 1%, and

x_5~15.51, x_5=15.51, or x_5=15.51 +/- 10%, 5% or 1%;

or the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^2 + x_3|I_3| + x_4}{x_5|I_4| + x_6}\right) - x_7}{x_8}$$

where:

G is representative of analyte concentration;

I_i ≈ magnitude of second transient signal at interval 19, I_i = magnitude of second transient signal at interval 19, or I_1 = magnitude of second transient signal at interval 19, +/- 10%, 5% or 1%;

I_2 ≈ magnitude of second transient signal at interval 16, I_2 = magnitude of second transient signal at interval 16, I_2 = magnitude of second transient signal at interval 16, +/- 10%, 5% or l%;

I_3 ≈ magnitude of second transient signal at interval 11, I_3 = magnitude of second transient signal at interval 11, or I_3 = magnitude of second transient signal at interval 11, +/- 10%, 5% or 1%;

I_4 ≈ magnitude of second transient signal at interval 5, I_4 = magnitude of second transient signal at interval 5, or I_4 = magnitude of second transient signal at interval 5, +/- 10%, 5% or 1%;

x_1~(—)1.68, x_1=(—)1.68, orx_1=(—)1.68 +/- 10%, 5% or 1%;

x_2~0.95, x_2=0.95, orx_2=0.95 +/- 10%, 5% or 1%;

x_3~(—)4.97, x_3=(—)4.97, or x_3=(—)4.97 +/- 10%, 5% or 1%;

x_4~6.29, x_4=6.29, or x_4=6.29 +/- 10%, 5% or 1%;

x_5~3.08, x_5=3.08, orx_5=3.08 +/- 10%, 5% or 1%;

x_6~(—)5.84, x_6=(—)5.84, or x_6=(—)5.84 +/- 10%, 5% or 1%;

x_7~(—)0.47, x_7=(—)0.47, or x_7=(—)0.47 +/- 10%, 5% or 1%;

x_s~0.01, x_s=0.01, orx_s=0.01 +/- 10%, 5% or 1%;

or the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^3 + x_3|I_3|^2 + x_4|I_3| + x_5}{x_6|I_4|^2 + x_7|I_4| + x_8}\right) - x_9}{x_{10}}$$

where:

G is representative of analyte concentration;

I_1 ≈ magnitude of second transient signal at interval 16, Ii = magnitude of second transient signal at interval 16, or I_1 = magnitude of second transient signal at interval 16, +/- 10%, 5% or 1%;

I_2 ≈ magnitude of second transient signal at interval 5, I_2 = magnitude of second transient signal at interval 5, or I_2 = magnitude of second transient signal at interval 5, +/- 10%, 5% or 1%;

I_3 ≈ magnitude of second transient signal at interval 12, I_3 = magnitude of second transient signal at interval 12, or I_3 = magnitude of second transient signal at interval 12, +/- 10%, 5% or 1%;

I_4 ≈ magnitude of second transient signal at interval 14, I_4 = magnitude of second transient signal at interval 14, or I_4 = magnitude of second transient signal at interval 14, +/- 10%, 5% or 1%;

x_i~1.18, x_i=1.18, orx_i=1.18 +/- 10%, 5% or 1%;

x_2-0.97, x_2=0.97, or x_2=0.97 +/- 10%, 5% or 1%;

x_3~(—)11.32, x_3=(—)11.32, or x_3=(—)11.32 +/- 10%, 5% or 1%;

x_4-38.76, x_4=38.76, orx_4=38.76 +/- 10%, 5% or 1%;

x_5~(—)39.32, x_5=(—)39.32, or x_5=(—)39.32 +/- 10%, 5% or 1%;

x_6~0.0928, x_6=0.0928, or x_6=0.0928 +/- 10%, 5% or 1%;

x_7~(—)0.85, x_7=(—)0.85, orx_7=(—)0.85 +/- 10%, 5% or 1%;

xs~1.75, xs=1.75, orx_s=1.75 +/- 10%, 5% or 1%;

x_9~(—)9.38, x_9=(—)9.38, or x_9=(—)9.38 +/- 10%, 5% or 1%; and

x_{i0}-0.25, x_{i0}=0.25, or x_{i0}=0.25 +/- 10%, 5% or 1%.

[0026] Additional features can also be utilized with the fifth, sixth and seventh aspects. For example, the magnitude of the second transient signal at each of the plurality of discrete intervals may include an average magnitude of the signal sampled throughout each interval; an error between a plurality of analyte concentrations calculated by the microprocessor may be less than ±15% as compared to referential value at 30% hematocrits; an error between a plurality of analyte concentrations calculated by the microprocessor may be less than ±15% as compared to referential value at 42%

hematocrits; an error between a plurality of analyte concentrations calculated by the microprocessor may be less than ±15% as compared to referential value at 55% hematocrits.

[0027] These and other embodiments, features and advantages will become apparent to those skilled in the art when taken with reference to the following more detailed description of the exemplary embodiments of the disclosure in conjunction with the accompanying drawings that are first briefly described.

[0028] In any of the above aspects, the fluid/physiological sample may be blood. In any of the above aspects, the analyte may be glucose. In any of the above aspects, the physical characteristic may include at least one of viscosity, hematocrit, or density of the sample, or the physical characteristic may be hematocrit, wherein, optionally, the hematocrit level is between 30% and 55%. In any of the above aspects, the first and/or second signal may be an electrical signal. In particular, the alternating signal may be an alternating electrical signal. In any of the above aspects, where H represents, or is, the physical characteristic of the sample, it may be in the form of hematocrit. In any of the above aspects, the physical characteristic may be determined from a measured characteristic, such as the impedance or phase angle difference or offset between the input signal and the output signal from the sample.

[0029] In the aforementioned aspects of the disclosure, the steps of extracting, defining, obtaining, dividing, deriving, determining, calculating and/or storing (possibly in conjunction with an equation) may be performed be an electronic circuit or a processor. These steps may also be implemented as executable instructions stored on a computer readable medium; the instructions, when executed by a computer may perform the steps of any one of the aforementioned methods.

[0030] In additional aspects of the disclosure, there are computer readable media, each medium comprising executable instructions, which, when executed by a computer, perform the steps of any one of the aforementioned methods.

[0031] In additional aspects of the disclosure, there are devices, such as test meters or analyte testing devices, each device or meter comprising an electronic circuit or processor configured to perform the steps of any one of the aforementioned methods.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] The accompanying drawings, which are incorporated herein and constitute part of this specification, illustrate presently preferred embodiments of the disclosure, and, together with the general description given above and the detailed description given below, serve to explain features of the disclosure (wherein like numerals represent like elements), in which:

[0033] Figure 1 illustrates an analyte measurement system.

[0034] Figure 2A illustrates in simplified schematic form the components of the meter 200.

[0035] Figure 2B illustrates in schematic form the components of yet another variation of the components of the meter 200.

[0036] Figure 3A(1) illustrates the biosensor 100 of the system of Figure 1 in which there are two physical characteristic sensing electrodes upstream of the measurement electrodes.

[0037] Figure 3A(2) illustrates a variation of the test strip of Figure 3A(1) in which a shielding or grounding electrode is provided for proximate the entrance of the test chamber;

[0038] Figure 3A(3) illustrates a variation of the test strip of Figure 3A(2) in which a reagent area has been extended upstream to cover at least one of the physical characteristic sensing electrodes;

[0039] Figure 3A(4) illustrates a variation of test strip 100 of Figures 3A(1), 3A(2) and 3A(3) in which certain components of the test strip have been integrated together into a single unit;

[0040] Figure 3A(5) illustrates a plan view of the biosensor.

[0041] Figure 3A(6) illustrates a close-up plan view of the electrodes in the biosensor.

[0042] Figure 3B illustrates a variation of the biosensor of Figures 3A(l -6) in which one physical characteristic sensing electrode is disposed proximate the entrance and the other physical characteristic sensing electrode is at the terminal end of the test cell with the measurement electrodes disposed between the pair of physical characteristic sensing electrodes.

[0043] Figures 3C and 3D illustrate variations of Figures 3A(l-6) in which the physical characteristic sensing electrodes are disposed next to each other at the terminal end of the test chamber with the measurement electrodes upstream of the physical characteristic sensing electrodes.

[0044] Figures 3E and 3F illustrates a physical characteristic sensing electrodes arrangement similar to that of Figures 3A(l-6) in which the pair of physical characteristic sensing electrodes are proximate the entrance of the test chamber.

[0045] Figure 3G is a simplified, perspective, exploded view of an analytical biosensor according to an embodiment of the present disclosure;

[0046] Figure 3H is a simplified top view of the analytical biosensor of Figure 3G;

[0047] Figure 31 is a simplified cross-sectional side view of the analytical biosensor of Figure 3H taken along line A-A of Figure 3H;

[0048] Figure 3J is a simplified cross-sectional end view of the analytical biosensor of Figure 3H taken along line B-B of Figure 3H; and

[0049] Figure 3K is a simplified, perspective exploded view of an analytical test strip according to an embodiment of the present disclosure;

[0050] Figure 3L is a simplified top view of the electrically-insulating substrate and a portion of a first patterned conductor layer of an analytical biosensor of Figure 3K;

[0051] Figure 3M is a simplified top view of the first patterned spacer layer of the analytical biosensor of Figure 3K;

[0052] Figure 3N is a simplified top view of the second patterned spacer layer of the analytical biosensor of Figure 3K;

[0053] Figure 30 is a simplified cross-sectional side view of the analytical biosensor of Figure 3K taken along line A-A of Figures 2A;

[0054] Figure 3P is a simplified, perspective exploded view of an analytical test strip according to another embodiment of the present disclosure;

[0055] Figure 3Q is a simplified top view of the electrically insulating substrate and first patterned conductor layer of the analytical biosensor of Figure 3P;

[0056] Figure 3R is a simplified top view of a portion of a second patterned spacer layer and second patterned conductor layer of the analytical biosensor of Figure 3P;

[0057] Figure 3S is a simplified top view of a third patterned spacer layer of the analytical biosensor of Figure 3P;

[0058] Figure 3T is a simplified cross-sectional side view of the analytical biosensor of Figure 3P taken along line B-B of Figures 3Q.

[0059] Figure 4A illustrates a graph of time over applied potential to the biosensor of Figure 1.

[0060] Figure 4B illustrates a graph of time over output current from the biosensor of Figure 1.

[0061] Figure 5 illustrates a waveform applied to the test chamber and a waveform as measured from the test chamber to show a time delay between the waveforms.

[0062] Figure 6A illustrates a logic diagram of an exemplary method to achieve a more accurate analyte determination.

[0063] Figure 6B illustrates a variation on the logical process of Figure 6A.

[0064] Figure 7A illustrates output signal transients that are sampled during a test sequence duration for respective high, medium, and low glucose concentrations for each range of hematocrits at 30%, 42% and 55%.

[0065] Figure 7B illustrates the relationship between hematocrits and the time at which a magnitude of the transient signal is measured.

[0066] Figure 7C illustrates one transient signal output, i.e., a "first transient signal" from the transient signals of Figure 7B.

[0067] Figure 7D illustrates the extraction of a portion of the one transient signal output in Figure 7C and the exemplary timing intervals for measuring the magnitudes of this portion, characterized here as a "second transient signal."

[0068] Figure 7E illustrates the extracted signals of Figure 7B and shifted to the left so that the start time for each of the second transient signals is about zero.

[0069] Figure 8A illustrates data from test measurements conducted with the known technique which shows relatively high bias along with substantial variations in the bias with respect to upper and lower hematocrit values.

[0070] Figures 8B, 8C, 8D, 8E, 8F, and 8G illustrate data from test measurements conducted with variations of the exemplary technique herein such that the data show the

bias of less than ±15% for the hematocrit range of about 30% to about 55% while attainting relatively little variations in bias for hematocrits at extreme values.

MODES OF CARRYING OUT THE INVENTION

[0071] The following detailed description should be read with reference to the drawings, in which like elements in different drawings are identically numbered. The drawings, which are not necessarily to scale, depict selected embodiments and are not intended to limit the scope of the invention. The detailed description illustrates by way of example, not by way of limitation, the principles of the invention. This description will clearly enable one skilled in the art to make and use the invention, and describes several embodiments, adaptations, variations, alternatives and uses of the invention, including what is presently believed to be the best mode of carrying out the invention.

[0072] As used herein, the terms "about" or "approximately" for any numerical values or ranges indicate a suitable dimensional tolerance that allows the part or collection of components to function for its intended purpose as described herein. More specifically, "about" or "approximately" may refer to the range of values ±10% of the recited value, e.g. "about 90%" may refer to the range of values from 81% to 99%. As used herein, "an absolute value" of a difference refers to the magnitude of the difference, *i.e.* it is always positive. In addition, as used herein, the terms "patient," "host," "user," and "subject" refer to any human or animal subject and are not intended to limit the systems or methods to human use, although use of the subject invention in a human patient represents a preferred embodiment. As used herein, "oscillating signal" includes voltage signal(s) or current signal(s) that, respectively, change polarity or alternate direction of current or are multi-directional. Also used herein, the phrase "electrical signal" or "signal" is intended to include direct current signal, alternating signal or any signal within the electromagnetic spectrum. The terms "processor"; "microprocessor"; or "microcontroller" are intended to have the same meaning and are intended to be used interchangeably.

[0073] Figure 1 illustrates a test meter 200, for testing analyte (e.g., glucose) levels in the blood of an individual with a biosensor produced by the methods and techniques illustrated and described herein. Test meter 200 may include user interface inputs (206, 210, 214), which can be in the form of buttons, for entry of data, navigation of menus, and execution

of commands. Data can include values representative of analyte concentration, and/or information that are related to the everyday lifestyle of an individual. Information, which is related to the everyday lifestyle, can include food intake, medication use, the occurrence of health check-ups, general health condition and exercise levels of an individual. Test meter 200 can also include a display 204 that can be used to report measured glucose levels, and to facilitate entry of lifestyle related information.

[0074] Test meter 200 may include a first user interface input 206, a second user interface input 210, and a third user interface input 214. User interface inputs 206, 210, and 214 facilitate entry and analysis of data stored in the testing device, enabling a user to navigate through the user interface displayed on display 204. User interface inputs 206, 210, and 214 include a first marking 208, a second marking 212, and a third marking 216, which help in correlating user interface inputs to characters on display 204.

[0075] Test meter 200 can be turned on by inserting a biosensor 100 (or its variants 400, 500, or 600) into a strip port connector 220, by pressing and briefly holding first user interface input 206, or by the detection of data traffic across a data port 218. Test meter 200 can be switched off by removing biosensor 100 (or its variants 400, 500, or 600), pressing and briefly holding first user interface input 206, navigating to and selecting a meter off option from a main menu screen, or by not pressing any buttons for a predetermined time. Display 104 can optionally include a backlight.

[0076] In one embodiment, test meter 200 can be configured to not receive a calibration input for example, from any external source, when switching from a first test strip batch to a second test strip batch. Thus, in one exemplary embodiment, the meter is configured to not receive a calibration input from external sources, such as a user interface (such as inputs 206, 210, 214), an inserted test strip, a separate code key or a code strip, data port 218. Such a calibration input is not necessary when all of the test strip batches have a substantially uniform calibration characteristic. The calibration input can be a set of values ascribed to a particular test strip batch. For example, the calibration input can include a batch slope and a batch intercept value for a particular test strip batch. The calibrations input, such as batch slope and intercept values, may be preset within the meter as will be described below.

[0077] Referring to Figure 2A, an exemplary internal layout of test meter 200 is shown. Test meter 200 may include a processor 300, which in some embodiments described and illustrated herein is a 32-bit RISC microcontroller. In the preferred embodiments described and illustrated herein, processor 300 is preferably selected from the MSP 430 family of ultra-low power microcontrollers manufactured by Texas Instruments of Dallas, Texas. The processor can be bi-directionally connected via I/O ports 314 to a memory 302, which in some embodiments described and illustrated herein is an EEPROM. Also connected to processor 300 via I/O ports 214 are the data port 218, the user interface inputs 206, 210, and 214, and a display driver 320. Data port 218 can be connected to processor 300, thereby enabling transfer of data between memory 302 and an external device, such as a personal computer. User interface inputs 206, 210, and 214 are directly connected to processor 300. Processor 300 controls display 204 via display driver 320. Memory 302 may be pre-loaded with calibration information, such as batch slope and batch intercept values, during production of test meter 200. This pre-loaded calibration information can be accessed and used by processor 300 upon receiving a suitable signal (such as current) from the strip via strip port connector 220 so as to calculate a corresponding analyte level (such as blood glucose concentration) using the signal and the calibration information without receiving calibration input from any external source.

[0078] In embodiments described and illustrated herein, test meter 200 may include an Application Specific Integrated Circuit (ASIC) 304, so as to provide electronic circuitry used in measurements of glucose level in blood that has been applied to a biosensor 100 (or its variants 400, 500, or 600) inserted into strip port connector 220. Analog voltages can pass to and from ASIC 304 by way of an analog interface 306. Analog signals from analog interface 306 can be converted to digital signals by an A/D converter 316. Processor 300 further includes a core 308, a ROM 310 (containing computer code), a RAM 312, and a clock 318. In one embodiment, the processor 300 is configured (or programmed) to disable all of the user interface inputs except for a single input upon a display of an analyte value by the display unit such as, for example, during a time period after an analyte measurement. In an alternative embodiment, the processor 300 is configured (or programmed) to ignore any input from all of the user interface inputs except for a single input upon a display of an analyte value by the display unit. Detailed

descriptions and illustrations of the meter 200 are shown and described in International Patent Application Publication No. WO2006070200, which is hereby incorporated by reference into this application as if fully set forth herein.

[0079] Figure 3A(1) is an exemplary exploded perspective view of a test strip 100, which may include seven layers disposed on a substrate 5. The seven layers disposed on substrate 5 can be a first conductive layer 50 (which can also be referred to as electrode layer 50), an insulation layer 16, two overlapping reagent layers 22a and 22b, an adhesive layer 60 which includes adhesive portions 24, 26, and 28, a hydrophilic layer 70, and a top layer 80 which forms a cover 94 for the test strip 100. Test strip 100 may be manufactured in a series of steps where the conductive layer 50, insulation layer 16, reagent layers 22, and adhesive layer 60 are sequentially deposited on substrate 5 using, for example, a screen-printing process. Note that the electrodes 10, 12, and 14 are disposed for contact with the reagent layer 22a and 22b whereas the physical characteristic sensing electrodes 19a and 20a are spaced apart and not in contact with the reagent layer 22. Hydrophilic layer 70 and top layer 80 can be disposed from a roll stock and laminated onto substrate 5 as either an integrated laminate or as separate layers. Test strip 100 has a distal portion 3 and a proximal portion 4 as shown in Figure 3A(1).

[0080] Test strip 100 may include a sample-receiving chamber 92 through which a physiological fluid sample 95 may be drawn through or deposited (Fig. 3A(2)). The physiological fluid sample discussed herein may be blood. Sample-receiving chamber 92 can include an inlet at a proximal end and an outlet at the side edges of test strip 100, as illustrated in Figure 3A(l). A fluid sample 95 can be applied to the inlet along axis L-L (Fig. 3A(2)) to fill a sample-receiving chamber 92 so that analyte can be measured from the sample. The side edges of a first adhesive pad 24 and a second adhesive pad 26 located adjacent to reagent layer 22 each define a wall of sample-receiving chamber 92, as illustrated in Figure 3A(1). A bottom portion or "floor" of sample-receiving chamber 92 may include a portion of substrate 5, conductive layer 50, and insulation layer 16, as illustrated in Figure 3A(1). A top portion or "roof of sample-receiving chamber 92 may include distal hydrophilic portion 32, as illustrated in Figure 3A(1). For test strip 100, as illustrated in Figure 3A(1), substrate 5 can be used as a foundation for helping support subsequently applied layers. Substrate 5 can be in the form of a polyester sheet such as a polyethylene tetraphthalate

(PET) material (Hostaphan PET supplied by Mitsubishi). Substrate 5 can be in a roll format, nominally 350 microns thick by 370 millimeters wide and approximately 60 meters in length.

[0081] A conductive layer is required for forming electrodes that can be used for the electrochemical measurement of glucose. First conductive layer 50 can be made from a carbon ink that is screen-printed onto substrate 5. In a screen-printing process, carbon ink is loaded onto a screen and then transferred through the screen using a squeegee. The printed carbon ink can be dried using hot air at about 140°C. The carbon ink can include VAGH resin, carbon black, graphite (KS 15), and one or more solvents for the resin, carbon and graphite mixture. More particularly, the carbon ink may incorporate a ratio of carbon black: VAGH resin of about 2.90: 1 and a ratio of graphite: carbon black of about 2.62: 1 in the carbon ink.

[0082] For test strip 100, as illustrated in Figure 3A(l), first conductive layer 50 may include a reference electrode 10, a first working electrode 12, a second working electrode 14, third and fourth physical characteristic sensing electrodes 19a and 19b, a first contact pad 13, a second contact pad 15, a reference contact pad 11, a first working electrode track 8, a second working electrode track 9, a reference electrode track 7, and a strip detection bar 17. The physical characteristic sensing electrodes 19a and 20a are provided with respective electrode tracks 19b and 20b. The conductive layer may be formed from carbon ink. First contact pad 13, second contact pad 15, and reference contact pad 11 may be adapted to electrically connect to a test meter. First working electrode track 8 provides an electrically continuous pathway from first working electrode 12 to first contact pad 13. Similarly, second working electrode track 9 provides an electrically continuous pathway from second working electrode 14 to second contact pad 15. Similarly, reference electrode track 7 provides an electrically continuous pathway from reference electrode 10 to reference contact pad 11. Strip detection bar 17 is electrically connected to reference contact pad 11. Third and fourth electrode tracks 19b and 20b connect to the respective electrodes 19a and 20a. A test meter can detect that test strip 100 has been properly inserted by measuring a continuity between reference contact pad 11 and strip detection bar 17, as illustrated in Figure 3A(1).

[0083] In the embodiment of Figure 3A(2) which is a variation of the test strip of Figure 3A(1), an additional electrode 10a is provided as an extension of any of the plurality of electrodes 19a, 20a, 14, 12, and 10. It must be noted that the built-in shielding or grounding electrode 10a is used to reduce or eliminate any capacitance coupling between the finger or body of the user and the characteristic measurement electrodes 19a and 20a. The grounding electrode 10a allows for any capacitance to be directed away from the sensing electrodes 19a and 20a. To do this, the grounding electrode 10a can be connected any one of the other five electrodes or to its own separate contact pad (and track) for connection to ground on the meter instead of one or more of contact pads 15, 17, 13 via respective tracks 7, 8, and 9. In a preferred embodiment, the grounding electrode 10a is connected to one of the three electrodes that has reagent 22 disposed thereon. In a most preferred embodiment, the grounding electrode 10a is connected to electrode 10. Being the grounding electrode, it is advantageous to connect the grounding electrode to the reference electrode (10) so not to contribute any additional current to the working electrode measurements which may come from background interfering compounds in the sample. Further by connecting the shield or grounding electrode 10a to electrode 10, this is believed to effectively increase the size of the counter electrode 10 which can become limiting especially at high signals. In the embodiment of Figure 3A(2), the reagent are arranged so that they are not in contact with the measurement electrodes 19a and 20a. Alternatively, in the embodiment of Figure 3A(3), the reagent 22 is arranged so that the reagent 22 contacts at least one of the sensing electrodes 19a and 20a.

[0084] In alternate version of test strip 100, shown here in Figure 3A(4), the top layer 38, hydrophilic film layer 34 and spacer 29 have been combined together to form an integrated assembly for mounting to the substrate 5 with reagent layer 22' disposed proximate insulation layer 16'.

[0085] In Figure 3A(5), it can be seen in the plan view that the first two electrodes 19a and 20a are nearest to the entrance of the blood receiving channel 18. The tracks of the electrodes are configured to mate with five respective contact surfaces of the strip receiving port. As shown in Figure 3A(6), which is a close-up of sample receiving end of the strip 100, the first electrode track 19a is spaced at a distance L I from the second electrode track 20a. The second electrode track 20a is spaced at a distance L2 from electrode 10, which

distance L2 may be from about 1 to about ½ of LI. The thickness hi of the electrode 19a can be the same or different in size as compared to thickness h2 of the second electrode 20a. For electrode 10, the thickness h3 can be about 6 to about 7 times that of thickness hi whereas respective thicknesses h4 and h5 can be about 2 to about 4 times that of hi or h2. In the preferred embodiment, the distance LI may be about 1.2 millimeters and the thickness hi may be about 0.2 millimeters.

[0086] Variations of the biosensor 100 (Figures 3A (1-6)) are shown in Figures 3B-3T. Briefly, with regard to variations of biosensor 100 (illustrated exemplarily in Figures 3B through 3T), these biosensors include an enzymatic reagent layer disposed on the working electrode, a patterned spacer layer disposed over the first patterned conductive layer and configured to define a sample chamber within the analytical biosensor, and a second patterned conductive layer disposed above the first patterned conductive layer. The second patterned conductive layer includes a first phase-shift measurement electrode and a second phase-shift measurement electrode. Moreover, the first and second phase-shift measurement electrodes are disposed in the sample chamber and are configured to measure, along with the hand-held test meter, a phase shift of an electrical signal forced through a bodily fluid sample introduced into the sample chamber during use of the analytical biosensor. Such phase-shift measurement electrodes are also referred to herein as bodily fluid phase-shift measurement electrodes. Analytical biosensors of various embodiments described herein are believed to be advantageous in that, for example, the first and second phase-shift measurement electrodes are disposed above the working and reference electrodes, thus enabling a sample chamber of advantageously low volume. This is in contrast to a configuration wherein the first and second phase-shift measurement electrodes are disposed in a co-planar relationship with the working and reference electrodes thus requiring a larger bodily fluid sample volume and sample chamber to enable the bodily fluid sample to cover the first and second phase-shift measurement electrodes as well as the working and reference electrodes.

[0087] In the embodiment of Figure 3B, the analyte measurement electrodes 10, 12, and 14 are disposed in generally the same configuration as in Figs. 3A(1, 2, 3, 4, 5, or 6). The electrodes 19a and 20a to sense hematocrit level, however, are disposed in a spaced apart configuration in which one electrode 19a is proximate an entrance 92a to the test chamber

92 and another electrode 20a is at the opposite end of the test chamber 92. At least one of the electrodes on the biosensor is disposed to be in contact with a reagent layer 22.

[0088] In Figures 3C, 3D, 3E and 3F, the hematocrit sensing electrodes 19a and 20a are disposed adjacent each other and may be placed at the opposite end 92b of the entrance 92a to the test chamber 92 (Figs. 3C and 3D) or adjacent the entrance 92a (Figs. 3E and 3F). In all of these embodiments, the physical characteristic sensing electrodes are spaced apart from the reagent layer 22 so that these physical characteristic sensing electrodes are not impacted by the electrochemical reaction of the reagent in the presence of a fluid sample (e.g., blood or interstitial fluid) containing glucose.

[0089] Referring to Figures 3G through 3J, electrochemical-based analytical biosensor 400 includes an electrically-insulating substrate layer 402, a first patterned conductive layer 404 disposed on the electrically-insulating substrate layer, an enzymatic reagent layer 406 (for clarity depicted in Figure 3G only), a patterned spacer layer 408, a second patterned conductive layer 410 disposed above first patterned conductive layer 404, and an electrically-insulating top layer 412. Patterned spacer layer 408 is configured such that electrochemical-based analytical biosensor 400 also includes a sample chamber 414 formed therein with patterned spacer layer 408 defining outer walls of sample chamber 414.

[0090] First patterned conductive layer 404 includes three electrodes, a counter electrode 404a (also referred to as a reference electrode), a first working electrode 404b and a second working electrode 404c (see Figure 3G).

[0091] Second patterned conductive layer 410 includes a first phase-shift measurement electrode 411 and a second phase shift measurement electrode 413. Second patterned conductive layer 410 also includes a first phase-shift probe contact 416 and a second phase-shift probe contact 418.

[0092] During use of electrochemical-based analytical biosensor 400 to determine an analyte in a bodily fluid sample (e.g., blood glucose concentration in a whole blood sample), electrodes 404a, 404b and 404c are employed by an associated meter (not shown) to monitor an electrochemical response of the electrochemical-based analytical biosensor. The electrochemical response can be, for example, an electrochemical reaction induced current of interest. The magnitude of such a current can then be correlated, taking into

consideration the physical characteristic (e.g., hematocrit) of the bodily fluid sample as determined by the bodily fluid sample's phase shift, with the amount of analyte present in the bodily fluid sample under investigation. During such use, a bodily fluid sample is applied to electrochemical-based analytical biosensor 400 and, thereby, received in sample chamber 414.

[0093] Electrically-insulating substrate layer 402 can be any suitable electrically-insulating substrate known to one skilled in the art including, for example, a nylon substrate, polycarbonate substrate, a polyimide substrate, a polyvinyl chloride substrate, a polyethylene substrate, a polypropylene substrate, a glycolated polyester (PETG) substrate, a polystyrene substrate, a silicon substrate, ceramic substrate, glass substrate or a polyester substrate (e.g., a 7 millimeters thick polyester substrate). The electrically-insulating substrate can have any suitable dimensions including, for example, a width dimension of about 5 mm, a length dimension of about 27 mm and a thickness dimension of about 0.5 mm.

[0094] First patterned conductive layer 404 can be formed of any suitable electrically conductive material such as, for example, gold, palladium, carbon, silver, platinum, tin oxide, iridium, indium, or combinations thereof (e.g., indium doped tin oxide). Moreover, any suitable technique or combination of techniques can be employed to form first patterned conductive layer 404 including, for example, sputtering, evaporation, electro-less plating, screen-printing, contact printing, laser ablation or gravure printing. A typical but non-limiting thickness for the patterned conductive layer is in the range of 5nanometers to 400nanometers.

[0095] As is known, conventional electrochemical-based analyte biosensors (e.g. test strips) employ a working electrode along with an associated counter/reference electrode and enzymatic reagent layer to facilitate an electrochemical reaction with an analyte of interest and, thereby, determine the presence and/or concentration of that analyte. For example, an electrochemical-based analyte biosensor for the determination of glucose concentration in a blood sample can employ an enzymatic reagent that includes the enzyme glucose oxidase and the mediator ferricyanide (which is reduced to the mediator ferrocyanide during the electrochemical reaction). Such conventional analyte test strips

and enzymatic reagent layers are described in, for example, U.S. Patents 5,708,247; 5,951,836; 6,241,862; and 6,284,125; each of which is hereby incorporated by reference herein to this application. In this regard, the reagent layer employed in various embodiments provided herein can include any suitable sample-soluble enzymatic reagents, with the selection of enzymatic reagents being dependent on the analyte to be determined and the bodily fluid sample. For example, if glucose is to be determined in a blood sample, enzymatic reagent layer 406 can include glucose oxidase or glucose dehydrogenase along with other components necessary for functional operation.

[0096] In general, enzymatic reagent layer 406 includes at least an enzyme and a mediator. Examples of suitable mediators include, for example, ruthenium, Hexaammine Ruthenium (III) Chloride, ferricyanide, ferrocene, ferrocene derivatives, osmium bipyridyl complexes, and quinone derivatives. Examples of suitable enzymes include glucose oxidase, glucose dehydrogenase (GDH) using a pyrroloquinoline quinone (PQQ) co-factor, GDH using a nicotinamide adenine dinucleotide (NAD) co-factor, and GDH using a flavin adenine dinucleotide (FAD) co-factor. Enzymatic reagent layer 406 can be applied during manufacturing using any suitable technique including, for example, screen printing.

[0097] Applicant notes that enzymatic reagent layer 406 may also contain suitable buffers (such as, for example, Tris HC1, Citraconate, Citrate and Phosphate), hydroxy ethylcelulose [HEC], carboxymethylcellulose, ethycellulose and alginate, enzyme stabilizers and other additives as are known in the field.

[0098] Further details regarding the use of electrodes and enzymatic reagent layers for the determination of the concentrations of analytes in a bodily fluid sample, albeit in the absence of the phase-shift measurement electrodes, analytical test strips and related methods described herein, are in U.S. Patent No. 6,733,655, which is hereby fully incorporated by reference herein to this application.

[0099] Patterned spacer layer 408 can be formed of any suitable material including, for example, a 95micrometers thick, double-sided pressure sensitive adhesive layer, a heat activated adhesive layer, or a thermo-setting adhesive plastic layer. Patterned spacer layer 408 can have, for example, a thickness in the range of from about 1 micron to about 500

microns, preferably between about 10 microns and about 400 microns, and more preferably between about 40 microns and about 200 microns.

[00100] Second patterned conductive layer 410 can be formed of any suitable conductive material including, for example, copper, silver, palladium, gold and conductive carbon materials. Second patterned conductive layer 410 can be, for example, disposed on a lower surface of electrically-insulating top layer 412 (as depicted in Figures 3G-3J) or embedded in the lower surface of electrically-insulating top layer 412. Second patterned conductive layer 410 can have any suitable thickness including, for example, a thickness in the range of 20 microns to 400 microns.

[00101] First phase-shift measurement electrode 411 and second phase shift measurement electrode 413 of second patterned conductive layer 410 are separated within sample chamber 414 by a gap (in the horizontal direction of Figure 3J) that is suitable for phase-shift measurement. Such a gap can be, for example, in the range of 20 microns to 1,400 microns with a typical gap being 500 microns. Moreover, the surface area of first phase-shift measurement electrode 111 and second phase shift measurement electrode 113 that is exposed to a bodily fluid sample within sample chamber 414 is typically about 0.5 mm^2 but can range, for example, from about 0.1 mm^2 to about 2.0 mm^2.

[00102] Electrochemical-based analytical biosensor 400 can be manufactured, for example, by the sequential aligned formation of first patterned conductive layer 404, enzymatic reagent layer 406, patterned spacer layer 408, second patterned conductive layer 410 and electrically insulating top layer 412 onto electrically-insulating substrate layer 402. Any suitable techniques known to one skilled in the art can be used to accomplish such sequential aligned formation, including, for example, screen printing, photolithography, photogravure, chemical vapour deposition, sputtering, tape lamination techniques and combinations thereof.

[00103] Analytical biosensors according to embodiments provided herein can be configured, for example, for operable electrical connection (via, for example, first and second phase shift probe contacts 416 and 418) and use with the analytical test strip sample cell interface of a hand-held test meter as described in co-pending patent application 13/250,525 [tentatively identified by attorney docket number DDI5209USNP], which is

hereby incorporated by reference herein to this application with a copy provided in the Appendix.

[00104] It has been determined that a relationship exists between the reactance of a whole blood sample and the physical characteristic (e.g., hematocrit) of that sample. Electrical modeling of a bodily fluid sample (e.g., a whole blood sample) as parallel capacitive and resistive components indicates that when an alternating current (AC) signal is forced through the bodily fluid sample, the phase shift of the alternating signal will be dependent on both the frequency of the alternating signal voltage and the physical characteristic (e.g., hematocrit) of the sample. Therefore, the physical characteristic (e.g., hematocrit) of a bodily fluid sample can be measured by, for example, driving alternating signals of a known frequency (or known frequencies) through the bodily fluid sample and detecting their phase shift. The phase-shift measurement electrodes of analytical biosensors of various embodiments described herein are particularly suitable for use in such phase-shift measurements since the first and second phase shift measurement electrodes are in direct contact with a bodily fluid sample present in the sample chamber.

[00105] Applicant notes that for various embodiments of analytical biosensors (e.g., an electrochemical-based analytical test strip) described here for use with a hand-held test meter in the determination of an analyte (such as glucose) in a bodily fluid sample (for example, a whole blood sample) may include an electrically insulating substrate, a first patterned conductor layer disposed on the electrically insulating substrate and having a working electrode and a reference electrode. The analytical biosensor may also include an enzymatic reagent layer disposed on the working electrode, a first patterned spacer layer disposed over the first patterned conductor layer and defining both a first sample-receiving channel and an analyte determination sample chamber within the analytical biosensor, and a second patterned spacer layer disposed over the first patterned spacer layer and defining at least a second sample-receiving channel. In addition, the analytical biosensor further includes a bodily fluid phase-shift sample chamber in fluidic communication with the second sample-receiving channel. Moreover, the first sample-receiving channel and analyte determination sample chamber of the analytical biosensor are isolated from the second sample-receiving channel and bodily fluid phase-shift sample chamber of the analytical biosensor.

[00106] Analytical biosensors of various embodiments described herein are believed by applicant to be beneficial in that, for example, the isolation (fluidic and electrical) between the analyte determination sample chamber and the bodily fluid phase-shift sample chamber prevents potential interference between the determination of the analyte in the bodily fluid sample and a phase-shift measurement of the bodily fluid. Applicant notes that certain advantages are obtained by having the first sample-receiving channel and analyte determination chamber are separated from the second sample-receiving channel and bodily fluid phase-shift sample chamber by portions of the first and/or second patterned spacer layers that can be thinner, thus providing for an analytical biosensor with a small, yet mechanically stable, cross-section.

[00107] Referring to Figures 3K-30, electrochemical-based analytical biosensor 500 includes an electrically-insulating substrate 502, a first patterned conductor layer 504 disposed on the electrically-insulating substrate layer, an enzymatic reagent layer 506 (for clarity depicted in Figure 3K only), a first patterned spacer layer 508, a second patterned spacer layer 510, and a top cover 511. In the embodiment of Figure 3K, first pattered spacer layer 508 and second patterned spacer layer 510 are depicted as bi-layer structures. However, the first and second patterned spacer layers employed in various embodiments provided herein can be unitary layers or any other suitably formed layer.

[00108] First patterned spacer layer 508 is configured such that electrochemical-based analytical biosensor 500 also includes a first sample-receiving channel 512 and an analyte determination sample chamber 514. First patterned spacer layer 508 is also configured to define a bodily fluid phase-shift sample chamber 516 and an analyte determination sample chamber vent 518 (for clarity not depicted in Figure 3K).

[00109] Second patterned spacer layer 510 is configured to define a second sample-receiving channel 520 and a bodily fluid phase-shift chamber vent 522 (for clarity not depicted in Figure 3K).

[00110] First patterned conductor layer 504 includes a first phase-shift measurement electrode 524, a second phase-shift measurement electrode 526, two working electrodes 528a and 528b and a reference electrode 530. For clarity, Figure 3L depicts only first phase-shift measurement electrode 524 and second phase-shift measurement electrode 526 and not the entirety of first patterned conductor layer 504.

[00111] First sample-receiving channel 512 and analyte determination sample chamber 514 are isolated, both fluidically and electrically, from second sample-receiving channel 520 and bodily fluid phase-shift sample chamber 516 (see Figure 30 in particular wherein the first and second patterned conductor layers are omitted for clarity). Moreover, in the embodiment of Figure 30, the bodily fluid phase-shift sample chamber is disposed in a side-by-side configuration with the analyte determination sample chamber.

[00112] During use of electrochemical-based analytical biosensor 500 to determine an analyte in a bodily fluid sample (e.g., blood glucose concentration in a whole blood sample), working and reference electrodes are employed by an associated meter (not shown) to monitor an electrochemical response of the electrochemical-based analytical biosensor. The electrochemical response can be, for example, an electrochemical reaction induced current of interest. The magnitude of such a current can then be correlated, taking into consideration the haematocrit of the bodily fluid sample as determined by the bodily fluid sample's phase shift, with the amount of analyte present in the bodily fluid sample under investigation. During such use, a bodily fluid sample is applied to electrochemical-based analytical biosensor 500 and, thereby, received in both analyte determination sample chamber 514 and bodily fluid phase-shift sample chamber 516.

[00113] Electrically-insulating substrate 502 can be any suitable electrically-insulating substrate known to one skilled in the art including, for example, a nylon substrate, polycarbonate substrate, a polyimide substrate, a polyvinyl chloride substrate, a polyethylene substrate, a polypropylene substrate, a glycolated polyester (PETG) substrate, a polystyrene substrate, a silicon substrate, ceramic substrate, glass substrate or a polyester substrate (e.g., a 7 millimeters thick polyester substrate). The electrically-insulating substrate can have any suitable dimensions including, for example, a width dimension of about 5 mm, a length dimension of about 27 mm and a thickness dimension of about 0.5 mm.

[00114] First patterned conductor layer 504 can be formed of any suitable electrically conductive material such as, for example, gold, palladium, carbon, silver, platinum, tin oxide, iridium, indium, or combinations thereof (e.g., indium doped tin oxide). Moreover, any suitable technique or combination of techniques can be employed to form first patterned conductor layer 504 including, for example, sputtering, evaporation, electro-less

plating, screen-printing, contact printing, laser ablation or gravure printing. A typical but non-limiting thickness for the patterned conductor layer is in the range of 5nanometers to 500nanometers.

[00115] Applicant notes that conventional electrochemical-based analyte biosensors employ a working electrode along with an associated counter/reference electrode and enzymatic reagent layer to facilitate an electrochemical reaction with an analyte of interest and, thereby, determine the presence and/or concentration of that analyte. For example, an electrochemical-based analyte biosensor for the determination of glucose concentration in a blood sample can employ an enzymatic reagent that includes the enzyme glucose oxidase and the mediator ferricyanide (which is reduced to the mediator ferrocyanide during the electrochemical reaction). Such conventional analyte test strips and enzymatic reagent layers are described in, for example, U.S. Patents 5,708,247; 5,951,836; 6,241,862; and 6,284,125; each of which is hereby incorporated by reference herein to this application. In this regard, the reagent layer employed in various embodiments provided herein can include any suitable sample-soluble enzymatic reagents, with the selection of enzymatic reagents being dependent on the analyte to be determined and the bodily fluid sample. For example, if glucose is to be determined in a blood sample, enzymatic reagent layer 506 can include glucose oxidase or glucose dehydrogenase along with other components necessary for functional operation.

[00116] In general, enzymatic reagent layer 506 includes at least an enzyme and a mediator. Examples of suitable mediators include, for example, ferricyanide, ferrocene, ferrocene derivatives, osmium bipyridyl complexes, and quinone derivatives. Examples of suitable enzymes include glucose oxidase, glucose dehydrogenase (GDH) using a pyrroloquinoline quinone (PQQ) co-factor, GDH using a nicotinamide adenine dinucleotide (NAD) co-factor, and GDH using a flavin adenine dinucleotide (FAD) co-factor. Enzymatic reagent layer 506 can be applied during manufacturing using any suitable technique including, for example, screen printing.

[00117] Applicant notes that enzymatic reagent layer 506 may also contain suitable buffers (such as, for example, Tris HC1, Citraconate, Citrate and Phosphate), hydroxy ethylcelulose

[HEC], carboxymethylcellulose, ethycellulose and alginate, enzyme stabilizers and other additives as are known in the field.

[00118] Further details regarding the use of electrodes and enzymatic reagent layers for the determination of the concentrations of analytes in a bodily fluid sample, albeit in the absence of the phase-shift measurement electrodes, bodily-fluid phase-shift sample chambers and second sample receiving channels analytical test strips and related methods described herein, are in U.S. Patent No. 6,733,655, which is hereby fully incorporated by reference herein to this application.

[00119] First and second patterned spacer layers 508 and 510 respectively can be formed of any suitable material including, for example, a 95micrometers thick, double-sided pressure sensitive adhesive layer, a heat activated adhesive layer, or a thermo-setting adhesive plastic layer. First patterned spacer layer 508 can have, for example, a thickness in the range of from about 1 micron to about 500 microns, preferably between about 10 microns and about 400 microns, and more preferably between about 40 microns and about 600 microns.

[00120] Electrochemical-based analytical biosensor 500 can be manufactured, for example, by the sequential aligned formation of first patterned conductor layer 504, enzymatic reagent layer 506, first patterned spacer layer 508, and second patterned spacer layer 510 onto electrically-insulating substrate 502. Any suitable techniques known to one skilled in the art can be used to accomplish such sequential aligned formation, including, for example, screen printing, photolithography, photogravure, chemical vapour deposition, sputtering, tape lamination techniques and combinations thereof.

[00121] Analytical biosensors according to embodiments can be configured, for example, for operable electrical connection and use with the analytical biosensor sample cell interface of a hand-held test meter as described in co-pending patent application 13/250,525 [tentatively identified by attorney docket number DDI5209USNP], which is hereby incorporated by reference herein to this application with a copy provided in the Appendix.

[00122] It has been determined that a relationship exists between the reactance of a whole blood sample and the physical characteristic (e.g., hematocrit) of that sample. Electrical modeling of a bodily fluid sample (e.g., a whole blood sample) as parallel

capacitive and resistive components indicates that when an alternating signal such as, for example, alternating-current (AC) signal is forced through the bodily fluid sample, the phase shift of the alternating signal will be dependent on both the frequency of the alternating signal voltage and the physical characteristic (e.g., hematocrit, viscosity, temperature) of the sample. Therefore, the physical characteristic (e.g., hematocrit, viscosity, temperature) of a bodily fluid sample can be measured by, for example, driving alternating signals of known frequencies through the bodily fluid sample and detecting their phase shift. The phase-shift measurement electrodes of analytical test strips of various embodiments described herein are particularly suitable for use in such phase-shift measurements since the first and second phase shift measurement electrodes are in direct contact with a bodily fluid sample present in the sample chamber.

[00123] Referring to Figures 3P-3T, electrochemical-based analytical test strip 600 includes an electrically-insulating substrate 602, a first patterned conductor layer 604 disposed on the electrically-insulating substrate layer, an enzymatic reagent layer 606 (for clarity depicted in Figure 3P only), a first patterned spacer layer 608, a second patterned conductor layer 609, a second patterned spacer layer 610, and a top cover 611. In the embodiment of Figure 3P, first pattered spacer layer 608 and second patterned spacer layer 610 are depicted as bi-layer structures. However, the first and second patterned spacer layers employed in various embodiments provided herein can be unitary layers or any other suitably formatted layer.

[00124] First patterned spacer layer 608 is configured such that electrochemical-based analytical biosensor 600 also includes a first sample-receiving channel 612, an analyte determination sample chamber 614 and an analyte determination sample chamber vent 618 (not depicted in Figure 3P but depicted with dashed lines in Figure 3R). Analyte determination sample chamber vent 618 is configured to aid in the introduction of a bodily fluid sample into analyte determination sample chamber 614 via first sample-receiving channel 612.

[00125] Second patterned spacer layer 610 is configured to define a second sample-receiving channel 620, a bodily fluid phase-shift sample chamber 616 and a bodily fluid phase-shift chamber vent 622 (not depicted in Figure 3P but depicted with dashed lines in Figure 3S). Bodily fluid phase-shift chamber vent 622 is configured to aid in the

introduction of a bodily fluid sample into bodily fluid phase-shift sample chamber 616 via second sample-receiving channel 620.

[00126] First patterned conductor layer 604 two working electrodes 628a and 628b (depicted in Figures 3P and 3Q) and a reference electrode 630 (also depicted in Figures 3P and 3Q). Second patterned conductor layer 609 includes a first phase-shift measurement electrode 624 and a second phase-shift measurement electrode 626 and is disposed above first patterned spacer layer 608 and embedded in the bi-layer structure of second pattered spacer layer 610.

[00127] First sample-receiving channel 612 and analyte determination sample chamber 614 are isolated, both fluidically and electrically, from second sample-receiving channel 620 and bodily fluid phase-shift sample chamber 616 (see Figure 3T in particular wherein the first and second patterned conductor layers are not depicted for clarity).

[00128] In the various embodiments of the test strip, there are two measurements that are made to a blood sample deposited on the test strip. One measurement is that of the glucose in the blood sample while the other is that of physical characteristic (e.g., hematocrit) in the same sample. Both measurements (glucose and hematocrit) can be performed in sequence, simultaneously or overlapping in duration. For example, the glucose measurement can be performed first then the physical characteristic (e.g., hematocrit); the physical characteristic (e.g., hematocrit) measurement first then the glucose measurement; both measurements at the same time; or a duration of one measurement may overlap a duration of the other measurement. Each measurement is discussed in detail as follow with respect to Figures 4A, 4B and 5.

[00129] Figure 4A is an exemplary chart of a test signal applied to test strip 100 and its variations shown here in Figures 3A-3T. Before a fluid sample is applied to test strip 100 (or its variants 400, 500, or 600), test meter 200 is in a fluid detection mode in which a first test signal of about 400 millivolts is applied between second working electrode and reference electrode. A second test signal of about 400 millivolts is preferably applied simultaneously between first working electrode (e.g., electrode 12 of strip 100) and reference electrode (e.g., electrode 10 of strip 100). Alternatively, the second test signal may also be applied contemporaneously such that a time interval of the application of the

first test signal overlaps with a time interval in the application of the second test voltage. The test meter may be in a fluid detection mode during fluid detection time interval T_{FD}, prior to the detection of physiological fluid at starting time at zero. In the fluid detection mode, test meter 200 determines when a fluid is applied to test strip 100 (or its variants 400, 500, or 600) such that the fluid wets second working electrode 14 and reference electrode 10. Once test meter 200 recognizes that the physiological fluid has been applied because of, for example, a sufficient increase in the measured test current at second working electrode 14, test meter 200 assigns a zero second marker at zero time "0" and starts the test time interval T_j. Test meter 200 may sample the current transient output at a suitable sampling rate, such as, for example, every 1 milliseconds to every 100 milliseconds. Upon the completion of the test time interval T_j, the test signal is removed. For simplicity, Figure 4A only shows the first test signal applied to test strip 100 (or its variants 400, 500, or 600).

[00130] Hereafter, a description of how analyte (e.g., glucose) concentration is determined from the known current transients (e.g., the measured electrical current response in microamperes as a function of time) that are measured when the test voltages of Figure 4A are applied to the test strip 100 (or its variants 400, 500, or 600).

[00131] In Figure 4A, the first and second test voltages applied to test strip 100 (or its variants described herein) are generally from about +100 millivolts to about +600 millivolts. In one embodiment in which the electrodes include carbon ink and the mediator includes ferricyanide, the test signal is about +400 millivolts. Other mediator and electrode material combinations will require different test voltages, as is known to those skilled in the art. The duration of the test voltages is generally from about 1 to about 5 seconds after a reaction period and is typically about 3 seconds after a reaction period. Typically, test sequence time T_S is measured relative to time t_0. As the voltage 401 is maintained in Figure 4A for the duration of T_S, output signals are generated, shown here in Figure 4B with the current transient 702 for the first working electrode 12 being generated starting at zero time and likewise the current transient 704 for the second working electrode 14 is also generated with respect to the zero time. It is noted that while the signal transients 702 and 704 have been placed on the same referential zero point for purposes of explaining the process, in physical term, there is a slight time differential between the two

signals due to fluid flow in the chamber towards each of the working electrodes 12 and 14 along axis L-L. However, the current transients are sampled and configured in the microcontroller to have the same start time. In Figure 4B, the current transients build up to a peak proximate peak time ***Tp*** at which time, the current slowly drops off until approximately one of 2.5 seconds or 5 seconds after zero time. At the point 706, approximately at 5 seconds, the output signal for each of the working electrodes 12 and 14 may be measured and added together. Alternatively, the signal from only one of the working electrodes 12 and 14 can be doubled.

[00132] Referring back to Fig. 2B, the system drives a signal to measure or sample the output signals I_{Σ} from at least one the working electrodes (12 and 14) at any one of a plurality of time points or positions T_1, T_2, T3, ... T^. As can be seen in Fig. 4B, the time position can be any time point or interval in the test sequence Tg. For example, the time position at which the output signal is measured can be a single time point $T_{1.5}$ at 1.5 seconds or an interval 708 (e.g., interval~10 milliseconds or more depending on the sampling rate of the system) overlapping the time point $T_{2.8}$ proximate 2.8 seconds..

[00133] From knowledge of the batch calibration code offset and batch slope for the particular test strip 100 and its variations in Figures 3B-3T, the analyte (e.g., glucose) concentration can be calculated.

[00134] It is noted that "Intercept" and "Slope" are the values obtained by measuring calibration data from a batch of test strips. Typically around 1500 strips (or more in some instances) are selected at random from the lot or batch. Physiological fluid (e.g., blood samples) from donors is spiked to various analyte levels, typically six different glucose concentrations. Typically, blood from 12 different donors is spiked to each of the six levels. Eight strips are given blood from identical donors and levels so that a total of $12 \times 6 \times 8 \approx 576$ tests are conducted for that lot. These are benchmarked against actual analyte level (e.g., blood glucose concentration) by measuring these using a standard laboratory analyzer such as Yellow Springs Instrument (YSI). A graph of measured glucose concentration is plotted against actual glucose concentration (or measured current versus YSI current) and a formula $y = mx+c$ least squares fitted to the graph to give a value for batch slope m and batch intercept c for the remaining strips from the lot or batch.

[00135] It is worthwhile here to note that the various components, systems and procedures described earlier allow for applicant to provide for analyte measurement system that heretofore was not available in the art. In particular, this system includes a test strip that has a substrate and a plurality of electrodes disposed on the substrate and connected to respective electrode connectors. The system further includes an analyte meter that has a housing, a test strip port connector configured to connect to the respective electrode connectors of the test strip, and a microprocessor 300. The microprocessor 300 is in electrical communication with the test strip port connector 220 to apply electrical signals or sense electrical signals from the plurality of electrodes.

[00136] Referring to Figure 2B, details of a preferred implementation of meter 200 where the same numeral in respective Figures 2A and 2B have a common description. In Figure 2B, a strip port connector 220 is connected to the analogue interface 306 by five lines including an impedance sensing line EIC to receive signals from physical characteristic sensing electrode(s), alternating signal line AC driving signals to the physical characteristic sensing electrode(s), reference line Ref for a reference electrode, and current sensing lines from respective working electrode 1 and working electrode 2 (i.e., I_{we}i and **Iwe2).** A strip detection line 221 can also be provided for the connector 220 to indicate insertion of a test strip. The analog interface 306 provides four inputs to the processor 300: (1) real impedance Z'; (2) imaginary impedance Z"; (3) current sampled or measured from working electrode 1 of the biosensor or I_{we1}; (4) current sampled or measured from working electrode 2 of the biosensor or I_{we2}. There is one output from the processor 300 to the interface 306 to drive an oscillating signal AC (of any value from about 25kHz to 250kHz or higher) to the physical characteristic sensing electrodes. A phase differential P (in degrees) can be determined from the real impedance Z' and imaginary impedance Z" where:

$$P=\tan^{-1}\{Z''/Z'\} \qquad \text{Eq. 3.1}$$

[00137] and magnitude M (in ohms and conventionally written as $|Z|$) from line Z' and Z" of the interface 306 can be determined where

[00138] $$M = \sqrt{(Z')^2 + (Z'')^2}$$ Eq. 3.2

[00139] In this system, the microprocessor is configured to: (a) apply a first signal to the plurality of electrodes so that a specific sampling time point is determined from a physical characteristic of a physiological fluid sample is derived, (b) apply a second signal to the plurality of electrodes, and (c) measure a current output from one of the plurality of electrodes at the defined specific time point so that an analyte concentration is determined. The "specific time point" may also be referred to herein as a "specified time point". For this system, the plurality of electrodes of the test strip or biosensor includes at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration. For example, the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate. Alternatively, the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate. It is noted that for some embodiments, all of the electrodes are disposed on the same plane defined by the substrate. In particular, in some of the embodiments described herein, a reagent is disposed proximate the at least two other electrodes and no reagent is disposed on the at least two electrodes. One feature of note in this system is the ability to provide for an accurate analyte measurement within about 10 seconds of deposition of a physiological sample onto the biosensor as part of the test sequence.

[00140] A description of applicant's technique to determine the physical characteristic (e.g., hematocrit) of the blood sample is provided in relation to Figure 5. In Figure 5, the system 200 (Fig. 2) applies a first oscillating input signal 800 at a first frequency (e.g., of about 25kilo-Hertz to 250 kHz or higher) to a pair of electrodes. The system is also set up to measure or detect a first oscillating output signal 802 from the third and fourth electrodes, which in particular involve measuring a first time differential At_1 between the first input and output oscillating signals. At the same time or during overlapping time durations, the system may also apply a second oscillating input signal (not shown for brevity) at a second frequency (e.g., about 1OOkilo-Hertz to about lMegaHertz or more, and preferably about 250 kilo Hertz) to a pair of electrodes and then measure or detect a second oscillating output signal from the third and fourth electrodes,

which may involve measuring a second time differential $\Delta ï_2$ (not shown) between the first input and output oscillating signals. From these signals, the system estimates a physical characteristic (e.g., hematocrit) of the blood sample based on the first and second time differentials $\Delta ï_1$ and $\Delta ï_2$. Thereafter, the system is able to derive a glucose concentration. The estimate of the physical characteristic (e.g., hematocrit) can be done by applying an equation of the form

$$HCT\ EST = \frac{(C_1\Delta t_1 - C_2\Delta t_2 - C_3)}{m_1} \qquad \text{Eq. 3.3}$$

where

each of Ci, C_2, and C_3 is an operational constant for the test strip,

mi represent a parameter from regressions data.

[00141] Details of this exemplary technique can be found in Provisional U.S. Patent Application S.N. 61/530,795 filed on September 2, 2011, entitled, "Hematocrit Corrected Glucose Measurements for Electrochemical Test Strip Using Time Differential of the Signals" with Attorney Docket No. DDI-5214USPSP, which is hereby incorporated by reference.

[00142] Another technique to determine physical characteristic (e.g., hematocrit) can be by two independent measurements of physical characteristic (e.g., hematocrit). This can be obtained by determining: (a) the impedance of the blood sample at a first frequency and (b) the phase angle of the blood sample at a second frequency substantially higher than the first frequency. In this technique, the blood sample is modeled as a circuit having unknown reactance and unknown resistance. With this model, an impedance (as signified by notation " | Z | ") for measurement (a) can be determined from the applied voltage, the voltage across a known resistor (e.g., the intrinsic strip resistance), and the voltage across the unknown impedance Vz; and similarly, for measurement (b) the phase angle can be measured from a time difference between the input and output signals by those skilled in the art. Details of this technique is shown and described in pending provisional patent application S.N. 61/530,808 filed September 2, 201 1 (Attorney Docket No. DDI5215PSP), which is incorporated by reference. Other suitable techniques for determining the physical characteristic (e.g., hematocrit, viscosity, or density) of the physiological fluid sample can

also be utilized such as, for example, US Patent No. 4,919,770 or "Electric Cell-Substrate Impedance Sensing (ECIS) as a Noninvasive Means to Monitor the Kinetics of Cell Spreading to Artificial Surfaces" by Joachim Wegener, Charles R. Keese, and Ivar Giaever and published by Experimental Cell Research 259, 158-166 (2000) doi: 10.1006/excr.2000.4919, available online at http://www.idealibrary.coml; "Utilization of AC Impedance Measurements for Electrochemical Glucose Sensing Using Glucose Oxidase to Improve Detection Selectivity" by Takuya Kohma, Hidefumi Hasegawa, Daisuke Oyamatsu, and Susumu Kuwabata and published by Bull. Chem. Soc. Jpn. Vol. 80, No. 1, 158-165 (2007), all of these documents are incorporated by reference.

[00143] Another technique to determine the physical characteristic (e.g., hematorcrits, density, or temperature) can be obtained by knowing the phase difference (e.g., phase angle) and magnitude of the impedance of the sample. In one example, the following relationship is provided for the estimate of the physical characteristic or impedance characteristic of the sample ("IC"):

$$IC = M^2 * y_1 + M * y_2 + y_3 + P^2 * y_4 + P * y_5 \qquad \text{Eq. 3.4}$$

where: M (from Equation 3.2) represents a magnitude $|Z|$ of a measured impedance (in ohms);

P (from Equation 3.1) represents a phase difference between the input and output signals (in degrees))

y_1 is about -3.2e-08 and ± 10%, 5% or 1% of the numerical value provided hereof;

y_2 is about 4.1e-03 and ± 10%, 5% or 1% of the numerical value provided hereof;

y_3 is about -2.5e+01 and ± 10%, 5% or 1% of the numerical value provided hereof);

y_4 is about 1.5e-01 and ± 100%, 5% or 1% of the numerical value provided hereof; and

y_5 is about 5.0 and ± 10%, 5% or 1% of the numerical value provided hereof.

[00144] It is noted here that where the frequency of the input AC signal is high (e.g., greater than 75kHz) then the parametric terms yi and y_2 relating to the magnitude of impedance M may be ±200% of the exemplary values given hereinsuch that each of the parametric terms may include zero or even a negative value. On the other hand, where the frequency of the AC signal is low (e.g., less than 75 kHz), the parametric terms y_4 and y_5 relating to the phase angle P may be ±200% of the exemplary values given hereinsuch that each of the parametric terms may include zero or even a negative value. It is noted here that a magnitude of H, as used herein, is generally equal to the magnitude of IC. In one exemplary implementation, the term H or HCT is equal to IC as the term H or HCT is used herein this application.

[00145] In another alternative implementation, Equation 3.5 is provided. Equation 3.5 is the exact derivation of the quadratic relationship, without using phase angles as in Equation 3.4.

$$IC = \frac{-y_2 + \left|\sqrt{y_2^2 - \left(4y_3\left(y_1 - M\right)\right)}\right|}{2y_1} \qquad \text{Eq. 3.5}$$

where:

IC is the Impedance Characteristic [%];

M is the magnitude of impedance [Ohm];

yiis about 1.2292el and ± 10%, 5% or 1% of the numerical value provided hereof;

y_2 is about -4.343 le2 and ± 10%, 5% or 1% of the numerical value provided hereof;

y_3 is about 3.5260e4 and ± 10%, 5% or 1% of the numerical value provided hereof.

[00146] By virtue of the various components, systems and insights provided herein, at least a method of determining an analyte concentration from a physiological sample, which may, for example, be blood (and variations of such method) is achieved by applicant. Briefly, applicant's techniques involve obtaining information or data on at least one physical characteristic of a physiological fluid sample (such as, for example, hematocrit or viscosity), deriving a specific sampling time in a test sequence sampling time duration, driving a predetermined signal into the sample, measuring or sampling a first transient signal output from the sample for the duration of the test sequence sampling time duration; defining a specific range of time that includes the specific sampling time in the test sequence sampling time duration, extracting magnitudes of the first transient signal at respective discrete intervals within the specific range of time, and determining the analyte concentration based on the extracted magnitudes of the first transient signal contained within the specific range of time.

[00147] With reference to Figure 6A, the method involves depositing a physiological sample on a biosensor at step 904 (e.g., in the form of a test strip 100 as shown in Figures 3A(l-6)-3T and preferably Figures 3A(l-6) that has been inserted into a meter (step 902). Once the meter 200 is turned on, a voltage is applied to the strip 100 (or its variants 400, 500, or 600) and when the sample is deposited onto the test chamber, the applied voltage physically transforms the analyte in the sample into a different form due to the enzymatic reaction of the analyte with the reagent in the test chamber. As the sample flows into the capillary channel of the test cell, at least one physical characteristic of the sample is obtained (step 908). In particular, the step of obtaining or measuring the physical characteristic (step 908) may include applying a first signal to the sample to derive a physical characteristic of the sample, while the step 906 of initiating an enzymatic reaction (e.g., by applying electrical signals to the sample and reagent) may involve driving a second signal to the sample for a duration that may coincide with the test sequence ("first sampling time duration"). The driving of a second signal into the sample (via electrodes) in step 910 allows for a measurement of output signals from the sample (via the electrodes) over a time period, which can be the same as the first sampling time duration. The output signal can also be characterized here as a first-transient-signal (e.g., transient curves 1002, 1004, and 1006 in Fig. 7A that relate to time and magnitudes) that is referenced with

respect to both magnitudes (e.g., microamps) and time (e.g, milliseconds). At step 912, an extraction or determination of a specific sampling time T is made based on the values of the physical characteristic of the sample. A discussion of how specific sampling time T is extracted from the physical characteristics will be provided at a later point in this application. Referring back to Figure 6A, at step 914, the first transient signal output is measured or sampled (and represented in Fig. 7A, in which the first transient signal is correlated to both time and magnitude, giving a plot of magnitude (e.g. current) against time) over a test sequence sampling time duration from about 0 seconds to about 10 seconds. At step 916, a specific range of time (from Tl to T2) that would include specific sampling time T on the first sampling time duration is defined to be a second sampling time duration. At step 918, magnitudes of the first transient signal (e.g., 1002a) that are found within the specific range of time (or second sampling time duration) are measured or sampled by the system processor. Although all of the magnitudes are measured at step 918, only selected magnitudes occurring at different intervals within the second sampling time duration (or specific time range) are utilized by the processor to convert these magnitudes into an analyte concentration value in step 920.

[00148] The process of extracting magnitudes of the first transient signal to provide for the second transient signal can be understood with reference to Figures 7C and 7D. In Figure 7C, the first transient signal 1002a is illustrated with reference to magnitude (in micro-amps from about 20 to about 180 microamps) and time (first sampling time duration from about 0 to about 7 seconds). In order to extract selected magnitudes of the first transient signal 1002a, the system must first define the specific time range T1-T2, characterized here as "second sampling time duration." This is done by determining the specific sampling time T.

[00149] Once specific sampling time T is determined, the start time Tl of this specific range can be determined by taking a difference of specific sampling time T (in seconds) and a predetermined time A (also in seconds). The end time T2 is set to be equal to about specific sampling time T. Once range T1-T2 is defined, the system removes all transient signals outside of this specific time range, which is seen in Figure 7D. To allow for processing, the remaining transient signal (now defined as a second transient signal 1002a') can be divided into intervals (which is preferably equal intervals but may be of

unequal intervals) and designated in Fig. 7D as numerals "1" to "22" for each interval of the second transient 1002a'. The system may determine as close a value of the magnitude for each interval as possible. However, it is preferable, for ease of processing to utilize an average of the sampled magnitudes within each interval as the magnitude representative of that specific interval. It is noted that the second transient signal 1002a' can be offset to reduce confusion in computing the selected magnitudes so that the start time Tl would be set to start at zero seconds, shown here in Fig. 7E, along with other transient signals extracted from first transient signals of Fig. 7A.

[00150] Now that an overview has been provided of applicant's technique, details will now be given of particular techniques used in some of the steps in Figure 6A or 6B. In particular, the step of applying of the first signal involves directing an alternating signal provided by an appropriate power source (e.g., the meter 200) to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal. The physical characteristic being detected may be one or more of viscosity, hematocrit or density. This may include driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency. Preferably, the first frequency is at least one order of magnitude lower than the second frequency. As an example, the first frequency may be any frequency in the range of about 10 kHz to about 100 kHz and the second frequency may be from about 250 kHz to about 1 MHz or more. As used herein, the phrase "alternating signal" can have some portions of the signal alternating in polarity or all alternating current signal or an alternating current with a direct current offset or even a multi-directional signal combined with a direct-current signal.

[00151] Once the physical characteristic of the sample has been determined or obtained from a suitable technique, the physical characteristic can be used to define a specific sampling time T at which point during the test sequence the output signal of the test chamber is used for further refinement of measured transient output signals to provide for an output of the analyte concentration in the sample. Specifically, applicant has found a relationship between the physical characteristic (e.g., hematocrit) and the analyte concentration, as shown here in Figure 7A, where hematocrit is related to the analyte concentration (shown by current magnitudes in microamps). This relationship has been further explored such that the inventor was able to derive a direct relationship between the

specific sampling time of the sample and the physical characteristic of the sample (e.g., hematocrit), shown here in Figure 7B as line 708. As a consequence, by knowing the physical characteristic of the sample (e.g., hematocrit) from Equation 4 above, the relationship 708 in Figure 7B can be exploited to allow the specific sampling time to be specified to accommodate the different levels of physical characteristic (e.g., hematocrit) so as to achieve much more accurate glucose concentration measurements.

[00152] In Figure 7A, it can be seen that as the analyte concentration (proportional to the current output) increases, the peak of the high glucose concentration (denoted by 1002a, 1004a, and 1006a) is shifted to the right as compared to the medium glucose concentration (denoted by 1002b, 1004b, and 1006b). Similarly, the peak of the medium glucose concentration is further to the right of Fig. 7A as compared to low glucose concentration (denoted by 1002c, 1004c, and 1006c). It can also be seen here that the steady-state of the low glucose concentrations (1002c, 1004c, and 1006c) is reached earlier than the medium glucose concentrations (1002b, 1004b, and 1006b). This pattern is repeated for high glucose concentration (1002a, 1004a, and 1006b) as compared to medium glucose concentrations.

[00153] From data in Figure 7A, the inventor was able to derive a second degree relationship between the sensed physical characteristic and the sampling time, shown here as line 708 in Figure 7B. In Figure 7B, a curve 708 is fitted to hematocrit values at about 30%, 42% and about 55% and glucose values for these ranges of hematocrits (from Fig. 7A). This fitted curve is found by the inventor to be an equation of the form:

$$SpecificSamplingTime = x_1 H^{x_2} + x_3 \qquad \text{Eq. 4}$$

where (for convenience),

"SpecificSamplingTime" is designated as an approximate time point from the start of the test sequence at which to sample the output signal of the test strip,

H represents physical characteristic of the sample (e.g. in the form of hematocrit);

x_i is about 4.3e5;

x_2 is about -3.9; and

x_3 is about 4.8.

[00154] Although the method may indicate only one sampling time point, the method may include sampling as many time points as required, such as, for example, sampling the current output over multiple discrete time points or continuously (e.g., at specified sampling time such as, every 10 milliseconds to 100 milliseconds or constantly over a duration) from the start of the test sequence until at least about 10 seconds or less after the start and the results stored for processing near the end of the test sequence. Applicant notes that the appropriate sampling time is measured from the start of the test sequence but any appropriate datum may be utilized in order to determine when to sample the output current. As a practical matter, the system can be programmed to sample the output current at an appropriate time sampling interval during the entire test sequence such as for example, one sampling every 100 milliseconds or even as little as about every 1 milliseconds. In this variation, the specific sampling time is the value used to further determine a specific time range of the first sampling time duration.

[00155] Instead of calculating from Equation 4 for the specific sampling time in the test sequence from about 0 to about 7 seconds, a look-up table, represented exemplarily here with reference to Table 1 can also be utilized in place of Equation 4 or in addition to Equation 4 to specify an appropriate sampling time point. In Table 1, the value of the physical characteristic is used by the processor of the system to look up the appropriate time at which the signal output of the biosensor is sampled or measured to determine the analyte concentration. For example, once the physical characteristic has been determined, in this case 33% hematocrit, the time at which the signal output of the biosensor 100 is utilized in determining the analyte concentration can be gleaned from Table 1, which shows that specific sampling time is at approximately 5.32 seconds after the start of the test sequence.

Table 1

Physical Characteristic (e.g., Hematocrit %)	Specific Time T (seconds)
30	5.56
31	5.46
32	5.38

Physical Characteristic (e.g., Hematocrit %)	Specific Time T (seconds)
33	5.32
34	5.26
35	5.2
36	5.16
37	5.12
38	5.08
39	5.06
40	5.02
41	5
42	5
43	4.98
44	4.96
45	4.96
46	4.94
47	4.92
48	4.92
49	4.9
50	4.9
51	4.9
52	4.88
53	4.88
54	4.88
55	4.86

[00156] It should be noted that the step of applying the first signal and the driving of the second signal is in sequential order in that the order may be the first signal then the second signal or both signals overlapping in sequence; alternatively, the second signal first then the first signal or both signals overlapping in sequence. Alternatively, the applying of the first signal and the driving of the second signal may take place simultaneously.

[00157] It is noted that in the preferred embodiments, the measurement of a current output for the glucose concentration is performed prior to the estimation of the physical characteristic (e.g., hematocrit). Alternatively, the physical characteristic (e.g., hematocrit) level can be estimated, measured, or obtained prior to the measurement of the glucose concentration.

[00158] With reference to Figure 6B, a refinement of the method of Figure 6A is discussed. Steps 900-910 are the same as discussed with reference to Figure 6A and therefore are not repeated for brevity. At step 912', a specific sampling time T in the first sampling time duration is defined based on the physical characteristic of the sample. A second sampling duration time is defined based on the specific sampling time T in step 914'. A second transient signal (1002a' in Fig. 7D) that is obtained by deleting magnitudes of the first transient signal 1002a (Fig. 7C) that are outside of the specific time range T1-T2 in Fig. 7D. By this process, a second transient signal (1002a' in Fig. 7D) is obtained from the first transient signal (1002a in Fig. 7C). As shown in Figure 7D, the specific time range Tl to T2 includes specific sampling time T. In particular, Tl is about equal to the difference between the specific sampling time T and a predetermined time A and T2 is about equal to specific sampling time T. In another embodiment, Tl is about equal to an absolute value of the difference of specific sampling time T and A, and where T2 is about equal to T. In the preferred embodiments, A is approximately 4.2 seconds. With reference to step 920 in Figures 6A or 6B, analyte concentration may be determined in step 920 by application of certain selected magnitudes of the second transient signal (e.g., 1002a') in various mathematical algorithms derived by applicant based on a large amount of known analyte concentrations, as actually measured, as compared to laboratory referential analyte concentrations which are referred to herein as referential or datum values for determining accuracy of the known analyte concentration . In particular, a first algorithm may utilize five different magnitudes of the second transient to arrive at the analyte concentration (G). The magnitudes of second transient signal are typically quoted in nA, thus the intercept is typically quoted in nA, and the slope is typically quoted in nA/(mg/dL), giving analyte concentration in mg/dL. The first analyte concentration algorithm is represented here as Equation 5:

$$G = \frac{\left(\frac{|I_3|}{|I_4|}\right)^{x_1} \times \left(\frac{|I_2| + x_4|I_5| - x_5|I_1|}{|I_2| + x_4|I_5|}|I_5|\right) - x_2}{x_3}$$

[00159] Eq. 5

where:

Ii = magnitude of signal at interval 17 (approximately 3.3seconds from Tl);

I_2 = magnitude of signal at interval 13 (approximately 2.5seconds from start time Tl);

I_3 = magnitude of signal at interval 5 (approximately 0.9seconds from start time Tl);

I_4 = magnitude of signal at interval 3 (approximately 0.5seconds from start time Tl);

I_5 = magnitude of signal at interval 22 (approximately 4.3seconds from start time Tl);

x,=0.7503, x_2=337.27, xH-)16.811, x_4=1.4128, x_5=2.6707,

wherein, as noted above, the magnitudes of second transient signal may be quoted in nA, x_2 may be quoted in nA, and x_3 may be quoted in nA/(mg/dL).

[00160] In a second variation of the algorithm, only two magnitudes of the extracted second transient signal may be used to determine the analyte concentration (G), which in this case is glucose. The second algorithm is represented by Eq. 6:

$$G = \frac{x_1(|I_1|)^{\left(x_2 - \frac{x_3}{|I_2|}\right)} - x_4}{x_5}$$

Eq. 6

where:

11 = magnitude of signal at interval 11 (approximately 2.1seconds from start time Tl);

12 = magnitude of signal at interval 7 (approximately 1.3seconds from start time Tl);

x_1=0.5865, x_2=2.5099, x_3=(-)12.738, x_4=(-)188.31, x_5=9.1996,

wherein, as noted above, the magnitudes of second transient signal may be quoted in nA, x_4 may be quoted in nA, and x_5 may be quoted in nA/(mg/dL).

[00161] In a third variation of the algorithm, only three magnitudes of the second transient signal may be used to determine the analyte concentration (G), which in this case is glucose. The third algorithm is represented by Eq. 7:

$$G = \frac{x_1 ln\left(x_2 \frac{|I_1|}{|I_2|}\right)^{x_3} |I_3|^{x_4 - x_5}}{x_6}$$

Eq. 7

where:

Ii = magnitude of signal at interval 20 (approximately 3.9seconds from start time Tl);

I_2 = magnitude of signal at interval 22 (approximately 4.3seconds from start time Tl);

I_3 = magnitude of signal at interval 19 (approximately 3.7seconds from start time Tl);

x,=20.154, x_2=1.0446, x_3=0.9546, x_4=1.3894, x_5=(-)0.7141, x_6=0.1 163,

wherein, as noted above, the magnitudes of second transient signal may be quoted in nA, x_5 may be quoted in nA, and x_6 may be quoted in nA/(mg/dL).

[00162] In a fourth variation of the algorithm, five magnitudes of the second transient signal may be used to determine the analyte concentration (G), which in this case is glucose. The fourth algorithm is represented by Eq. 8:

$$G = \frac{x_3 \left|\frac{I_1}{I_2}\right|^{\left(x_1 - x_2 \left|\frac{I_3}{I_4}\right|\right)} \times |I_5| - x_5}{x_4}$$

[00163] Eq. 8

where:

Ii = magnitude of signal at interval 5 (approximately 0.9seconds from start time

Tl);

I_2 = magnitude of signal at interval 1 (approximately 0.1 seconds from start time Tl);

I_3 = magnitude of signal at interval 2 (approximately 0.3seconds from start time Tl);

I_4 = magnitude of signal at interval 10 (approximately 1.9seconds from start time Tl);

Is = magnitude of signal at interval 22 (approximately 4.3seconds from start time Tl);

x,=0.7060, x_2=0.4864, x_3=28.5946, x_4=0.6979, x_5=l5.5099,

wherein, as noted above, the magnitudes of second transient signal may be quoted in nA, x_5 may be quoted in nA, and x_4 may be quoted in nA/(mg/dL).

[00164] In a fifth variation of the algorithm, four magnitudes of the second transient signal may be used to determine the analyte concentration (G), which in this case is glucose. The fifth algorithm is represented by Eq. 9:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \cdot x_2|I_3|^2 + x_3|I_3| + x_4\right) - x_7}{x_8} \quad \text{Eq. 9}$$

where:

Ii = magnitude of signal at interval 19 (approximately 3.7seconds from start time Tl);

I_2 = magnitude of signal at interval 16 (approximately 3.1 seconds from start time Tl);

I_3 = magnitude of signal at interval 11 (approximately 2.1seconds from start time Tl);

I_4 = magnitude of signal at interval 5 (approximately 0.9seconds from start time Tl);

x_i=(-)1.6842, x_2=0.9527, x_3=(-)4.9724, x_4=6.2936, x_5=3.0770, x_6=(-)5.8427, x_7=(-)0.4714, x_8=0.0079,

wherein, as noted above, the magnitudes of second transient signal may be quoted in nA, x_7 may be quoted in nA, and x_8 may be quoted in nA/(mg/dL).

[00165] In a sixth variation of the algorithm, four magnitudes of the second transient signal may be used to determine the analyte concentration (G), which in this case is glucose. The sixth algorithm is represented by Eq. 10:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^3 + x_3|I_3|^2 + x_4|I_3| + x_5}{x_6|I_4|^2 + x_7|I_4| + x_8}\right) - x_9}{x_{10}}$$

[00166] Eq. 10

where:

I_i = magnitude of signal at interval 16 (approximately 3.1 seconds from start time Tl);

I_2 = magnitude of signal at interval 5 (approximately 0.9seconds from start time Tl);

I_3 = magnitude of signal at interval 12 (approximately 2.3seconds from start time Tl);

I_4 = magnitude of signal at interval 14 (approximately 2.7seconds from start time Tl);

x_1=1.1842, x_2=0.9740, x_3=(-)\ 1.316, x_4=38.763, x_5=(-)39.319, x_6=0.0928, x_7=(-)0·8503, x_8=1.7545, x_9=(-)9.3804, x_{10}=0.2465,

wherein, as noted above, the magnitudes of second transient signal may be quoted in nA, x_9 may be quoted in nA, and x_{10} may be quoted in nA/(mg/dL).

[00167] It is noted that each of the current outputs (e.g., Ii, I_2, I_3, I_4, I_5) in Equations 5-10 being measured can be a current output from one working electrode in a biosensor that has one working electrode or where there is more than one working electrode, a sum of current outputs from the plurality of working electrodes in a biosensor with plural working electrodes. In the exemplary embodiments, each of the current outputs at the specified sampling time points (e.g., Ii, I_2, I_3, I_4, I_5) is a total of or a sum of the current outputs from working electrodes 12 and 14 of exemplary biosensor 100. For example, in Equation 10, if the current output for first working electrode at the sixteenth interval (at ~ 3.1 sees) is 120

nanoamperes and the current output at the second working electrode is 150 nanoamperes at the same interval (-3.1 sees), the magnitude of I_1 is the sum of both values and therefore 270 nanoamperes. Similarly, the current output of I_2 is the sum of the current output from first working electrode 12 at the fifth interval (~0.9sec) and the current output from second working electrode 14 at the fifth interval. The remainder of the currents are obtained in the same manner for Equation 10.

[00168] Instead of a total current summed from each working electrode for each sampling time, an average of the current from each working electrode at each sampling time can be used in the Equations 5-10 described herein, and of course, with appropriate modification to the operational coefficients (as known to those skilled in the art) to account for a lower measured current at each sampling time than as compared to an embodiment where the measured currents at each sampling time point are added together. Alternatively, the average of the measured currents at each sampling time required by Equations 5-10 can be multiplied by two and used without the necessity of deriving the operational coefficients as in the prior example.

[00169] Thus, as another benefit of the teaching provided herein, an increased accuracy of an analyte test measurement is heretofore is achieved as compared to the known technique which provides for a higher bias or error of ±20% for hematocrits of 30%, 42% and 55%, shown here in Figure 8A in the known test strips. Specifically, a method is provided in which a batch of test strips is provided, typically in a batch of about 845 samples (and in some cases up to 1 million samples (or test strips) per batch), introducing a referential sample containing a referential concentration of an analyte to each test strip of the batch to initiate a test sequence. The method involves reacting the analyte to cause a physical transformation of the analyte with the reagent between the two electrodes, determining a physical characteristic of the referential sample, selecting specific multiple sampling time points that are generally unaffected by the physical characteristic and determining an analyte concentration based on the multiple specific sampling time points such that at least 95% of the analyte concentration values of the batch of test strips are within ±15% of the referential analyte concentration for the range of hematocrit from about 30% to about 55% hematocrit (e.g. about 42% hematocrit), shown here in Figures 8B, 8C, 8D, 8E, 8F, and 8G.

[00170] In each of Figures 8A-8G, experiments were performed with a batch of strips (in this case about 845 strip samples) to quantify the improvement in the glucose measurements from the methods described herein. The quantification of the improvement can be shown by the "bias" at different levels of hematocrit. The bias, which is an estimate of the relative error in the glucose measurement, was calculated for each glucose concentration determined with the methods described herein. The bias for each glucose concentration was determined with equations of the form:

$$Biasabs \approx G'calculated - G_{reference}$$ for $\mathbf{G_{re}f_{er}e_{n}ce}$ less than 100 mg/dL glucose and

$$Bias_{\%} = \frac{G_{calculated} - G_{reference}}{G_{reference}}$$ for $\mathbf{G_{ref}e_{r}e_{n}c_{e}}$ greater than or equal to 100 mg/dL glucose

where $\boldsymbol{Bias_{abs}}$ is absolute bias,

$\boldsymbol{Bias_{\%}}$ is percent bias,

$\boldsymbol{G_{caicuiated}}$ is the glucose concentration determined by the method herein and

$\boldsymbol{G_{reference}}$ is the reference glucose concentration.

[00171] In Figure 8A, when the results are plotted for error or bias in the known test strips, the glucose concentrations at low hematocrits (30%) show a substantial bias of greater than 20% for glucose concentration at 100 mg/dL or greater concentrations. At the other range of hematocrit (55%), the bias again is substantially high for glucose concentrations of 100 mg/dL or greater.

[00172] In sharp contrast, when the techniques of the present invention are applied, it can be seen in Figures 8B, 8C, 8D, 8E, 8F, and 8G that glucose concentrations at extremes of hematocrits (30% or 55%) are now within the bias of +15% and -15% regardless of whether the glucose concentration is 100 mg/dL or higher.

[00173] Plotting the centroids of the glucose data against hematocrits, it can be seen that the centroids of the data define a line 1100 extending between the centroids for glucose concentrations at 30%, 42% and 55% hematocrit. Line 1100 shows a negative slope thereby indicating the variations in bias of the results at low hematocrit (30%) to high hematocrit (55%). Surprisingly, for the embodiments provided herein, it can be seen in

these figures 8B, 8C, 8D, 8E, 8F and 8G that the centroids of the glucose concentration data are generally flat at zero bias regardless of the hematocrit parameters of 30%, 42% or 55%. Specifically, with respect to Figure 8B, which uses Equation 5 as part of inventor's first new technique, line 1102 connecting the centroids of glucose data for low, medium and high hematocrits is virtually horizontal or flat. With respect to Figure 8C, which uses Equation 6 as part of the inventor's second new technique, line 1104 connecting the centroids of the data at the three hematocrit parameters is not quite as flat as line 1102. Nevertheless, the slope of line 1104 is almost insignificant when compared to line 1100 of the known technique in Figure 8A. With respect to Figure 8D, which uses Equation 7 as part of the inventor's third technique to determine the glucose concentrations, line 1106 connecting the centroids of the data is again not quite as flat as line 1102 of Fig. 8B. Nevertheless, the slope of line 1106 (Fig. 8D) is almost insignificant when compared to line 1100 of the known technique (Fig. 8A). With respect to Figure 8E, which uses Equation 8 as part of the inventor's fourth new technique to determine the glucose concentrations, line 1108 connecting the centroids of the data is virtually flat, indicating that variations in bias between extremes of hematocrit are virtually insignificant. With respect to Figures 8F and 8G, which use respective Equations 9 and 10 as part of the inventor's respective fifth and sixth new techniques, the line (1110 or 1112) connecting the centroids of the glucose concentration data (for each of the Figures 8F and 8G) is also virtually flat for each of these figures.

[00174] Applicant notes that the equations presented above which result in generation of glucose results Gi-G_6 (in respective Figs. 8B - 8G) were generated using test strip 100 (as shown generally in Figures 3A(1), 3A(5) and 3A(6)). If a test strip is used with differing sizes of the various electrodes (including the working electrodes), the division parameter (e.g. x_{10} in equation 10) must be adjusted by measuring the current outputs specific to the respective sizes of the strips and conducting regression analysis of the current outputs for adjustment of the division parameters.

[00175] Applicant further notes that while all six equations are equivalent in terms of returning an accurate glucose concentration result, they have they strong and weak points. A combination of these equations may be used to cover optimal performance across different ranges. For example, Equation 10 may be used for low glucose concentration and

Equation 5 for high glucose concentration. Alternatively, some or all of the equations may be utilized together in various permutations to allow for a derivation of a glucose concentration that account for large variations in glucose values depending on the operating parameters.

[00176] Although the techniques described herein have been directed to determination of glucose, the techniques can also applied to other analytes (with appropriate modifications by those skilled in the art) that are affected by physical characteristic(s) of the fluid sample in which the analyte(s) is disposed in the fluid sample. For example, the physical characteristic (e.g., hematocrit, viscosity, temperature or density) of a blood sample could be accounted for in determination of ketone or cholesterol in the blood sample. Other biosensor configurations can also be utilized. For example, the biosensors shown and described in the following US Patents can be utilized with the various embodiments described herein: US Patent Nos. 6179979; 6193873; 6284125; 6413410; 6475372; 6716577; 6749887; 6863801; 6890421; 7045046; 7291256; 7498132, all of which are incorporated by reference in their entireties herein.

[00177] As is known, the detection of the physical characteristic does not have to be done by alternating signals but can be done with other techniques. For example, a suitable sensor can be utilized (e.g., US Patent Application Publication No. 20100005865 or EP1804048 Bl) to determine the viscosity or other physical characteristics. Alternatively, the viscosity can be determined and used to derive for hematocrits based on the known relationship between hematocrits and viscosity as described in "Blood Rheology and Hemodynamics" by Oguz K. Baskurt, M.D., Ph.D.,1 and Herbert J. Meiselman, Sc.D., *Seminars in Thrombosis and Hemostasis,* volume 29, number 5, 2003.

[00178] As described earlier, the microcontroller or an equivalent microprocessor (and associated components that allow the microcontroller to function for its intended purpose in the intended environment such as, for example, the processor 300 in Figure 2B) can be utilized with computer codes or software instructions to carry out the methods and techniques described herein. Applicant notes that the exemplary microcontroller 300 (along with suitable components for functional operation of the processor 300) in Figure 2B is embedded with firmware or loaded with computer software representative of the logic diagrams in Figures 6A or 6B and the microcontroller 300, along with associated

connector 220 and interface 306 and equivalents thereof, are the means for: (a) determining a specified sampling time based on a sensed or estimated physical characteristic of a sample deposited on a plurality of electrodes of the test strip, the specified sampling time being at least one time point or interval referenced from a start of a test sequence upon deposition of a sample on the test strip; (b) applying a second signal to the plurality of electrodes to measure a first transient output signal from the plurality of electrodes due to application of the second signal to the plurality of electrodes; (c) extracting a second transient output signal from the first output signal; (d) determining a magnitude of the second transient output signal over a plurality of discrete time intervals; and (e) calculating the analyte concentration from the magnitudes of the second transient output signal at selected intervals of the plurality of discrete time intervals.

[00179] The means for calculating may include a microprocessor programmed to calculate the analyte concentration with any one of Equations 5-10, along with their respective parameters, as described earlier.

[00180] Moreover, while the invention has been described in terms of particular variations and illustrative figures, those of ordinary skill in the art will recognize that the invention is not limited to the variations or figures described. In addition, where methods and steps described above indicate certain events occurring in certain order, it is intended that certain steps do not have to be performed in the order described but in any order as long as the steps allow the embodiments to function for their intended purposes. Therefore, to the extent there are variations of the invention, which are within the spirit of the disclosure or equivalent to the invention found in the claims, it is the intent that this patent will cover those variations as well.

EMBODIMENTS

Thefollowing embodiments may or may not be claimed:

1. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on any one of the at least two electrodes to start an analyte test sequence;

applying a first signal to the sample to derive a physical characteristic of the sample;

driving a second signal to the sample for a first sampling time duration that overlaps with the test sequence to obtain a first transient signal output from the sample, the first transient signal correlated to both time and magnitude during the first sampling time duration;

extracting a specific sampling time during the test sequence in the first sampling time duration based on the physical characteristic of the sample;

defining a second sampling time duration based on the specific sampling time such that the second sampling time duration overlaps the first sampling time duration;

obtaining from the first transient signal a second transient signal referenced with respect to the second sampling time duration;

dividing the second transient signal into discrete intervals with respect to the second sampling time duration;

deriving respective magnitudes of the second transient signal at discrete selected intervals in the second sampling time duration; and

determining an analyte concentration based on respective magnitudes of the second transient signal at the discrete selected time intervals.

2. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on any one of the at least two electrodes to start an analyte test sequence;

applying a first signal to the sample to derive a physical characteristic of the sample;

driving a second signal to the sample for a first sampling time duration that overlaps with the test sequence to obtain a first transient signal output from the sample, the first transient signal correlated to both time and magnitude during the first sampling time duration;
extracting a specific sampling time during the test sequence in the first sampling time duration based on the physical characteristic of the sample;
obtaining from the first transient signal a second transient signal over a second sampling time duration;
deriving respective magnitudes of the second transient signal at selected intervals in the second sampling time duration; and
determining an analyte concentration based on respective magnitudes of the second transient signal at the selected time intervals.

3. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:
depositing a physiological sample on any one of the at least two electrodes to start an analyte test sequence;
applying a first signal to the sample to derive a physical characteristic of the sample;
extracting a specific sampling time in a first sampling time duration;
driving a second signal into the sample for the first sampling time duration, measuring or sampling a first transient signal output from the sample for the duration of the first sampling time duration;
defining a specific range of time that includes the specific sampling time in the first sampling time duration;
obtaining plural magnitudes of the first transient signal at respective discrete intervals within the specific range of time, and
determining the analyte concentration based on the magnitudes of the first transient signal from the obtaining step.

4. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on any one of the at least two electrodes to start an analyte test sequence;
applying a first signal to the sample to derive a physical characteristic of the sample;
extracting a specific sampling time in a first sampling time duration;
driving a second signal into the sample for the first sampling time duration, measuring or sampling a first transient signal output from the sample for the duration of the first sampling time duration;
obtaining plural magnitudes of the first transient signal output at time intervals other than at about the specific sampling time; and
determining the analyte concentration based on the plural magnitudes of the first transient signal from the obtaining step.

5. A method of demonstrating the accuracy of an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:
depositing a physiological sample on any one of the at least two electrodes to start an analyte test sequence for each of a plurality of the biosensors;
applying a first signal to the sample to derive a physical characteristic of the sample for each of the plurality of the biosensors;
extracting a specific sampling time in a first sampling time duration for each of the plurality of the biosensors;
driving a second signal into the sample for the first sampling time duration for each of a plurality of the biosensors;
measuring or sampling a first transient signal output from the sample for the duration of the first sampling time duration for each of the plurality of the biosensors;
defining a specific range of time that includes the specific sampling time in the first sampling time duration for each of the plurality of the biosensors;
obtaining plural magnitudes of the first transient signal at respective discrete intervals within the specific range of time for each of the plurality of the biosensors; and
determining the analyte concentration based on the magnitudes of the first transient signal from the obtaining step for each of the plurality of the biosensors such that an error between a plurality of analyte concentrations determined by the determining step for the plurality of the biosensors is

less than ±15% as compared to referential value at each of 30%, 42%, and 55% hematocrits.

6. The method of embodiment 3 or embodiment 5, in which the specific range of time includes magnitudes of first transient signal measured before the specific sampling time.

7. The method of one of embodiments 1, 2, 3, 4, or 5, in which the step of extracting the specific sampling time comprises calculating a defined specific sampling time in the first sampling time duration based on the physical characteristic of the sample.

8. The method of embodiment 7, in which the calculating step for the defined specific sampling time comprises utilizing an equation of the form:

$$SpecificSamplingTime = x_1 H^{x_2} + x_3$$

where

"SpecificSamplingTime" is designated as a time point from the start of the test sequence at which to sample the output signal of the biosensor,

H represents physical characteristic of the sample;

xi is about 4.3e5;

x_2 is about (—)3.9; and

x_3 is about 4.8.

9. The method of embodiment 1, in which the step of defining the second sampling time duration comprises obtaining an absolute value of a difference between the defined specific sampling time and a predetermined time point to define a start time (Tl) and an end time (T2) approximately equal to the specific sampling time point, and the first sampling time duration comprises about 10 seconds or less from the step of depositing the sample.

10. The method of embodiment 2, in which the step of obtaining further comprises defining a second sampling time duration that overlaps the first sampling time duration and includes a portion of the first transient signal and its magnitudes with respect to time of the second sampling time duration, wherein the portion is designated as a second transient signal.

11. The method of embodiment 9, in which the step of obtaining the second transient signal comprises extracting from the first transient signal a portion of the first transient signal that is designated as a second transient signal that is within the second sampling time duration.

12. The method of embodiment 11, in which the deriving of respective magnitudes of the second transient signal at discrete selected time intervals comprises calculating a magnitude of the second transient signal during each selected time interval.

13. The method of embodiment 12, in which the dividing comprises dividing the second transient signal into at least 22 intervals in sequence starting from interval one at about the start time to interval twenty-two at about the end time.

14. The method of embodiment 13, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left(\frac{|I_3|}{|I_4|}\right)^{x_1} \times \left(\frac{|I_2|+x_4|I_5|-x_5|I_1|}{|I_2|+x_4|I_5|}|I_5|\right)-x_2}{X_3}$$

where:

G is representative of analyte concentration;

$I_1 \approx$ magnitude of second transient signal at interval 17;

$I_2 \approx$ magnitude of second transient signal at interval 13;

$I_3 \approx$ magnitude of second transient signal at interval 5;

$I_4 \approx$ magnitude of second transient signal at interval 3;

$I_5 \approx$ magnitude of second transient signal at interval 22;

x_i «0.75;

$x_i \approx 337.27$;

$x_3 \approx (—)16.81$;

$x_4 \approx 1.41$; and

x_5-2.67.

15. The method of embodiment 13, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_1(|I_1|)^{\left(x_2 - \frac{x_3}{|I_2|}\right)} - x_4}{x_5}$$

where:

G is representative of analyte concentration;

$Ii \approx$ magnitude of second transient signal at interval 11;

$I_2 \approx$ magnitude of second transient signal at interval 7;

x_i -0.59;

$x_2 \approx 2.51$;

$x_3 \approx (—)12.74$;

$x_4 \sim (—)$ 188.31; and

$x_5 \sim 9.2$.

16. The method of embodiment 13, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_1 ln\left(x_2 \frac{|I_1|}{|I_2|}\right)^{x_3} |I_3|^{x_4} - x_5}{X_6}$$

where

G is representative of analyte concentration;

$Ii \approx$ magnitude of second transient signal at interval 20;

$I_2 \approx$ magnitude of second transient signal at interval 22;

$I_3 \sim$ magnitude of second transient signal at interval 19;

χ,~20.15;

x^l.0446;

x_3-0.95;

x_4-1.39;

x_5~(—)0.71; and

x_6~0.1 1.

17. The method of embodiment 13, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_3 \left|\frac{I_1}{I_2}\right|^{\left(x_1 - x_2\left|\frac{I_3}{I_4}\right|\right)} \times |I_5| - x_5}{x_4}$$

where:

G is representative of analyte concentration;

$Ii \approx$ magnitude of second transient signal at interval 5;

$I_2 \simeq$ magnitude of second transient signal at interval 1;

$I_3 \sim$ magnitude of second transient signal at interval 2;

$I_4 \simeq$ magnitude of second transient signal at interval 10;

$I_5 \simeq$ magnitude of second transient signal at interval 22;

xi-0.70;

x^0.49;

x_3-28.59;

x^-0.7; and

x_5~15.51.

18. The method of embodiment 13, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^2 + x_3|I_3| + x_4}{x_5|I_4| + x_6}\right) - x_7}{x_8}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 19;

I_2 ≈ magnitude of second transient signal at interval 16;

I_3 ~ magnitude of second transient signal at interval 11;

I_4 ≈ magnitude of second transient signal at interval 5;

x_{1} (—)1·68;

x_2-0.95;

x_3≈(—)4.97;

x_4~6.29;

x_5~3.08;

x_6≈(—)5.84;

x_7~(—)0.47; and

xs~0.01.

19. The method of embodiment 13, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^3 + x_3|I_3|^2 + x_4|I_3| + x_5}{x_6|I_4|^2 + x_7|I_4| + x_8}\right) - x_9}{x_{10}}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 16;

I_2 ≈ magnitude of second transient signal at interval 5;

I_3 ~ magnitude of second transient signal at interval 12;

I_4 ≈ magnitude of second transient signal at interval 14;

x_1 ~1.18;

x^0.97;

x_3 ~(—) 1 1.32;

x_4 ~38.76;

x_5 ~(—)39.32;

x_6 ~0.0928;

x_7 « (—)0.85;

xs~1.75;

x_9 ~(—)9.38; and

x_{10} ~0.25.

20. The method of any one of embodiments 14-19, in which the magnitude of the second transient signal at each of the plurality of discrete intervals comprises an average magnitude of measured magnitudes at each discrete interval.

21. The method of any one of embodiment 1, embodiment 2, embodiment 3, embodiment 4 or embodiment 5, in which the applying of the first signal and the driving of the second signal is in sequential order.

22. The method of any one of embodiment 1, embodiment 2, embodiment 3, embodiment 4, or embodiment 5 in which the applying of the first signal overlaps with the driving of the second signal.

23. The method of any one of embodiment 1, embodiment 2, embodiment, 3, embodiment 4, or embodiment 5 in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

24. The method of any one of embodiment 1, embodiment 2, or embodiment, 3, embodiment 4, or embodiment 5 in which the applying of the first signal comprises directing an optical signal

to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

25. The method of embodiment 24, in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

26. The method of any one of embodiment 1, embodiment 2, or embodiment, 3, embodiment 4, or embodiment 5 in which the physical characteristic comprises at least one of viscosity, hematocrit, temperature or density of the sample.

27. The method of embodiment 23, in which the directing comprises driving first and second alternating signals at different respective frequencies in which a first frequency comprises a frequency than the second frequency.

28. The method of embodiment 27, in which the first frequency is at least one order of magnitude lower than the second frequency.

29. The method of embodiment 28, in which the first frequency comprises any frequency in the range of about 10kHz to about 250kHz.

30. The method of embodiment 2, in which the obtaining comprises extracting from the first transient signal a second transient signal referenced with respect to the second sampling time duration.

31. The method of embodiment 1 or embodiment 2, in which the obtaining comprises removing signals from the first transient signals that are outside of the second sampling time duration to leave the second transient signal within the second sampling time duration.

32. The method of one of embodiment 30 or 31, in which the deriving comprises storing magnitudes of the second transient signal for each discrete interval in the second sampling time duration.

33. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes disposed on the substrate and connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence,

the microprocessor is configured to:

(a) apply a first signal to the plurality of electrodes so that a physical characteristic of the sample is derived to provide a specific sampling time,

(b) apply a second signal to the plurality of electrodes,

(c) measure a first transient output signal from the plurality of electrodes;

(d) extract a second transient output signal from the first output signal;

(e) determine a magnitude of the second transient output signal over a plurality of discrete time intervals; and

(f) calculate the analyte concentration from the magnitudes of the second transient output signal at selected intervals of the plurality of discrete time intervals.

34. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes disposed on the substrate and connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence,

the microprocessor is configured to:

(a) apply a first signal to the plurality of electrodes so that a physical characteristic of the sample is derived to provide a specific sampling time,

(b) apply a second signal to the plurality of electrodes,

(c) measure a first transient output signal from the plurality of electrodes;

(d) extract a second transient output signal from the first output signal;

(e) determine a magnitude of the second transient output signal over a plurality of discrete time intervals; and

(f) calculate the analyte concentration from the magnitudes of the second transient output signal at selected intervals of the plurality of discrete time intervals to annunciate the analyte concentration within about 10 seconds of a start of the test sequence.

35. The system of embodiment 33 or embodiment 34, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

36. The system of embodiment 35, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

37. The system of embodiment 35, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

38. The system of embodiment 37, in which the different chambers are disposed adjacent to each other on an edge of the substrate.

39. The system of embodiment 35, in which the at least two electrodes and the at least two other electrodes are disposed in a common chamber that receives a fluid sample.

40. The system of embodiment 33 or embodiment 34, in which the plurality of electrodes comprises two electrodes to measure the physical characteristic and the analyte concentration.

41. The system of one of embodiments 33-40, in which all of the electrodes are disposed on the same plane defined by the substrate.

42. The system of one of embodiments 35-39, in which a reagent is disposed proximate the at least two other electrodes and no reagent is disposed on the at least two electrodes.

43. The system of embodiment 33 or embodiment 34, in which the specific sampling time is calculated using an equation of the form:

$$SpecificSamplingTime = x_1 H^{x_2} + x_3$$

where

"SpecificSamplingTime" is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

H represents physical characteristic of the sample;

x_i represents about 4.3e5;

x_2 represents about (—)3.9; and

x_3 represents about 4.8.

44. The system of any one of embodiments 33, 34, or 41, in which the plurality of discrete time intervals comprises at least 22 discrete time intervals.

45. The system of embodiment 44, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\frac{|I_3|}{|I_4|}\right)^{x_1} \times \left(\frac{|I_2|+x_4|I_5|-x_5|I_1|}{|I_2|+x_4|I_5|}|I_5|\right)-x_2}{x_3}$$

where:

G is representative of analyte concentration;

$1_1 \approx$ magnitude of second transient signal at interval 17;

$1_2 \sim$ magnitude of second transient signal at interval 13;

$1_3 \sim$ magnitude of second transient signal at interval 5;

$1_4 \approx$ magnitude of second transient signal at interval 3;

$Is \approx$ magnitude of second transient signal at interval 22;

x_i«0.75;

xi≈337.27;

$x_3 \approx$ (—)16.81;

$x_4 \approx$l .41; and

x_5-2.67.

46. The system of embodiment 44, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_1(|I_1|)^{\left(x_2-\frac{x_3}{|I_2|}\right)}-x_4}{x_5}$$

where:

G is representative of analyte concentration;

$Ii \approx$ magnitude of second transient signal at interval 11;

$I_2 \approx$ magnitude of second transient signal at interval 7;

x_i-0.59;

$x_2 \approx$2.5l;

$x_3 \approx$(—)12.74;

x_4~{—) 188.31; and

x_5~9.2.

47. The system of embodiment 44, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_1 ln\left(x_2 \frac{|I_1|}{|I_2|}\right)^{x_3} |I_3|^{x_4 - x_5}}{x_6}$$

where

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 20;

I_2 ≈ magnitude of second transient signal at interval 22;

I_3 ~ magnitude of second transient signal at interval 19;

x,~20.15;

x^l.0446;

x_3-0.95;

x_4~1.39;

x_5~(—)0.71; and

x_6~0.1 1.

48. The system of embodiment 44, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_3 \left|\frac{I_1}{I_2}\right|^{\left(x_1 - x_2\left|\frac{I_3}{I_4}\right|\right)} \times |I_5| - x_5}{x_4}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 5;

I_2 ~ magnitude of second transient signal at interval 1;

I_3 ~ magnitude of second transient signal at interval 2;

I_4 ≈ magnitude of second transient signal at interval 10;

I_5 ~ magnitude of second transient signal at interval 22;

x_i -0.70,

x^0.49,

x_3-28.59,

x_4≈0.1 , and

x_5~15.51.

49. The system of embodiment 44, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^2+x_3|I_3|+x_4}{x_5|I_4|+x_6}\right)-x_7}{x_8}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 19;

I_2 ~ magnitude of second transient signal at interval 16;

I_3 ~ magnitude of second transient signal at interval 11;

I_4 ~ magnitude of second transient signal at interval 5;

x_{1} (—)1.68;

x_2-0.95;

x_3≈(—)4.97;

x_4≈6.29;

x_5~3.08;

x_6~(—)5.84;

x_7~(—)0.47; and

xs~0.01.

50. The system of embodiment 44, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^3 + x_3|I_3|^2 + x_4|I_3| + x_5}{x_6|I_4|^2 + x_7|I_4| + x_8}\right) - x_9}{X_{10}}$$

where:

G is glucose concentration;

I_1 ~ magnitude of second transient signal at interval 16;

I_2 ~ magnitude of second transient signal at interval 5;

I_3 ~ magnitude of second transient signal at interval 12;

I_4 ~ magnitude of second transient signal at interval 14;

x_1~1.18;

x^0.97;

x_3~(—)11.32;

x_4-38.76;

x_5~(—)39.32;

x_6~0.0928;

x_7~(—)0.85;

xs~1.75;

x_9~(—)9.38; and

x_{10}~0.25.

51. The system of any one of embodiments 33-50, in which the magnitude of the second transient signal at each of the plurality of discrete time intervals comprises an average magnitude of the signal sampled throughout each interval.

52. The system of any one of embodiments 43-50, in which an error between a plurality of analyte concentrations calculated by the microprocessor is less than ±15% as compared to referential value at 30% hematocrits.

53. The system of any one of embodiments 43-50, in which an error between the plurality of analyte concentrations calculated by the microprocessor is less than ±15% as compared to referential value at 42% hematocrits.

54. The system of any one of embodiments 43-50, in which an error between a plurality of analyte concentrations calculated by the microprocessor is less than ±15% as compared to referential value at 55% hematocrits.

55. The method of embodiment 2, further comprising the step of dividing the second transient signal into discrete intervals with respect to the second sampling time duration.

56. The method of embodiment 3, further comprising the step of dividing the first transient signal into discrete intervals with respect to the specific range of time.

57. The method of embodiment 5, further comprising dividing the first transient signal into discrete intervals with respect to the specific range of time.

58. The method or system of any one of the embodiments from 1-57, in which the physical characteristic represented by H is generally equal to an impedance characteristic determined by an equation of the form:

$$IC = M^2 * y_1 + M * y_2 + y_3 + P^2 * y_4 + P * y_5$$

where: IC represents an impedance characteristic;

M represents a magnitude | Z | of a measured impedance in ohms);

P represents a phase difference between the input and output signals (in degrees)

yi is about -3.2e-08;

y_2 is about 4.1e-03;

y_3 is about -2.5e+01;

y_4 is about 1.5e-01; and

y_5 is about 5.0.

59. The method or system of any one of the embodiments from 1-57, in which the physical characteristic represented by H is generally equal to an impedance characteristic determined by an equation of the form:

$$IC = \frac{-y_2 + \left|\sqrt{y_2^2 - \left(4y_3\left(y_1 - M\right)\right)}\right|}{2y_1}$$

where:

IC represents the Impedance Characteristic [%]

M represents the magnitude of impedance [Ohm]

y_i is about 1.2292el

y_2 is about -4.3431e2

y_3 is about 3.5260e4.

ADDITIONAL ASPECTS OF THE DISCLOSURE

Section "A"

The following aspects, which were originally presented in US Provisional Patent Application Serial No. 61/581,087 (Attorney Docket No. DDI5220USPSP), form part of the present disclosure:

1. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to measure a physical characteristic of the sample;

deriving a batch slope for the reagent based on the measured physical characteristic from an equation of the form:

$$x = aH^2 + bH + c$$

where x represents a derived batch slope;

H is measured or estimated hematocrit;

a represents aboutl.4e-6,

b represents about-3.8e-4,

c represents about3.6e-2;

driving a second electrical signal to the sample; and

measuring an output current from at least one of the at least two electrodes;

calculating an analyte concentration based on the measured output current and derived batch slope with an equation of the form:

$$G_0 = \left[\frac{I_E - Intercept}{x} \right]$$

where

Go represents an analyte concentration
IE represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at a predetermined time;
Intercept represents calibration parameter for a batch of biosensors;
x represents a derived batch slope from the deriving step.

2. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to measure a physical characteristic of the sample;

deriving a batch slope for the reagent based on the measured physical characteristic;

driving a second electrical signal to the sample; and

measuring an output current from at least one of the at least two electrodes;

calculating an analyte concentration based on the measured output current and derived batch slope from the measured physical characteristic of the sample.

3. The method of aspect A1 or aspect A2, in which the applying of the first signal and the driving of the second signal is in sequential order.

4. The method of aspect A1 or aspect A2, in which the applying of the first signal overlaps with the driving of the second signal.

5. The method of aspect A1 or aspect A2, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

6. The method of aspect A1 or aspect A2, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

7. The method of one of aspect A5 or aspect A6, in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

8. The method of one of aspect A5 or aspect A6, in which the physical characteristic comprises at least one of viscosity, hematocrit, and density of the sample.

9. The method of aspect A5, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

10. The method of aspect A9, in which the first frequency is at least one order of magnitude lower than the second frequency.

11. The method of aspect A10, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.

12. The method of aspect A2, in which the deriving comprises calculating a batch slope from an equation of the form:

$$x = aH^{9} + bH + c$$

where x represents a derived batch slope from the deriving step;
H is measured or estimated hematocrit; a represents aboutl.4e-6, b represents about-3.8e-4, c represents about3.6e-2.

13. The method of aspect A12, in which the calculating of the analyte concentration comprises utilizing an equation of the form:

$$G_0 = \left[\frac{I_E - Intercept}{x} \right]$$

where

Go represents an analyte concentration

IE represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at a predetermined time of about 5 seconds after a start of the test sequence;

Intercept represents calibration parameter for a batch of biosensors;

x represents a derived batch slope from the deriving step.

14. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence, the microprocessor is configured to, during the test sequence,: (a) apply a first electrical signal to the plurality of electrodes so that batch slope defined by a physical characteristic of a physiological fluid sample is derived and (b) apply a second electrical signal to the plurality of electrodes so that an analyte concentration is determined based on the derived batch slope.

15. The system of aspect A14, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

16. The system of aspect A14, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

17. The system of aspect A14, in which the at least two electrodes and the at least two other

electrodes are disposed in different chambers provided on the substrate.

18. The system of aspect A14, in which the at least two electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.

19. The system of one of aspects A16, A17, or A18, in which all of the electrodes are disposed on the same plane defined by the substrate.

20. The system of one of aspect A17 or aspect A18, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.

21. The system of aspect A14, in which the batch slope is calculated from an equation of the form:

$$x = aH^2 + bH + c$$

where x represents a derived batch slope from the deriving step;

H represents measured or estimated hematocrit; a represents aboutl.4e-6, b represents about-3.8e-4, c represents about3.6e-2.

22. The system of aspect A21, in which the analyte concentration is determined from an equation of the form:

$$G_0 = \left[\frac{I_E - Intercept}{x} \right]$$

where

G_0 represents an analyte concentration

I_E represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at a predetermined time;

Intercept represents calibration parameter for a batch of test strips;

x represents a derived batch slope from the deriving step.

23. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes, the microprocessor is configured to, during a test sequence: (a) apply a first electrical signal to the plurality of electrodes so that batch slope defined by a physical characteristic of a physiological fluid sample is derived and (b) apply a second electrical signal to the plurality of electrodes so that an analyte concentration is determined based on the derived batch slope obtained from the physical characteristic of the sample within about 10 seconds of a start of the test sequence.

24. The system of aspect A23, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

25. The system of aspect A23, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

26. The system of aspect A23, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

27. The system of aspect A23, in which the at least two electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.

28. The system of one of aspects A24, A25, or A26, in which all of the electrodes are disposed on the same plane defined by the substrate.

29. The system of one of aspect A23 or aspect A24, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.

30. The system of aspect A23, in which the batch slope is calculated from an equation of the form:

$$x = aH^2 + bH + c$$

where x represents a derived batch slope from the deriving step;

H represents measured or estimated hematocrit; a represents aboutl.4e-6, b represents about-3.8e-4, c represents about3.6e-2.

31. The system of aspect A30, in which analyte concentration is calculated from an equation of the form:

$$G_0 = \left[\frac{I_E - Intercept}{x} \right]$$

where

G_0 represents an analyte concentration

I_E represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at a predetermined time;

Intercept represents calibration parameter for a batch of test strips;

x represents a derived batch slope from the deriving step.

32. A method of obtaining increased accuracy of a test strip, the method comprising:

providing for a batch of test strips;

introducing a referential sample containing a referential concentration of an analyte to each of the batch of test strips to initiate a test sequence;

reacting the analyte with a reagent on the test strip to cause a physical transformation of the analyte between the two electrodes;

determining a physical characteristic of the referential sample;

deriving a batch slope for the batch of test strips based on the determined physical characteristics of the referential sample;

sampling an electrical output of the referential sample at a predetermined time point during the test sequence;

calculating an analyte concentration based on the defined batch slope and sampled electrical output to provide for a final analyte concentration value for each of the batch of test strips such that at least 95% of the final analyte concentration values of the batch of test strips are within ±15% of the referential analyte concentration.

33. The method of aspect A32, in which the applying of the first signal and the driving of the second signal is in sequential order.

34. The method of aspect A32, in which the applying of the first signal overlaps with the driving of the second signal.

35. The method of aspect A32, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

36. The method of aspect A32, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

37. The method of one of aspect A35 or aspect A36 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

38. The method of one of aspect A35 or aspect A36 in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.

39. The method of aspect A34, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

40. The method of aspect A39, in which the first frequency is at least one order of magnitude lower than the second frequency.

41. The method of aspect A40, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.

42. The method of aspect A32, in which the deriving comprises calculating a batch slope from an equation of the form:

$$x = aH^2 + bH + c$$

where x represents a derived batch slope from the deriving step;
H represents measured or estimated hematocrit; a represents aboutl.4e-6, b represents about-3.8e-4, c represents about3.6e-2.

43. The method of aspect A42, in which the calculating of the analyte concentration comprises utilizing an equation of the form:

$$G_0 = \left[\frac{I_E - Intercept}{x} \right]$$

where

G_0 represents an analyte concentration
I_E represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at a predetermined time;

Intercept represents calibration parameter for a batch of test strips;
x represents a derived batch slope from the deriving step.

44. A method of determining an analyte concentration from a physiological sample, the method comprising:

depositing a physiological sample on a biosensor;

applying electrical signals to the sample to transform the analyte into a different material;

measuring a physical characteristic of the sample;

evaluating signal output from the sample;

deriving a parameter of the biosensor from the measured physical characteristic; and

determining an analyte concentration based on the derived parameter of the biosensor and the signal output of the sample.

45. The method of aspect A44, in which the measuring comprises applying a first electrical signal to the sample to measure a physical characteristic of the sample.

46. The method of aspect A44, in which the evaluating comprises driving a second electrical signal to the sample.

47. The method of aspect A46, in which the applying of the first signal and the driving of the second signal is in sequential order.

48. The method of aspect A46, in which the applying of the first signal overlaps with the driving of the second signal.

49. The method of aspect A46, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

50. The method of aspect A44, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an

output of the optical signal.

51. The method of one of aspect A49 or aspect A50 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

52. The method of one of aspect A49 or aspect A50 in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.

53. The method of aspect A49, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

54. The method of aspect A53, in which the first frequency is at least one order of magnitude lower than the second frequency.

55. The method of aspect A54, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.

56. The method of aspect A44, in which the deriving comprises calculating a batch slope from an equation of the form:

$$x = aH^2 + bH + c$$

where x represents a derived batch slope from the deriving step;
H represents measured or estimated hematocrit; a represents about 1.4e-6, b represents about -3.8e-4, c represents about 3.6e-2.

57. The method of aspect A56, in which the calculating of the analyte concentration comprises utilizing an equation of the form:

$$G_0 = \left[\frac{I_E - Intercept}{x} \right]$$

where

Go represents an analyte concentration

IE represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at a predetermined time;

Intercept represents calibration parameter for a batch of test strips;

x represents a derived batch slope from the deriving step.

Section "B"

The following aspects, which were originally presented in US Provisional Patent Application Serial No. 61/581,089 (Attorney Docket No. DDI5220USPSP1), form part of the present disclosure:

1. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to derive a physical characteristic of the sample;

obtaining a physical characteristic of the sample;

specifying a sampling time based on the obtained physical characteristic;

driving a second electrical signal to the sample; and

measuring an output current at the specified sampling time from at least one electrode of the at least two electrodes;

calculating an analyte concentration based on the measured output current.

2. The method of aspect Bl, in which the applying of the first signal and the driving of the second signal is in sequential order.

3. The method of aspect Bl, in which the applying of the first signal overlaps with the driving of the second signal.

4. The method of aspect Bl, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

5. The method of aspect Bl, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

6. The method of one of aspect B4 or aspect B5 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

7. The method of aspect B1, in which the physical characteristic comprises at least one of viscosity, hematocrit, and density of the sample.

8. The method of aspect B4, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

9. The method of aspect B8, in which the first frequency is at least one order of magnitude lower than the second frequency.

10. The method of aspect B9, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.

11. The method of aspect Bl, in which the specified sampling time is calculated using an equation of the form:

$$SpecifiedSamplingTime = x_1 H^{X2} + x_3$$

where *"SpecifiedSamplingTime"* is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

H represents physical characteristic of the sample in the form of hematocrit;

x_i is about 4.3e5;

x_2 is about -3.9; and

x_3 is about 4.8.

12. The method of aspect B11, in which the calculating of the analyte concentration is computed with an equation of the form: $G_0 = \left[\frac{I_E - Intercept}{Slope} \right]$

where

G_0 represents an analyte concentration

I_E represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at the *SpecifiedSamplingTime;*

Slope represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

13. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to

apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence, the microprocessor is configured to, during the test sequence,: (a) apply a first electrical signal to the plurality of electrodes so that a specific sampling time point is determined from a physical characteristic of a physiological fluid sample is derived, (b) apply a second electrical signal to the plurality of electrodes, and (c) measure a current output from one of the plurality of electrodes at the specified sampling time point so that an analyte concentration is determined.

14. The system of aspect B13, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

15. The system of aspect B14, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

16. The system of aspect B14, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

17. The system of aspect B14, in which the at least two electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.

18. The system of one of aspects B15, B16, or B17, in which all of the electrodes are disposed on the same plane defined by the substrate.

19. The system of one of aspect B16 or aspect B17, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.

20. The system of aspect B13, in which the specified sampling time is calculated using an equation of the form:

$$SpecifiedSamplingTime = x_1 H^{X2} + x_3$$

where *"SpecifiedSamplingTime"* is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

H represents physical characteristic of the sample in the form of hematocrit;

x_i represents about 4.3e5;

x_2 represents about -3.9; and

x_3 represents about 4.8.

21. The system of aspect B20, in which the analyte concentration is determined from an equation of the form: $G_0 = \left[\frac{I_E - Intercept}{Slope} \right]$

where

G_0 represents an analyte concentration

I_E represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at the *SpecifiedSamplingTime;*

Slope represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

22. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes, the

microprocessor is configured to, during a test sequence: (a) apply a first electrical signal to the plurality of electrodes so that a specific sampling time point is determined from a physical characteristic of a physiological fluid sample is derived , (b) apply a second electrical signal to the plurality of electrodes, and (c) measure a current output from one of the plurality of electrodes at the specified sampling time point so that an analyte concentration of the sample is determined based on the specific sampling time point within about 10 seconds of a start of the test sequence.

23. The system of aspect B22, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

24. The system of aspect B23, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

25. The system of aspect B23, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

26. The system of aspect B23, in which the at least two electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.

27. The system of one of aspects B23, B24, B25, or B26, in which all of the electrodes are disposed on the same plane defined by the substrate.

28. The system of one of aspect B22 or aspect B23, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.

29. The system of aspect B22, in which the specified sampling time is calculated using an equation of the form:

$$SpecifiedSamplingTime = x_1 H^{X2} + x_3$$

where *"SpecifiedSamplingTime"* is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

H represents physical characteristic of the sample in the form of hematocrit;

x_i represents about 4.3e5;

x_2 represents about -3.9; and

x_3 represents about 4.8.

30. The system of aspect B29, in which analyte concentration is calculated from an equation of the form: $G_0 = \left[\frac{I_E - Intercept}{Slope} \right]$

where

G_0 represents an analyte concentration

I_E represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at the *SpecifiedSamplingTime;*

Slope represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

31. A method of determining an analyte concentration from a physiological sample, the method comprising:

depositing a physiological sample on a biosensor having a reagent deposited thereon;

applying electrical signals to the sample and the reagent to transform the analyte into a different material;

obtaining a physical characteristic of the sample;

specifying a time point for sampling of current output based on the obtained physical characteristic;

measuring signal output at the specified sampling time point; and

determining an analyte concentration based the measured signal output of the sample.

32. The method of aspect B31, in which the obtaining comprises driving a second electrical signal to the sample to derive a physical characteristic of the sample.

33. The method of aspect B44, in which the applying comprises applying a first electrical signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal and the driving of the second signal is in sequential order.

34. The method of aspect B33, in which the applying of the first signal overlaps with the driving of the second signal.

35. The method of aspect B33, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

36. The method of aspect B33, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

37. The method of one of aspect B35 or aspect B36 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

38. The method of one of aspect B36 or aspect B37 in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.

39. The method of aspect B36, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

40. The method of aspect B39, in which the first frequency is at least one order of magnitude

lower than the second frequency.

41. The method of aspect B40, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.

42. The method of aspect B31, in which the specified sampling time is calculated using an equation of the form:

$$SpecifiedSamplingTime = x_1 H^{X2} + x_3$$

where *"SpecifiedSamplingTime"* is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

H represents physical characteristic of the sample in the form of hematocrit;

x_1 represents about 4.3e5;

x_2 represents about -3.9; and

x_3 represents about 4.8.

43. The method of aspect B42, in which the calculating of the analyte concentration comprises utilizing an equation of the form: $G_0 = \left[\frac{I_E - Intercept}{Slope} \right]$

where

G_0 represents an analyte concentration

I_E represents a current (proportional to analyte concentration) determined from the sum of the end currents measured at the *SpecifiedSamplingTime;*

Slope represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

Section "C"

The following aspects, which were originally presented in US Provisional Patent Application Serial No. 61/581,099(Attorney Docket No. DDI5220USPSP2), form part of the present disclosure:

1. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to derive a physical characteristic of the sample;

obtaining a physical characteristic of the sample;

specifying a sampling time based on the physical characteristic from the obtaining step;

deriving a batch slope for the reagent based on the physical characteristic from the obtaining step;

driving a second electrical signal to the sample; and

measuring an output signal at the specified sampling time from at least one electrode of the at least two electrodes;

calculating an analyte concentration based on the measured output signal at the specified sampling time and the derived batch slope.

2. The method of aspect CI, in which the applying of the first signal and the driving of the second signal is in sequential order.

3. The method of aspect CI, in which the applying of the first signal overlaps with the driving of the second signal.

4. The method of aspect CI, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from

an output of the alternating signal.

5. The method of aspect CI, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

6. The method of one of aspect C4 or aspect C5 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

7. The method of aspect CI, in which the physical characteristic comprises at least one of viscosity, hematocrit, and density of the sample.

8. The method of aspect C4, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

9. The method of aspect C8, in which the first frequency is at least one order of magnitude lower than the second frequency.

10. The method of aspect C9, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.

11. The method of aspect CI, in which the specified sampling time is calculated using an equation of the form: $SpecifiedSamplingTime = x_1 H^{x_2} + x_3$

where *"SpecifiedSamplingTime"* is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,
H represents physical characteristic of the sample in the form of hematocrit;
xi is about 4.3e5;

x_2 is about -3.9; and

x_3 is about 4.8.

12. The method of aspect CI 1, in which the derived slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where H is measured or estimated physical characteristic (e.g., hematocrit);

a is about 1.35e-6,

b is about -3. 79e-4,

c is about 3.5 6e-2.

13. The method of aspect CI2, in which the calculating of the analyte concentration is computed with an equation of the form: $G_0 = \left[\frac{I_E - Intercept}{NewSlope}\right]$

where

G_0 represents an analyte concentration

I_E represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at the *SpecifiedSamplingTime;*

NewSlope represents the value derived from the measured physical characteristic; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

14. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode

connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence, the microprocessor is configured to, during the test sequence,: (a) apply a first electrical signal to the plurality of electrodes so that a specific sampling time point and a batch slope are determined from a physical characteristic of a physiological fluid sample are derived, (b) apply a second electrical signal to the plurality of electrodes, and (c) measure a signal output from one of the plurality of electrodes at the specified sampling time point so that an analyte concentration is determined based on the measured signal at the specified time point and the batch slope.

15. The system of aspect CI4, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

16. The system of aspect CI5, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

17. The system of aspect CI5, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

18. The system of aspect CI5, in which the at least two electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.

19. The system of one of aspects CI6, CI7, or CI8, in which all of the electrodes are disposed on the same plane defined by the substrate.

20. The system of one of aspect CI7 or aspect CI8, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.

21. The system of aspect CI4, in which the specified sampling time is calculated using an equation of the form: $SpecifiedSamplingTime = x_1 H^{x_2} + x_3$

where *"SpecifiedSamplingTime"* is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

H represents physical characteristic of the sample in the form of hematocrit;

x_1 represents about 4.3e5;

x_2 represents about -3.9; and

x_3 represents about 4.8.

22. The method of aspect C21, in which the derived slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where H is measured or estimated physical characteristic (e.g., hematocrit);

a is about 1.35e-6,

b is about -3. 79e-4,

c is about 3.5 6e-2.

23. The method of aspect C22, in which the calculating of the analyte concentration is computed with an equation of the form: $G_0 = \left[\frac{I_E - Intercept}{NewSlope} \right]$

where

G_0 represents an analyte concentration

I_E represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at the *SpecifiedSamplingTime;*

NewSlope represents the value derived from the measured physical characteristic; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

24. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes, the microprocessor is configured to, during a test sequence:

(a) apply a first electrical signal to the plurality of electrodes so that a specific sampling time point and a batch slope of the test strip are determined from a physical characteristic of a physiological fluid sample is derived,

(b) apply a second electrical signal to the plurality of electrodes, and

(c) measure a signal output from one of the plurality of electrodes at the specified sampling time point so that an analyte concentration of the sample is determined based on the specific sampling time point and batch slope within about 10 seconds of a start of the test sequence.

25. The system of aspect C24, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

26. The system of aspect C24, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

27. The system of aspect C24, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

28. The system of aspect C24, in which the at least two electrodes comprise two electrodes to

measure the physical characteristic and the analyte concentration.

29. The system of one of aspects C24, C25, C26, or C27, in which all of the electrodes are disposed on the same plane defined by the substrate.

30. The system of one of aspect C23 or aspect C24, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.

31. The system of aspect C24, in which the specified sampling time is calculated using an equation of the form: $SpecifiedSamplingTime = x_1 H^{x_2} + x_3$

where *"SpecifiedSamplingTime"* is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,
H represents physical characteristic of the sample in the form of hematocrit;
x_1 represents about 4.3e5;
x_2 represents about -3.9; and
x_3 represents about 4.8.

32. The system of aspect C31, in which the derived slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where ***NewSlope*** *represents the derived slope;*
His measured or estimated physical characteristic (e.g., hematocrit);
a is about 1.35e-6,
b is about -3.79e-4,
c is about 3.56e-2.

33. The method of aspect C32, in which the calculating of the analyte concentration is

computed with an equation of the form: $G_0 = \left[\frac{I_E - Intercept}{NewSlope} \right]$

where

G_0 represents an analyte concentration

I_E represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at the *SpecifiedSamplingTime;*

NewSlope represents the value derived from the measured physical characteristic; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

34. A method of obtaining increased accuracy of a test strip, the method comprising:

providing for a batch of test strips;

introducing a referential sample containing a referential concentration of an analyte to each of the batch of test strips to initiate a test sequence;

reacting the analyte to cause a physical transformation of the analyte between the two electrodes;

determining a physical characteristic of the referential sample;

deriving a batch slope of the batch of test strips based on the determined physical characteristic;

sampling an electrical output of the referential sample at a specified time point during the test sequence defined by the measured physical characteristic;

calculating an analyte concentration based on the specified time point and the derived batch slope to provide for a final analyte concentration value for each of the batch of test strips such that at least 95% of the final analyte concentration values of the batch of test strips are within ±15% of the referential analyte concentration.

35. The method of aspect C34, in which the reacting comprises driving a second electrical signal to the sample and the determining comprises applying a first electrical signal to the sample

to derive a physical characteristic of the sample, and the applying of the first signal and the driving of the second signal is in sequential order.

36. The method of aspect C35, in which the applying of the first signal overlaps with the driving of the second signal.

37. The method of aspect C34, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

38. The method of aspect C34, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

39. The method of one of aspect C37 or aspect C38 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

40. The method of one of aspect C37 or aspect C38 in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.

41. The method of aspect C37, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

42. The method of aspect C41, in which the first frequency is at least one order of magnitude lower than the second frequency.

43. The method of aspect C41, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.

44. The method of aspect C34, in which the specified sampling time is calculated using an

equation of the form: $SpecifiedSamplingTime = \chi_1 H^{X_2} + x_3$

where *"SpecifiedSamplingTime"* is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

H represents physical characteristic of the sample in the form of hematocrit;

x_i represents about 4.3e5;

x_2 represents about -3.9; and

x_3 represents about 4.8.

45. The method of aspect C44, in which the derived slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where H is measured or estimated physical characteristic (e.g., hematocrit);

a is about 1.35e-6,

b is about -3. 79e-4,

c is about 3.5 6e-2.

46. The method of aspect C45, in which the calculating of the analyte concentration is computed with an equation of the form: $G_0 = \left[\frac{I_E - Intercept}{NewSlope} \right]$

where

G_0 represents an analyte concentration

I_E represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at the *SpecifiedSamplingTime;*

NewSlope represents the value derived from the measured physical characteristic; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

47. A method of determining an analyte concentration from a physiological sample, the method comprising:

depositing a physiological sample on a biosensor having a reagent deposited thereon;

applying electrical signals to the sample and the reagent to transform the analyte into a different material;

obtaining a physical characteristic of the sample;

specifying a time point for sampling of signal output based on the physical characteristic from the specifying step;

deriving a batch slope of the biosensor;

measuring signal output at the specified sampling time point; and

determining an analyte concentration based on the measured signal output of the sample at the specified sampling time point and the derived batch slope.

48. The method of aspect C47, in which the obtaining comprises driving a second electrical signal to the sample to derive a physical characteristic of the sample.

49. The method of aspect C48, in which the applying comprises applying a first electrical signal to the sample to derive a physical characteristic of the sample, and the applying of the first signal and the driving of the second signal is in sequential order.

50. The method of aspect C49, in which the applying of the first signal overlaps with the driving of the second signal.

51. The method of aspect C50, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

52. The method of aspect C50, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

53. The method of one of aspect C51 or aspect C52 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

54. The method of one of aspect C52 or aspect C53 in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.

55. The method of aspect C53, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

56. The method of aspect C55, in which the first frequency is at least one order of magnitude lower than the second frequency.

57. The method of aspect C56, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.

58. The method of aspect C47, in which the specified sampling time is calculated using an equation of the form: $SpecifiedSamplingTime = x_1 H^{x_2} + x_3$

where *"SpecifiedSamplingTime"* is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,
H represents physical characteristic of the sample in the form of hematocrit;
x_1 represents about 4.3e5;
x_2 represents about -3.9; and
x_3 represents about 4.8.

59. The method of aspect C58, in which the derived slope is determined from an equation of the form:

$$NewSlope = aH^2 + bH + c$$

where H is measured or estimated physical characteristic (e.g., hematocrit);

a is about 1.35e-6,

b is about -3. 79e-4,

c is about 3.5 6e-2.

60. The method of aspect C59, in which the calculating of the analyte concentration is computed with an equation of the form: $G_0 = \left[\frac{I_E - Intercept}{NewSlope} \right]$

where

G_0 represents an analyte concentration

$\mathbf{I_E}$ represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at the *SpecifiedSamplingTime;*

NewSlope represents the value derived from the measured physical characteristic; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

61. The method or system of respective one of aspects C12, C22, C32, C44, or C59, in which *a* is about -1.98e-6; b is about -2.87e-5; and *c* is about 2.67e-2.

Section "D"

The following aspects, which were originally presented in US Provisional Patent Application Serial No. 61/581,100 (Attorney Docket No. DDI5221USPSP), form part of the present disclosure:

1. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to measure a physical characteristic of the sample;

driving a second electrical signal to the sample to cause an enzymatic reaction of the analyte and the reagent;

estimating an analyte concentration based on a predetermined sampling time point from the start of the test sequence;

selecting a sampling time point from a look-up table that includes a matrix in which different qualitative categories of the estimated analyte are set forth in the leftmost column of the matrix and different qualitative categories of the measured physical characteristic are set forth in the topmost row of the matrix and the sampling times are provided in the remaining cells of the matrix;

measuring signal output from the sample at the selected sampling time point from the look-up table;

calculating an analyte concentration from measured output signal sampled at said selected sampling time point in accordance with an equation of the form:

$$G_0 = \left[\frac{I_T - Intercept}{Slope} \right]$$

where G_0 represents an analyte concentration;

I_T represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at a specified sampling time T;

Slope represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from.

2. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to measure a physical characteristic of the sample;

driving a second electrical signal to the sample to cause an enzymatic reaction of the analyte and the reagent;

estimating an analyte concentration based on a predetermined sampling time point from the start of the test sequence;

selecting a sampling time point based on both the measured physical characteristic and the estimated analyte concentration;

measuring signal output from the sample at the selected sampling time point;

calculating an analyte concentration from measured output signal sampled at said selected sampling time point.

3. The method of aspect D1 or aspect D2, in which the applying of the first signal and the driving of the second signal is sequential.

4. The method of aspect D1 or aspect D2, in which the applying of the first signal overlaps with the driving of the second signal.

5. The method of aspect D1 or aspect D2, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

6. The method of aspect D5 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

7. The method of one of aspect D5 or aspect D6 in which the physical characteristic

comprises at least one of viscosity, hematocrit, and density.

8. The method of aspect D5, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

9. The method of aspect D8, in which the first frequency is at least one order of magnitude lower than the second frequency.

10. The method of aspect D8, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.

11. The method of aspect D1 or aspect D2, in which the measuring comprises sampling the signal output continuously at the start of the test sequence until at least about 10 seconds after the start.

12. The method of aspect D2, further comprising estimating an analyte concentration based on a measurement of the output signal at a predetermined time.

13. The method of aspect D12, in which the predetermined time comprises about 5 seconds from the start of the test sequence.

14. The method of aspect D12, in which the estimating comprises comparing the estimated analyte concentration and the measured physical characteristic against a look-up table having different respective ranges of analyte concentration and physical characteristic of the sample indexed against different sample measurement times so that the point in time for measurement of the output from the sample of the second signal is obtained for the calculating step.

15. The method of aspect D2, in which the calculating step comprises utilizing an equation of the form:

$$G_0 = \left[\frac{I_T, - \ Intercept}{Slope} \right]$$

where G_0 represents an analyte concentration;

I_T represents a signal (proportional to analyte concentration) determined from the sum of the end signals measured at a specified sampling time T;

Slope represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from; and

Intercept represents the value obtained from calibration testing of a batch of test strip of which this particular strip comes from

16. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes, the microprocessor is configured to: (a) apply a first electrical signal to the plurality of electrodes so that a physical characteristic of a physiological fluid sample is determined; (b) estimating an analyte concentration based on a predetermined sampling time point during a test sequence; and (c) apply a second electrical signal to the plurality of electrodes at a sampling time point during the test sequence dictated by the determined physical characteristic so that an analyte concentration is calculated from the second electrical signal.

17. The system of aspect D16, in which the plurality of electrodes comprises at least two

electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

18. The system of aspect D17, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

19. The system of aspect D17, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

20. The system of one of aspect D18 or aspect D19, in which all of the electrodes are disposed on the same plane defined by the substrate.

21. The system of one of aspect D18 or aspect D19, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.

22. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes, the microprocessor is configured to: (a) apply a first electrical signal to the plurality of electrodes so that a physical characteristic of a physiological fluid sample is determined during a test sequence; (b) estimating an analyte concentration based on a predetermined sampling time point during a test sequence; and (c) apply a second electrical signal to the plurality of electrodes at a sampling time point during the test sequence dictated by the

determined physical characteristic so that so that an analyte concentration is determined from the second electrical signal within about 10 seconds of a start of the test sequence.

23. The system of aspect D23, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

24. The system of aspect D23, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

25. The system of aspect D23, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

26. The system of one of aspect D24 or aspect D25, in which all of the electrodes are disposed on the same plane defined by the substrate.

27. The system of one of aspect D24 or aspect D25, in which a reagent is disposed proximate on the at least two other electrodes and no reagent is disposed on the at least two electrodes.

28. A method of obtaining increased accuracy of a test strip, the method comprising:

providing for a batch of test strips;

introducing a referential sample containing a referential concentration of an analyte to each of the batch of test strips to start a test sequence;

reacting the analyte with reagent disposed on each of the test strips to cause a physical transformation of the analyte between the two electrodes;

estimating an analyte concentration based on measured signal output of the sample at a predetermined time point from the start of the test sequence;

determining a physical characteristic of the referential sample;

sampling an electrical output of the referential sample at a dictated time point during the test sequence defined by the measured physical characteristic and the estimated analyte concentration;

calculating an analyte concentration based on the dictated time point to provide for a final analyte concentration value for each of the batch of test strips such that at least 95% of the final analyte concentration values of the batch of test strips are within ±10% of the referential analyte concentration for a range of hematocrit of the sample from about 30% to about 55%.

29. The method of aspect D28, in which the applying of the first signal and the driving of the second signal is sequential.

30. The method of aspect D28, in which the applying of the first signal overlaps with the driving of the second signal.

31. The method of aspect D28, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

32. The method of aspect D28, in which the applying of the first signal comprises directing an electromagnetic signal to the sample so that a physical characteristic of the sample is determined from an output of the electromagnetic signal.

33. The method of one of aspect D31 or aspect D32, in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

34. The method of one of aspect D31 or aspect D32, in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.

35. The method of aspect D30, in which the directing comprises driving first and second

alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

36. The method of aspect D35, in which the first frequency is at least one order of magnitude lower than the second frequency.

37. The method of aspect D36, in which the first frequency comprises any frequency in the range of about 1OkHz to about 90kHz.

38. The method of aspect D29, in which the measuring comprises sampling the signal output continuously at the start of the test sequence until at least about 10 seconds after the start.

39. The method of aspect D29, further comprising estimating an analyte concentration based on a measurement of the output signal at a predetermined time.

40. The method of aspect D39, in which the estimating comprises comparing the estimated analyte concentration and the measured physical characteristic against a look-up table having different respective ranges of analyte concentration and physical characteristic of the sample indexed against different sample measurement times so that the point in time for measurement of the output from the sample of the second signal is obtained for the calculating step.

41. A method of determining an analyte concentration from a physiological sample, the method comprising:

depositing a physiological sample on a biosensor to start a test sequence;

causing the analyte in the sample to undergo an enzymatic reaction;

estimating an analyte concentration in the sample;

measuring at least one physical characteristic of the sample;

defining a time point from the start of the test sequence to sample output signals of the biosensor based on the estimated analyte concentration and at least one physical characteristic from the measuring step;

sampling output signals of the biosensor at the defined time point;

determining an analyte concentration from sampled signals at the defined time point.

42. The method of aspect D41, in which the measuring comprises applying a first electrical signal to the sample to measure a physical characteristic of the sample; the causing step comprises driving a second electrical signal to the sample; the measuring comprises evaluating an output signal from the at least two electrodes at a point in time after the start of the test sequence, in which the point in time is set as a function of at least the measured physical characteristic; and the determining step comprises calculating an analyte concentration from the measured output signal at said point in time.

43. The method of aspect D41, in which the applying of the first signal and the driving of the second signal is sequential.

44. The method of aspect D41, in which the applying of the first signal overlaps with the driving of the second signal.

45. The method of aspect D41, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

46. The method of aspect D41, further comprising estimating an analyte concentration based on a predetermined sampling time point from the start of the test sequence.

47. The method of aspect D46, in which the defining comprises selecting a defined time point based on both the measured physical characteristic and the estimated analyte concentration.

48. The method of one of aspect D45 or aspect D46 in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

49. The method of one of aspect D44 or aspect D45 in which the physical characteristic comprises at least one of viscosity, hematocrit, and density.

50. The method of aspect D46, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency is lower than the second frequency.

51. The method of aspect D50, in which the first frequency is at least one order of magnitude lower than the second frequency.

52. The method of aspect D51, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.

53. The method of aspect D41, in which the measuring comprises sampling the signal output continuously at the start of the test sequence until at least about 10 seconds after the start.

54. The method of aspect D53, further comprising estimating an analyte concentration based on a measurement of the output signal at a predetermined time.

55. The method of aspect D54, in which the estimating comprises comparing the estimated analyte concentration and the measured physical characteristic against a look-up table having different respective ranges of analyte concentration and physical characteristic of the sample indexed against different sample measurement times so that the point in time for measurement of the output from the sample of the second signal is obtained for the calculating step.

56. The method or system of any one of aspects D1 to D55, in which the sampling time point is selected from a look-up table that includes a matrix in which different qualitative categories of the estimated analyte are set forth in the leftmost column of the matrix and different qualitative categories of the measured physical characteristic are set forth in the topmost row of the matrix and the sampling times are provided in the remaining cells of the matrix.

Section "E"

The following aspects, which were originally presented in US Provisional Patent Application Serial No. 61/654,013 (Attorney Docket No. DDI5228USPSP), form part of the present disclosure:

1. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to derive a physical characteristic of the sample;

driving a second electrical signal to the sample for a first sampling time duration that overlaps with the test sequence to obtain a first transient signal output from the sample, the first transient signal correlated to both time and magnitude during the first sampling time duration;

extracting a specific sampling time during the test sequence in the first sampling time duration based on the physical characteristic of the sample;

defining a second sampling time duration based on the specific sampling time such that the second sampling time duration overlaps the first sampling time duration;

obtaining from the first transient signal a second transient signal referenced with respect to the second sampling time duration;

dividing the second transient signal into discrete intervals with respect to the second sampling time duration;

deriving respective magnitudes of the second transient signal at discrete selected intervals in the second sampling time duration; and

determining an analyte concentration based on respective magnitudes of the second transient signal at the discrete selected time intervals.

2. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to derive a physical characteristic of the sample;

driving a second electrical signal to the sample for a first sampling time duration that overlaps with the test sequence to obtain a first transient signal output from the sample, the first transient signal correlated to both time and magnitude during the first sampling time duration;

extracting a specific sampling time during the test sequence in the first sampling time duration based on the physical characteristic of the sample;

obtaining from the first transient signal a second transient signal over a second sampling time duration;

deriving respective magnitudes of the second transient signal at selected intervals in the second sampling time duration; and

determining an analyte concentration based on respective magnitudes of the second transient signal at the selected time intervals.

3. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to derive a physical characteristic of the sample;

extracting a specific sampling time in a first sampling time duration;

applying or driving a second signal into the sample for the first sampling time duration,

measuring or sampling a first transient signal output from the sample for the duration of the first sampling time duration;

defining a specific range of time that includes the specific sampling time in the first sampling time duration;

obtaining plural magnitudes of the first transient signal at respective discrete intervals within the specific range of time, and

determining the analyte concentration based on the magnitudes of the first transient signal from the obtaining step.

4. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence;

applying a first electrical signal to the sample to derive a physical characteristic of the sample;

extracting a specific sampling time in a first sampling time duration;

applying or driving a second signal into the sample for the first sampling time duration, measuring or sampling a first transient signal output from the sample for the duration of the first sampling time duration;

obtaining plural magnitudes of the first transient signal output at time intervals other than at about the specific sampling time; and

deterring the analyte concentration based on the plural magnitudes of the first transient signal from the obtaining step.

5. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on the at least two electrodes to start an analyte test sequence for each of a plurality of the biosensors;

applying a first electrical signal to the sample to derive a physical characteristic of the sample for each of the plurality of the biosensors;

extracting a specific sampling time in a first sampling time duration for each of the

plurality of the biosensors;

applying or driving a second signal into the sample for the first sampling time duration for each of a plurality of the biosensors;

measuring or sampling a first transient signal output from the sample for the duration of the first sampling time duration for each of the plurality of the biosensors;

defining a specific range of time that includes the specific sampling time in the first sampling time duration for each of the plurality of the biosensors;

obtaining plural magnitudes of the first transient signal at respective discrete intervals within the specific range of time for each of the plurality of the biosensors; and

determining the analyte concentration based on the magnitudes of the first transient signal from the obtaining step for each of the plurality of the biosensors such that an error between a plurality of analyte concentrations determined by the determining step for the plurality of the biosensors is less than ±15% as compared to referential value at each of 30%, 42%, and 55% hematocrits.

6. The method of one of aspects El, E2, or E3, in which the specific range of time include magnitudes of first transient signal measured before the specific sampling time.

7. The method of one of aspects El, E2, E3, E4, or E5, in which the step of extracting the specific sampling time comprises calculating a defined specific sampling time in the first sampling time duration based on the physical characteristic of the sample.

8. The method of aspect E6, in which the calculating step for the defined specific sampling time comprises utilizing an equation of the form:

$$SpecifiedSamplingTime = x_1 H^{X2} + x_3$$

where *"SpecifiedSamplingTime"* is designated as a time point from the start of the test sequence at which to sample the output signal of the biosensor, *H* represents physical characteristic of the sample in the form of hematocrit;

x_1 is about 4.3e5;

x_2 is about (—)3.9; and

x_3 is about 4.8.

9. The method of aspect E8, in which the step of defining the second sampling time duration comprises obtaining an absolute value of a difference between the defined specific sampling time and a predetermined time point to define a start time (Tl) and an end time (T2) approximately equal to the specified sampling time point, and the first sampling time duration comprises about 10 seconds or less from the step of depositing the sample.

10. The method of aspect E8, in which the step of obtaining further comprises defining a second sampling time duration that overlaps the first sampling time duration and includes a portion of the first transient signal and its magnitudes with respect to time of the second sampling time duration, wherein the portion is designated as a second transient signal.

11. The method of aspect E9, in which the step of obtaining the second transient signal comprises extracting from the first transient signal a portion of the first transient signal that is designated as a second transient signal that is within the second sampling time duration.

12. The method of aspect E1 1, in which the deriving of respective magnitudes of the second transient signal at discrete selected time intervals comprises calculating a magnitude of the second transient signal during each selected time intervals.

13. The method of aspect E12, in which the dividing comprises dividing the second transient signal into at least 22 intervals in sequence starting from interval one at about the start time to interval twenty-two at about the end time.

14. The method of aspect E13, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left(\frac{|I_3|}{|I_4|}\right)^{x_1} \times \left(\frac{|I_2| + x_4|I_5| - x_5|I_1|}{|/_2\ \text{l+*4}\quad \text{I}^{I_5}|}|I_5|\right) - x_2}{x_3}$$

where:

G comprises analyte concentration; I_1 ~ magnitude of second transient signal at interval 17; I_2 ≃ magnitude of second transient signal at interval 13; I_3 ≈ magnitude of second transient signal at interval 5; I_4 ≃ magnitude of second transient signal at interval 3; I_5 ≈ magnitude of second transient signal at interval 22; x_1≈0.75; x^—337.27; x^~ (—)16.81; χ_4≈1.41; andx $_5$~2.67.

15. The method of aspect E10, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_1(|I_1|)^{\left(x_2 - \frac{x_3}{|I_2|}\right)} - x_4}{x_5}$$

where:

G comprises analyte concentration; I_1 ≈ magnitude of second transient signal at interval 11; I_2 ≃ magnitude of second transient signal at interval 7; x$_1$~0.59; x_2≈2.5\; $x_{3\sim(}$ —)12.74; x_4~{—) 188.31; andx $_5$~9.2.

16. The method of aspect E13, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_1 ln\left(x_2 \frac{|I_1|}{|I_2|}\right)^{x_3} |I_3|^{x_4} - x_5}{x_6}$$

where G comprises analyte concentration; I_1 ≈ magnitude of second transient signal at interval 20; $I2$ ≈ magnitude of second transient signal at interval 22; I_3 ~ magnitude of second transient signal at interval 19; Xi~20. 15; x_2~1.0446; x_3≈0.95; x_4~\.39; x_5~(—)0.7\; x_6~0.1 1.

17. The method of aspect E13, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_3\left|\frac{I_1}{I_2}\right|^{\left(x_1 - x_2\left|\frac{I_3}{I_4}\right|\right)} \times |I_5| - x_5}{x_4}$$

where:

Ii ≈ magnitude of second transient signal at interval 5; $I2$≈ magnitude of second transient signal at interval 1; $I3$ ~ magnitude of second transient signal at interval 2; I_4 ≈ magnitude of second transient signal at interval 10; I_5 ~ magnitude of second transient signal at interval 22; Xi~0.70; x_2~0.49, x_3~28.59, x_4~0.7, and x_5~l 5.51.

18. The method of aspect E10, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^2 + x_3|I_3| + x_4}{x_5|I_4| + x_6}\right) - x_7}{X\ Q}$$

where:

G comprises glucose concentration; I_1 ≈ magnitude of second transient signal at interval 19; $I2$≈ magnitude of second transient signal at interval 16; I_3 ≈ magnitude of second transient signal at interval 11; I_4 ≈ magnitude of second transient signal at interval 5; *xi*~(—) 1.68; x_2-0.95; x^(_)4.97; x_4~6.29; x_5~3.08; x_6~(—)5.84; x_7~(—)0.47; x_s~0.01.

19. The method of aspect E10, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^3 + x_3|I_3|^2 + x_4|I_3| + x_5}{x_6|I_4|^2 + x_7|I_4| + x_8}\right) - x_9}{x_{10}}$$

where:

G comprises glucose concentration; I_1 ~ magnitude of second transient signal at interval 16; I_2 ≈ magnitude of second transient signal at interval 5; I_3 ≈ magnitude of second transient signal at interval 12; I_4 ≈ magnitude of second transient signal at interval 14; x_1~1.18; x_2-0.97; x_3~(—)11.32; x_4~38.76; x_5~(—)39.32; x_6~0.0928; x_7~(—)0.85; x_8~1.75; x_9~(—)9.38; and x_{10}~0.25.

20. The method of any one of aspects E14-E19, in which the magnitude of the second transient signal at each of the plurality of discrete intervals comprises an average magnitude of measured magnitudes at each discrete interval.

21. The method of any one of aspect El, aspect E2, or aspect E3, in which the applying of the first signal and the driving of the second signal is in sequential order.

22. The method of any one of aspect El, aspect E2, or aspect E3, in which the applying of the first signal overlaps with the driving of the second signal.

23. The method of any one of aspect El, aspect E2, or aspect E3, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

24. The method of any one of aspect El, aspect E2, or aspect E3, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

25. The method of aspect E24, in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

26. The method of any one of aspect El, aspect E2, or aspect E3, in which the physical characteristic comprises at least one of viscosity, hematocrit, or density of the sample.

27. The method of aspect E24, in which the directing comprises driving first and second alternating signal at different respective frequencies in which a first frequency comprises a frequency than the second frequency.

28. The method of aspect E25, in which the first frequency is at least one order of magnitude lower than the second frequency.

29. The method of aspect E26, in which the first frequency comprises any frequency in the range of about 10kHz to about 90kHz.

30. The method of any one of aspect El, aspect E2, or aspect E3, in which the obtaining comprises extracting from the first transient signal a second transient signal referenced with respect to the second sampling time duration

31. The method of any one of aspect E1, aspect E2, or aspect E3, in which the obtaining comprises removing signals from the first transient signals that are outside of the second sampling time duration to leave the second transient signal within the second sampling time duration.

32. The method of one of aspect E30 or aspect E31, in which the deriving comprises storing magnitudes of the second transient signal for each discrete intervals in the second sampling time duration.

33. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes disposed on the substrate and connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence, the microprocessor is configured to: (a) apply a first electrical signal to the plurality of electrodes so that a physical characteristic of the sample is derived to provide a specific sampling time, (b) apply a second electrical signal to the plurality of electrodes, (c) measure a first transient output signal from the plurality of electrodes; (d) extract a second transient output signal from the first output signal; (e) determine a magnitude of the second transient output signal over at least 22 discrete time intervals; and (f) calculate the analyte concentration from the magnitudes of the second transient output signal at selected intervals of the at least 22 discrete time intervals.

34. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes disposed on the substrate and connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence, the microprocessor is configured to: (a) apply a first electrical signal to the plurality of electrodes

so that a physical characteristic of the sample is derived to provide a specific sampling time, (b) apply a second electrical signal to the plurality of electrodes, (c) measure a first transient output signal from the plurality of electrodes; (d) extract a second transient output signal from the first output signal; (e) determine a magnitude of the second transient output signal over at least 22 discrete time intervals; and (f) calculate the analyte concentration from the magnitudes of the second transient output signal at selected intervals of the at least 22 discrete time intervals to annunciate the analyte concentration within about 10 seconds of a start of the test sequence

35. The system of one of aspect E33 or aspect E34, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

36. The system of aspect E35, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

37. The system of aspect E35, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

38. The system of aspect E37, in which the different chambers are disposed adjacent to each other on an edge of the substrate.

39. The system of aspect E35, in which the at least two electrodes and the other at least two electrodes are dispose in a common chamber that receives a fluid sample.

40. The system of aspect E35, in which the at least two electrodes comprise two electrodes to measure the physical characteristic and the analyte concentration.

41. The system of one of aspects E33-40, in which all of the electrodes are disposed on the same plane defined by the substrate.

42. The system of one of aspects E33-40, in which a reagent is disposed proximate on the at

least two other electrodes and no reagent is disposed on the at least two electrodes.

43. The system of aspect E33 or aspect E34, in which the specified sampling time is calculated using an equation of the form:

$$SpecifiedSamplingTime = x_1 H^{X2} + x_3$$

where *"SpecifiedSamplingTime"* is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip, *H* represents physical characteristic of the sample in the form of hematocrit;

x_1 represents about 4.3e5;

x_2 represents about (—)3.9; and

x_3 represents about 4.8.

44. The system of any one of aspects E33, E34, or E41, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\frac{|I_3|}{|I_4|}\right)^{x_1} \times \left(\frac{|I_2| + x_4|I_5| - x_5|I_1|}{|I_2| + x_4|I_5|}|I_5|\right) - x_2}{x_3}$$

where:

G comprises analyte concentration; I_1 ≃ magnitude of second transient signal at interval 17; I_2 ≃ magnitude of second transient signal at interval 13; I_3 ≃ magnitude of second transient signal at interval 5; I_4 ≃ magnitude of second transient signal at interval 3; I_5 ~ magnitude of second transient signal at interval 22; x_1≈0.75; x^—337.27; x^~ (—)16.81; χ_4≈1.41; and x_5~2.67.

45. The system of any one of aspects E33, E34, or E44, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_1(|I_1|)^{\left(x_2-\frac{x_3}{|I_2|}\right)}-x_4}{x_5}$$

where:

G comprises analyte concentration; $I_1 \approx$ magnitude of second transient signal at interval 11; $I_2 \approx$ magnitude of second transient signal at interval 7; x_i~0.59; $x_2 \approx 2.5$\; x_3~(—)12.74; x_4~{— 188.31; and x_5~9.2.

46. The system of any one of aspects E33, E34, or E41, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_1 ln\left(x_2\frac{|I_1|}{|I_2|}\right)^{x_3}|I_3|^{x_4}-x_5}{x_6}$$

where G comprises analyte concentration; $Ii \sim$ magnitude of second transient signal at interval 20; $I_2 \approx$ magnitude of second transient signal at interval 22; $I_3 \approx$ magnitude of second transient signal at interval 19 ;xi~20. 15; x_2~1.0446; x_3~0.95; x_4~\39; x_5~(—)0.71; x_6~0.11.

47. The system of any one of aspects E33, E34, or E41, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_3\left|\frac{I_1}{I_2}\right|^{\left(x_1-x_2\left|\frac{I_3}{I_4}\right|\right)}\times|I_5|-x_5}{x_4}$$

where:

I_1 ~ magnitude of second transient signal at interval 5; I_2 ≈ magnitude of second transient signal at interval 1; I_3 ~ magnitude of second transient signal at interval 2; I_4 ≈ magnitude of second transient signal at interval 10; I_5 ≈ magnitude of second transient signal at interval 22; x_1~0.70, x_2≈0$A9$, x_3~28.59, x_4~0.7, and x_5~l 5.51.

48. The system of any one of aspects E33, E34, or E41, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^2 + x_3|I_3| + x_4}{x_5|I_4| + x_6}\right) - x_7}{x_8}$$

where:

G comprises glucose concentration; I_1 ~ magnitude of second transient signal at interval 19; I_2 ~ magnitude of second transient signal at interval 16; I_3 ~ magnitude of second transient signal at interval 11; I_4 ≈ magnitude of second transient signal at interval 5; x_1~(—)1.68; x_2-0.95; x_3~(—)4.97; x_4~6.29; x_5~3.08; x_6~(—)5.84; x_7~(—)0.47; x_8~0.01.

49. The system of any one of aspects E33, E34, or E41, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^3 + x_3|I_3|^2 + x_4|I_3| + x_5}{x_6|I_4|^2 + x_7|I_4| + x_8}\right) - x_9}{x_{10}}$$

where:

G comprises glucose concentration; I_1 ~ magnitude of second transient signal at interval 16; I_2 ~ magnitude of second transient signal at interval 5; I_3 ≈ magnitude of second transient signal at interval 12; I_4 ≈ magnitude of second transient signal at interval 14; x_1~1.18; x_2-0.97; x_3~(—)1 1.32; x_4~38.76; x_5~(—)39.32; x_6~0.0928; x_7~(—)0.85; x_8~1.75; x_9~(—)9.38; and

$xi_0 \approx 0.25$.

50. The system of any one of aspects E33, E34, or E41, in which the magnitude of the second transient signal at each of the plurality of discrete intervals comprises an average magnitude of the signal sampled throughout each interval.

51. The system of any one of aspects E33, E34, or E41, in which an error between a plurality of analyte concentrations calculated by the microprocessor is less than ± 15% as compared to referential value at 30% hematocrits.

52. The system of any one of aspects E33, E34, or E41, in which an error between the plurality of analyte concentrations calculated by the microprocessor is less than ±15% as compared to referential value at 42% hematocrits.

53. The system of any one of aspects E33, E34, or E41, in which an error between a plurality of analyte concentrations calculated by the microprocessor is less than ±15% as compared to referential value at 55% hematocrits.

Section "F"

The following aspects, which were originally presented in US Patent Application Serial No. 13/250,525 (Attorney Docket No. DDI5209USNP) and in PCT/GB2012/052421 (Attorney Docket No. DDI5209WOPCT), herein incorporated by reference, form part of the present disclosure:

1. A hand-held test meter for use with an analytical test strip in the determination of an analyte in a bodily fluid sample, the hand-held test meter comprising:

a housing;

a microcontroller block disposed in the housing; and

a phase-shift-based hematocrit measurement block that includes:

a signal generation sub-block;

a low pass filter sub-block;

an analytical test strip sample cell interface sub-block;

a transimpedance amplifier sub-block; and

a phase detector sub-block,

wherein the phase-shift-based hematocrit measurement block and microcontroller block are configured to measure the phase shift of a bodily fluid sample in a sample cell of an analytical test strip inserted in the hand-held test meter, and

wherein the microcontroller block is configured to compute the hematocrit of the bodily fluid based on the measured phase shift.

2. The hand-held test meter of aspect F1 wherein the phase-shift-based hematocrit measurement block and microcontroller block are configured to measure the phase shift using a signal of a first frequency and a second signal of a second frequency.

3. The hand-held test meter of aspect F2 wherein the bodily fluid sample is a whole blood sample and wherein the first frequency is in the range of 10kHz to 25kHz and the second frequency is in the range of 250kHz to 500kHz.

4. The hand-held test meter of aspect F1 wherein the phase detector sub-block is configured as a rising edge capture phase detector.

5. The hand-held test meter of aspect F1 wherein the phase detector sub-block is configured as a dual edge capture phase detector.

6. The hand-held test meter of aspect F1 wherein the phase detector sub-block is configured as an XOR phase detector.

7. The hand-held test meter of aspect F1 wherein the phase detector sub-block is configured as a synchronous modulation phase detector.

8. The hand-held test meter of aspect F1 further including a calibration load sub-block configured in parallel with the analytical test strip sample cell interface sub-block.

9. The hand-held test meter of aspect F1 wherein the signal generation sub-block is configured to generate at least a first electrical signal of a first frequency and a second electrical signal of a second frequency.

10. The hand-held test meter of aspect F1 wherein the phase-shift-based hematocrit measurement block and microcontroller block are configured to measure the phase shift of a bodily fluid sample in a sample cell of an analytical test strip inserted in the hand-held test meter by forcing a signal of known frequency through the bodily fluid sample and measuring the phase-shift of the signal.

11. The hand-held test meter of aspect F9 wherein the first frequency is in the range of 10kHz to 25kHz and the second frequency is in the range of 250kHz to 500kHz, and wherein the phase-shift-based hematocrit measurement block and microcontroller block are configured such that the signal of the first frequency is employed as a reference signal during the measurement of the phase shift of a bodily fluid sample.

12. The hand-held test meter of aspect F9 wherein the signal generation block is integrated with the microcontroller block.

13. The hand-held test meter of aspect F1 wherein the analytical test strip sample cell interface block is configured to operatively interface with the sample cell of the analytical test strip via a first electrode and as second electrode of the analytical test strip disposed in the sample cell.

14. The hand-held test meter of aspect F1 wherein the analytical test strip is an electrochemical-based analytical test strip configured for the determination of glucose in a whole blood sample.

15. The hand-held test meter of aspect F1 wherein the phase detector sub-block is configured as a Quadratur DEMUX phase detector.

16. A method for employing a hand-held test meter and analytical test strip, the method comprising:

introducing a whole blood sample into a sample cell of an analytical test strip;

measuring a phase shift of the bodily fluid sample in the sample cell using a phase-shift-based measurement block and a microcontroller block of a hand-held test meter; and

computing the hematocrit of whole blood sample based on the measured phase shift using the microcontroller block.

17. The method of aspect F16 further including:

determining an analyte in the introduced bodily fluid sample using the analytical test strip, hand-held test meter and computed hematocrit.

18. The method of aspect F17 wherein the analytical test strip is an electrochemical-based analytical test strip and the analyte is glucose.

19. The method of aspect F16 wherein the measuring step includes measuring the phase shift with a phase-shift based measurement circuit block that includes:

a signal generation sub-block;

a low pass filter sub-block;

an analytical test strip sample cell interface sub-block;

a transimpedance amplifier sub-block; and

a phase detector sub-block.

20. The method of aspect F19 wherein the phase detector sub-block is configured as a rising edge capture phase detector.

21. The method of aspect F19 wherein the phase detector sub-block is configured as a dual edge capture phase detector.

22. The method of aspect F19 wherein the phase detector sub-block is configured as an XOR phase detector.

23. The method of aspect F19 wherein the phase detector sub-block is configured as a synchronous modulation phase detector.

24. The method of aspect F19 wherein the phase detector sub-block is configured as a Quadratur DEMUX phase detector.

25. The method of aspect F16 wherein the phase-shift-based hematocrit measurement block and microcontroller block are configured to measure the phase shift using a signal of a first frequency and a second signal of a second frequency.

26. The method of aspect F25 wherein the bodily fluid sample is a whole blood sample and wherein the first frequency is in the range of 10kHz to 25kHz and the second frequency is in the range of 250kHz to 500kHz.

APPENDIX

The following appendix, which was originally presented in US Patent Application Serial No. 13/250,525 (Attorney Docket No. DDI5209USNP) and PCT/GB2012/052421 (Attorney Docket No. DDI5209WOPCT) alongside aspects "F" above and incorporated by reference as part of each of the prior filed US Provisional Patent Application Serial Nos. 61/581,087 (Attorney Docket No. DDI5220USPSP); 61/581,089 (Attorney Docket No. DDI5220USPSP 1); 61/581,099 (Attorney Docket No. DDI5220USPSP2); and 61/581,100 (Attorney Docket No. DDI5221USPSP), and 61/654,013 (Attorney Docket No. DDI5228USPSP), forms part of the present disclosure and is hereinbefore incorporated by reference:

The disclosure below relates, in general, to medical devices and, in particular, to test meters and related methods.

The determination (e.g., detection and/or concentration measurement) of an analyte in a fluid sample is of particular interest in the medical field. For example, it can be desirable to determine glucose, ketone bodies, cholesterol, lipoproteins, triglycerides, acetaminophen and/or HbAlc concentrations in a sample of a bodily fluid such as urine, blood, plasma or interstitial fluid. Such determinations can be achieved using a hand-held test meter in combination with analytical test strips (e.g., electrochemical-based analytical test strips).

The novel features of the disclosure are set forth with particularity in aspects F. A better understanding of the features and advantages of the present disclosure will be obtained by reference to the following detailed description that sets forth illustrative embodiments, in which the principles of the disclosure are utilized, and the accompanying drawings, in which like numerals indicate like elements, of which:

FIG. 9 is a simplified depiction of a hand-held test meter according to an embodiment of the present disclosure;

FIG. 10 is a simplified block diagram of various blocks of the hand-held test meter of FIG. 9;

FIG. 11 is a simplified block diagram of a phase-shift-based hematocrit measurement block as can be employed in embodiments according to the present disclosure;

FIG. 12 is a simplified annotated schematic diagram of a dual low pass filter sub-block as can be employed in embodiments of the present disclosure;

FIG. 13 is a simplified annotated schematic diagram of a transimpedance amplifier (TIA) sub-block as can be employed in embodiments of the present disclosure;

FIG. 14 is a simplified annotated schematic block diagram depicting a dual low pass filter sub-block, a calibration load sub-block, an analytical test strip sample cell interface sub-block, a transimpedance amplifier sub-block, an XOR phase shift measurement sub-block and a Quadratur DEMUX phase-shift measurement sub-block as can be employed in a phase-shift-based hematocrit measurement block of embodiments of the present disclosure; and

FIG. 15 is a flow diagram depicting stages in a method for employing a hand-held test meter according to an embodiment of the present disclosure.

The following detailed description should be read with reference to the drawings, in which like elements in different drawings are identically numbered. The drawings, which are not necessarily to scale, depict exemplary embodiments for the purpose of explanation only and are not intended to limit the scope of the disclosure. The detailed description illustrates by way of example, not by way of limitation, the principles of the disclosure. This description will clearly enable one skilled in the art to make and use the disclosure, and describes several embodiments, adaptations, variations, alternatives and uses of the disclosure, including what is presently believed to be the best mode of carrying out the disclosure.

As used herein, the terms "about" or "approximately" for any numerical values or ranges indicate a suitable dimensional tolerance that allows the part or collection of components to function for its intended purpose as described herein.

In general, hand-held test meters for use with an analytical test strip in the determination of an analyte (such as glucose) in a bodily fluid sample (i.e., a whole blood sample) according to embodiments of the present disclosure include a housing, a microcontroller block disposed in the housing, and a phase-shift-based hematocrit measurement block (also referred to as

a phase-shift-based hematocrit circuit). In such hand-held test meters, the phase-shift-based hematocrit measurement block includes a signal generation sub-block, a low pass filter sub-block, an analytical test strip sample cell interface sub-block, a transimpedance amplifier sub-block, and a phase detector sub-block. In addition, the phase-shift-based hematocrit measurement block and microcontroller block are configured to measure the phase shift of a bodily fluid sample in a sample cell of an analytical test strip inserted in the hand-held test meter and the microcontroller block is also configured to compute the hematocrit of the bodily fluid sample based on the measured phase shift.

Hand-held test meters according to embodiments of the present disclosure are beneficial in that they provide improved accuracy of analyte determination (such as glucose determination) in whole blood samples by measuring the hematocrit of the whole blood sample and then employing the measured hematocrit during analyte determination.

Once one skilled in the art is apprised of the present disclosure, he or she will recognize that an example of a hand-held test meter that can be readily modified as a hand-hand test meter according to the present disclosure is the commercially available OneTouch® Ultra® 2 glucose meter from LifeScan Inc. (Milpitas, California). Additional examples of hand-held test meters that can also be modified are found in U.S. Patent Application Publications No's. 2007/0084734 (published on April 19, 2007) and 2007/0087397 (published on April 19, 2007) and in International Publication Number WO201 0/049669 (published on May 6, 2010), each of which is hereby incorporated herein in full by reference.

FIG. 9 is a simplified depiction of a hand-held test meter 100 according to an embodiment of the present disclosure. FIG. 10 is a simplified block diagram of various blocks of hand-held test meter 100. FIG. 11 is a simplified combined block diagram of a phase-shift-based hematocrit measurement block of hand-held test meter 100. FIG. 12 is a simplified annotated schematic diagram of a dual low pass filter sub-block of hand-held test meter 100. FIG. 13 is a simplified annotated schematic diagram of a transimpedance amplifier sub-block of hand-held test meter 100. FIG. 14 is a simplified annotated schematic block diagram of portions of a phase-shift-based hematocrit measurement block of hand-held test meter 100.

Referring to FIGs. 9 through 14, hand-held test meter 100 includes a display 102, a plurality of user interface buttons 104, a strip port connector 106, a USB interface 108, and a housing 110 (see FIG. 9). Referring to FIG. 10 in particular, hand-held test meter 100 also includes a microcontroller block 112, a phase-shift-based hematocrit measurement block 114, a display control block 116, a memory block 118 and other electronic components (not shown) for applying a test voltage to analytical test strip (labeled TS in FIG. 9), and also for measuring an electrochemical response (e.g., plurality of test current values) and determining an analyte based on the electrochemical response. To simplify the current descriptions, the figures do not depict all such electronic circuitry.

Display 102 can be, for example, a liquid crystal display or a bi-stable display configured to show a screen image. An example of a screen image may include a glucose concentration, a date and time, an error message, and a user interface for instructing an end user how to perform a test.

Strip port connector 106 is configured to operatively interface with an analytical test strip TS, such as an electrochemical-based analytical test strip configured for the determination of glucose in a whole blood sample. Therefore, the analytical test strip is configured for operative insertion into strip port connector 106 and to operatively interface with phase-shift-based hematocrit measurement block 114 via, for example, suitable electrical contacts.

USB Interface 108 can be any suitable interface known to one skilled in the art. USB Interface 108 is essentially a passive component that is configured to power and provide a data line to hand-held test meter 100.

Once an analytical test strip is interfaced with hand-held test meter 100, or prior thereto, a bodily fluid sample (e.g., a whole blood sample) is introduced into a sample chamber of the analytical test strip. The analytical test strip can include enzymatic reagents that selectively and quantitatively transform an analyte into another predetermined chemical form. For example,

the analytical test strip can include an enzymatic reagent with ferricyanide and glucose oxidase so that glucose can be physically transformed into an oxidized form.

Memory block 118 of hand-held test meter 100 includes a suitable algorithm and can be configured, along with microcontroller block 112 to determine an analyte based on the electrochemical response of analytical test strip and the hematocrit of the introduced sample. For example, in the determination of the analyte blood glucose, the hematocrit can be used to compensate for the effect of hematocrit on electrochemically determined blood glucose concentrations.

Microcontroller block 112 is disposed within housing 110 and can include any suitable microcontroller and/or micro-processer known to those of skill in the art. One such suitable microcontroller is a microcontroller commercially available from Texas Instruments, Dallas, TX USA and part number MSP430F5138. This microcontroller can generate a square wave of 25 to 250kHz and a 90 degree phase-shifted wave of the same frequency and, thereby, function as a signal generation s-block described further below. MSP430F5138 also has Analog-to-Digital (A/D) processing capabilities suitable for measuring voltages generated by phase shift based hematocrit measurement blocks employed in embodiments of the present disclosure.

Referring in particular to FIG. 11, phase-shift-based hematocrit measurement block 114 includes a signal generation sub-block 120, a low pass filter sub-block 122, an analytical test strip sample cell interface sub-block 124, an optional calibration load block 126 (within the dashed lines of FIG. 11), a transimpedance amplifier sub-block 128, and a phase detector sub-block 130.

As described further below, phase-shift-based hematocrit measurement block 114 and microcontroller block 112 are configured to measure the phase shift of a bodily fluid sample in a sample cell of an analytical test strip inserted in the hand-held test meter by, for example, measuring the phase shift of one or more high frequency electrical signals driven through the bodily fluid sample. In addition, microcontroller block 112 is configured to compute the hematocrit of the bodily fluid based on the measured phase shift. Microcontroller 112 can compute the hematocrit by, for example, employing an A/D converter to measure voltages

received from a phase-detector sub-block, convert the voltages into a phase-shift and then employing a suitable algorithm or look-up table to convert the phase-shit into a hematocrit value. Once apprised of the present disclosure, one skilled in the art will recognize that such an algorithm and/or look-up table will be configured to take into account various factors such as strip geometry (including electrode area and sample chamber volume) and signal frequency.

It has been determined that a relationship exists between the reactance of a whole blood sample and the hematocrit of that sample. Electrical modeling of a bodily fluid sample (i.e., a whole blood sample) as parallel capacitive and resistive components indicates that when an alternating current (AC) signal is forced through the bodily fluid sample, the phase shift of the AC signal will be dependent on both the frequency of the AC voltage and the hematocrit of the sample. Moreover, modeling indicates that hematocrit has a relatively minor effect on the phase shift when the frequency of the signal is in the range of approximately 10kHz to 25kHz and a maximum effect on the phase shift when the frequency of the signal is in the range of approximately 250 kHz to 500KHz. Therefore, the hematocrit of a bodily fluid sample can be measured by, for example, driving AC signals of known frequency through the bodily fluid sample and detecting their phase shift. For example, the phase-shift of a signal with a frequency in the range of 10kHz to 25kHz can be used as a reference reading in such a hematocrit measurement while the phase shift of a signal with a frequency in the range of 250 kHz to 500kHz can be used as the primary measurement.

Referring to FIGs. 11 through 14 in particular, signal generation sub-block 120 can be any suitable signal generation block and is configured to generate a square wave (0V to Vref) of a desired frequency. Such a signal generation sub-block can, if desired, be integrated into microcontroller block 112.

The signal generated by signal generation sub-block 120 is communicated to dual low pass filter sub-block 122, which is configured to convert the square wave signal to a sine wave signal of a predetermined frequency. The dual LPF of FIG. 12 is configured to provide both a signal of a first frequency (such as a frequency in the range of 10kHz to 25kHz) and a

signal of a second frequency (such as a frequency in the range of 250 kHz to 500kHz) to the analytical test strip sample cell interface sub-block and an analytical test strips' sample chamber (also referred to as the HCT measurement cell). Selection of the first and second frequency is accomplished using switch IC7 of FIG. 12. The dual LPF of FIG. 12 includes employs two suitable operational amplifiers (IC4 and IC5) such as the operational amplifier available from Texas Instruments, Dallas, Texas, USA as high-speed, voltage feedback, CMOS operational amplifier part number OPA354.

Referring to FIG. 12, F-DRV represents a square wave input of either a low or high frequency (e.g., 25kHz or 250 kHz) and is connected to both IC4 and IC5. Signal Fi-HIGH/LOW (from the microcontroller) selects the output of dual low pass filter sub-block 122 via switch IC7. C5 in FIG. 12 is configured to block the operating voltage of dual low pass filter sub-block 122 from the HCT measurement cell.

Although a specific dual LPF is depicted in FIG. 12, dual low pass filter sub-block 122 can be any suitable low pass filter sub-block known to one skilled in the art including, for example, any suitable multiple feedback low pass filter, or a Sallen and Key low pass filter.

The sine wave produced by low pass filter sub-block 122 is communicated to analytical test strip sample cell interface sub-block 124 where it is driven across the sample cell of the analytical test strip (also referred to as an HCT measurement cell). Analytical test strip sample cell interface block 124 can be any suitable sample cell interface block including, for example, an interface block configured to operatively interface with the sample cell of the analytical test strip via first electrode and second electrodes of the analytical test strip disposed in the sample cell. In such a configuration, the signal can be driven into the sample cell (from the low pass filter sub-block) via the first electrode and picked-up from the sample cell (by the transimpedance amplifier sub-block) via the second electrode as depicted in FIG. 14.

The current produced by driving the signal across the sample cell is picked-up by transimpedance amplifier sub-block 128 and converted into a voltage signal for communication to phase detector sub-block 130.

Transimpedance sub-block 128 can be any suitable transimpedance sub-block known to one skilled in the art. FIG. 13 is a simplified annotated schematic block diagram of one such transimpedance amplifier sub-block (based on two OPA354 operational amplifiers, IC3 and IC9). The first stage of TIA sub-block 128 operates at, for example, 400mV, which limits the AC amplitude to +/-400mV. The second stage of TIA sub-block 128 operates at Vref/2, a configuration which enables the generation of an output of the full span of the microcontroller A/D inputs. C9 of TIA sub-block 128 serves as a blocking component that only allows an AC sine wave signal to pass.

Phase detector sub-block 130 can be any suitable phase detector sub-block that produces either a digital frequency that can be read back by microcontroller block 112 using a capture function, or an analog voltage that can be read back by microcontroller block 112 using an analog to digital converter. FIG. 14 depicts a schematic that includes two such phase detector sub-blocks, namely an XOR phase detector (in the upper half of FIG. 14 and including IC22 and IC23) and a Quadrature DEMUX phase detector (in the lower half of FIG. 14 and including IC12 and IC13).

FIG. 14 also depicts a calibration load sub-block 126 that includes a switch (IC16) and a dummy load R7 and C6. Calibration load sub-block 126 is configured for the dynamic measurement of a phase offset for the known phase shift of zero degrees produced by resistor R7, thus providing a phase offset for use in calibration. C6 is configured to force a predetermined slight phase shift, e.g. to compensate for phase delays caused by parasitic capacities in the signal traces to the sample cell, or for phase delays in the electrical circuits (LPF and TIA).

The Quadrature DEMUX phase detector circuit of FIG. 14 includes two portions, one portion for a resistive part of the incoming AC signal and one portion for the reactive portion of the incoming AC signal. Use of such two portions enables the simultaneous measurement of both the resistive and reactive portion of the AC signal and a measurement range that covers 0 degrees to 360 degrees. The Quadrature DEMUX circuit of FIG. 14 generates two separate output voltages. One of these output voltages represents the "in phase measurement" and is proportional

to the "resistive" part of the AC signal, the other output voltage represents the "Quadrature Measurement" and is proportional to the "reactive part of the signal. The phase shift is calculated as:

$$\Phi = \tan^{-1}(\text{VQUAD-PHASE} / \text{VIN-PHASE})$$

Such a Quadrature DEMUX phase detector circuit can also be employed to measure the impedance of a bodily fluid sample in the sample cell. It is hypothesized, without being bound, that the impedance could be employed along with the phase-shift, or independently thereof, to determine the hematocrit of the bodily sample. The amplitude of a signal forced through the sample cell can be calculated using the two voltage outputs of the Quadrature DEMUX circuit as follows :

$$\text{Amplitude} = \text{SQR}\left((V_{QUAD\text{-}PHASE})^2 + (V_{IN\text{-}PHASE})^2\right)$$

This amplitude can then be compared to an amplitude measured for the known resistor of calibration load block 126 to determine the impedance.

The XOR phase detector portion has a measurement range of 0° to 180°, or alternatively a measurement range of -90° to +90°, depending whether the "Square wave input from μC" is in phase to the sine wave or is set to a 90° phase shift. The XOR phase detector produces an output frequency that is always double the input frequency, however the duty cycle varies. If both inputs are perfectly in phase, the output is LOW, if both inputs are 180° shifted the output is always HIGH. By integrating the output signal (e.g. via a simple RC element) a voltage can be generated that is directly proportional to the phase shift between both inputs.

Once apprised of the present disclosure, one skilled in the art will recognize that phase detector sub-blocks employed in embodiments of the present disclosure can take any suitable form and include, for example, forms that employ rising edge capture techniques, dual edge capture techniques, XOR techniques and synchronous demodulation techniques.

Since low pass filter sub-block 122, transimpedance amplifier sub-block 128 and phase detector sub-block 130 can introduce a residual phase shift into phase-shift-based hematocrit measurement block 114, calibration load block 126 can be optionally included in the phase-shift-based hematocrit measurement block. Calibration load block 126 is configured to be essentially resistive in nature (for example a 33k-ohm load) and, therefore, induces no phase shift between excitation voltage and generated current. Calibration load block 126 is configured to be switched in across the circuit to give a "zero" calibration reading. Once calibrated, the hand-held test meter can measure the phase shift of a bodily fluid sample, subtract the "zero" reading to compute a corrected phase shift and subsequently compute the bodily sample hematocrit based on the corrected phase shift.

FIG. 15 is a flow diagram depicting stages in a method 200 for employing a hand-held test meter and analytical test strip (e.g., an electrochemical-based analytical test strip). Method 200, at step 210, includes introducing a whole blood sample into a sample cell of the analytical test strip.

At step 220, a phase shift of the whole blood sample in the sample cell is measured using a phase-shift-based measurement block and a microcontroller block of a hand-held test meter. Method 200 further includes computing the hematocrit of whole blood sample based on the measured phase shift using the microcontroller block (see step 230 of FIG. 15).

Once apprised of the present disclosure, one skilled in the art will recognize that methods according to embodiments of the present disclosure, including method 200, can be readily modified to incorporate any of the techniques, benefits and characteristics of hand-held test meters according to embodiments of the present disclosure and described herein. For example, if desired, an analyte in the introduced bodily fluid sample using the analytical test strip, hand-held test meter and computed hematocrit.

CLAIMS

1. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:
depositing a physiological sample on any one of the at least two electrodes to start an analyte test sequence;
applying a first signal to the sample to derive a physical characteristic of the sample;
driving a second signal to the sample for a first sampling time duration that overlaps with the test sequence to obtain a first transient signal output from the sample, the first transient signal correlated to both time and magnitude during the first sampling time duration;
extracting a specific sampling time during the test sequence in the first sampling time duration based on the physical characteristic of the sample;
obtaining from the first transient signal a second transient signal over a second sampling time duration;
deriving respective magnitudes of the second transient signal at selected time intervals in the second sampling time duration; and
determining an analyte concentration based on respective magnitudes of the second transient signal at the selected time intervals.

2. The method of claim 1, further comprising
defining the second sampling time duration based on the specific sampling time such that the second sampling time duration overlaps the first sampling time duration; and
dividing the second transient signal into discrete time intervals with respect to the second sampling time duration, and
in which the second transient signal is referenced with respect to the second sampling time duration.

3. A method of determining an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:

depositing a physiological sample on any one of the at least two electrodes to start an analyte test sequence;
applying a first signal to the sample to derive a physical characteristic of the sample;
extracting a specific sampling time in a first sampling time duration;
driving a second signal into the sample for the first sampling time duration,
measuring or sampling a first transient signal output from the sample for the duration of the first sampling time duration;
defining a specific range of time that includes the specific sampling time in the first sampling time duration, and obtaining plural magnitudes of the first transient signal at respective discrete intervals within the specific range of time; or
obtaining plural magnitudes of the first transient signal output at time intervals other than at about the specific sampling time; and
determining the analyte concentration based on the magnitudes of the first transient signal from the obtaining step.

4. The method of claim 3, comprising:

i. defining a specific range of time that includes the specific sampling time in the first sampling time duration, and obtaining plural magnitudes of the first transient signal at respective discrete intervals within the specific range of time

5. The method of claim 3, comprising:

ii. obtaining plural magnitudes of the first transient signal output at time intervals other than at about the specific sampling time.

6. A method of demonstrating the accuracy of an analyte concentration from a physiological sample with a biosensor having at least two electrodes and a reagent disposed on at least one electrode of the electrodes, the method comprising:
depositing a physiological sample on any one of the at least two electrodes to start an analyte test sequence for each of a plurality of the biosensors;
applying a first signal to the sample to derive a physical characteristic of the sample for each of the plurality of the biosensors;

extracting a specific sampling time in a first sampling time duration for each of the plurality of the biosensors;

driving a second signal into the sample for the first sampling time duration for each of a plurality of the biosensors;

measuring or sampling a first transient signal output from the sample for the duration of the first sampling time duration for each of the plurality of the biosensors;

defining a specific range of time that includes the specific sampling time in the first sampling time duration for each of the plurality of the biosensors;

obtaining plural magnitudes of the first transient signal at respective discrete intervals within the specific range of time for each of the plurality of the biosensors; and

determining the analyte concentration based on the magnitudes of the first transient signal from the obtaining step for each of the plurality of the biosensors such that an error between a plurality of analyte concentrations determined by the determining step for the plurality of the biosensors is less than ±15% as compared to referential value at each of 30%, 42%, and 55% hematocrits.

7. The method of claim 1 or claim 2, in which the second sampling time duration includes magnitudes of second transient signal measured before the specific sampling time,

or the method of any one of claims 3, 4 and 6, in which the specific range of time includes magnitudes of first transient signal measured before the specific sampling time.

8. The method of any preceding claim, in which the step of extracting the specific sampling time comprises calculating a defined specific sampling time in the first sampling time duration based on the physical characteristic of the sample.

9. The method of claim 8, in which the calculating step for the defined specific sampling time comprises utilizing an equation of the form:

$$SpecificSamplingTime = x_1 H^{x_2} + x_3$$

where

"SpecificSamplingTime" is designated as a time point from the start of the test sequence at which to sample the output signal of the biosensor,

H represents physical characteristic of the sample;

x_1 is about 4.3e5;

x_2 is about (—)3.9; and

x_3 is about 4.8.

10. The method of claim 2, in which the step of defining the second sampling time duration comprises obtaining an absolute value of a difference between the defined specific sampling time and a predetermined time point to define a start time (Tl) and an end time (T2) approximately equal to the specific sampling time point, and the first sampling time duration comprises about 10 seconds or less from the step of depositing the sample.

11. The method of claim 1, in which the step of obtaining further comprises defining a second sampling time duration that overlaps the first sampling time duration and includes a portion of the first transient signal and its magnitudes with respect to time of the second sampling time duration, wherein the portion is designated as a second transient signal.

12. The method of claim 10, in which the step of obtaining the second transient signal comprises extracting from the first transient signal a portion of the first transient signal that is designated as a second transient signal that is within the second sampling time duration.

13. The method of claim 12, in which the deriving of respective magnitudes of the second transient signal at discrete selected time intervals comprises calculating a magnitude of the second transient signal during each selected time interval.

14. The method of any one of claims 2, 10, 12 and 13, in which the dividing comprises dividing the second transient signal into at least 22 intervals in sequence starting from interval one at about the start time to interval twenty-two at about the end time.

15. The method of claim 14, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left(\frac{|I_3|}{|I_4|}\right)^{x_1} \times \left(\frac{|I_2| + x_4|I_5| - x_5|I_1|}{|I_2| + x_4|I_5|}|I_5|\right) - x_2}{x_3}$$

where:

G is representative of analyte concentration;

I_1 ≈ magnitude of second transient signal at interval 17;

I_2 ~ magnitude of second transient signal at interval 13;

I_3 ~ magnitude of second transient signal at interval 5;

I_4 ≈ magnitude of second transient signal at interval 3;

I_s ≈ magnitude of second transient signal at interval 22;

x_i «0.75;

xi ≈337.27;

x_3 ≈ (—)16.81;

x_4 ~\.4\; and

x_5 -2.67.

16. The method of claim 14, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_1(|I_1|)^{\left(x_2 - \frac{x_3}{|I_2|}\right)} - x_4}{x_5}$$

where:

G is representative of analyte concentration;

I_i ≈ magnitude of second transient signal at interval 11;

I_2 ≈ magnitude of second transient signal at interval 7;

x_i -0.59;

x_2 ≈2.51;

x_3 ≈(—)12.74;

x_4~ {—) 188.31; and

x_5~9.2.

17. The method of claim 14, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_1 ln\left(x_2 \frac{|I_1|}{|I_2|}\right)^{x_3} |I_3|^{x_4 - x_5}}{x_6}$$

where

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 20;

I_2 ≈ magnitude of second transient signal at interval 22;

I_3 ~ magnitude of second transient signal at interval 19;

x,~20.15;

x^l.0446;

x_3-0.95;

x_4~1.39;

x_5~(—)0·71; and

x_6~0.1 1.

18. The method of claim 14, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_3 \left|\frac{I_1}{I_2}\right|^{\left(x_1 - x_2 \left|\frac{I_3}{I_4}\right|\right)} \times |I_5| - x_5}{x_4}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 5;

I_2 ≈ magnitude of second transient signal at interval 1;

I_3 ~ magnitude of second transient signal at interval 2;

I_4 ≈ magnitude of second transient signal at interval 10;

I_5 ≈ magnitude of second transient signal at interval 22;

x_i -0.70;

x^0.49;

x_3-28.59;

x_4≈0.1 ; and

x_5~15.51.

19. The method of claim 14, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^2+x_3|I_3|+x_4}{x_5|I_4|+x_6}\right)-x_7}{x_8}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 19;

I_2 ≈ magnitude of second transient signal at interval 16;

I_3 ≈ magnitude of second transient signal at interval 11;

I_4 ~ magnitude of second transient signal at interval 5;

x_1 (—)1.68;

x_2-0.95;

x_3≈(—)4.97;

x_4~6.29;

x_5~3.08;

x_6~(—)5.84;

x_7~(—)0.47; and

xs~0.01.

20. The method of claim 14, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^3 + x_3|I_3|^2 + x_4|I_3| + x_5}{x_6|I_4|^2 + x_7|I_4| + x_8}\right) - x_9}{x\ 10}$$

where:

G is representative of analyte concentration;

I_1 ≈ magnitude of second transient signal at interval 16;

I_2 ~ magnitude of second transient signal at interval 5;

I_3 ≈ magnitude of second transient signal at interval 12;

I_4 ≈ magnitude of second transient signal at interval 14;

x_1~1.18;

x^0.97;

x_3~(—)11.32;

x_4~38.76;

x_5~(—)39.32;

x_6~0.0928;

x_7~(—)0.85;

xs~1.75;

x_9~(—)9.38; and

x_{10}~0.25.

21. The method of any one of claims 1, 2, and 10-20, in which the magnitude of the second transient signal at each of the plurality of discrete intervals comprises an average magnitude of

measured magnitudes at each discrete interval.

22. The method of claim 4, further comprising the step of dividing the first transient signal into discrete intervals with respect to the specific range of time.

23. The method of claim 6, further comprising dividing the first transient signal into discrete intervals with respect to the specific range of time.

24. The method of claim 22 or claim 23, in which the dividing comprises dividing the first transient signal into at least 22 intervals in sequence starting from interval one at about the start time to interval twenty-two at about the end time.

25. The method of claim 24, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left(\frac{|I_3|}{|I_4|}\right)^{x_1} \times \left(\frac{|I_2|+x_4|I_5|-x_5|I_1|}{|I_2|+x_4|I_5|}|I_5|\right)-x_2}{X_3}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of first transient signal at interval 17;

I_2 ~ magnitude of first transient signal at interval 13;

1_3 ~ magnitude of first transient signal at interval 5;

1_4 ≈ magnitude of first transient signal at interval 3;

Is ≈ magnitude of first transient signal at interval 22;

x_i «0.75;

xi ≈337.27;

x_3 ≈ (—)16.81;

x_4 ≈l .41; and

x_5 -2.67.

26. The method of claim 24, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_1(|I_1|)^{\left(x_2 - \frac{x_3}{|I_2|}\right)} - x_4}{x_5}$$

where:

G is representative of analyte concentration;

$Ii \approx$ magnitude of first transient signal at interval 11;

$I_2 \approx$ magnitude of first transient signal at interval 7;

x_i -0.59;

$x_2 \approx 2.51$;

$x_3 \approx (—)12.74$;

$x_4 \sim (—)$ 188.31; and

$x_5 \sim 9.2$.

27. The method of claim 24, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_1 ln\left(x_2 \frac{|I_1|}{|I_2|}\right)^{x_3} |I_3|^{x_4} - x_5}{X_6}$$

where

G is representative of analyte concentration;

$Ii \approx$ magnitude of first transient signal at interval 20;

$I_2 \approx$ magnitude of first transient signal at interval 22;

$I_3 \sim$ magnitude of first transient signal at interval 19;

χ,~20.15;

x^l.0446;

x_3-0.95;

x_4-1.39;

x_5~(—)0.71; and

x_6~0.1 1.

28. The method of claim 24, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{x_3 \left|\frac{I_1}{I_2}\right|^{\left(x_1 - x_2\left|\frac{I_3}{I_4}\right|\right)} \times |I_5| - x_5}{x_4}$$

where:

G is representative of analyte concentration;

$Ii \approx$ magnitude of first transient signal at interval 5;

$I_2 \approx$ magnitude of first transient signal at interval 1;

$I3 \approx$ magnitude of first transient signal at interval 2;

$I_4 \approx$ magnitude of first transient signal at interval 10;

$I_5 \approx$ magnitude of first transient signal at interval 22;

Xi-0.70;

x^0.49;

x_3-28.59;

x^-0.7; and

x_5~15.51.

29. The method of claim 24, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^2 + x_3|I_3| + x_4}{x_5|I_4| + x_6}\right) - x_7}{x_8}$$

where:

G is representative of analyte concentration;

I_1 ~ magnitude of first transient signal at interval 19;

I_2 ≈ magnitude of first transient signal at interval 16;

I_3 ≈ magnitude of first transient signal at interval 11;

I_4 ≈ magnitude of first transient signal at interval 5;

x_1 « (—)1·68;

x_2-0.95;

x_3≈(—)4.97;

x_4~6.29;

x_5~3.08;

x_6≈(—)5.84;

x_7~(—)0.47; and

xs~0.01.

30. The method of claim 24, in which the determination of analyte concentration is obtained by utilizing an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^3 + x_3|I_3|^2 + x_4|I_3| + x_5}{x_6|I_4|^2 + x_7|I_4| + x_8}\right) - x_9}{x_{10}}$$

where:

G is representative of analyte concentration;

I_1 ~ magnitude of first transient signal at interval 16;

I_2 ~ magnitude of first transient signal at interval 5;

I_3 ~ magnitude of first transient signal at interval 12;

$I_4 \approx$ magnitude of first transient signal at interval 14;

$x_1 \sim 1.18$;

$x \wedge 0.97$;

$x_3 \sim (-)11.32$;

$x_4 \sim 38.76$;

$x_5 \sim (-)39.32$;

$x_6 \sim 0.0928$;

$x_7 \sim (-)0.85$;

$x_8 \sim 1.75$;

$x_9 \sim (-)9.38$; and

$x_{10} \sim 0.25$.

31. The method of any one of claims 4, 6, and 22-30, in which the magnitude of the first transient signal at each of the plurality of discrete intervals comprises an average magnitude of measured magnitudes at each discrete interval.

32. The method of any preceding claim, in which the applying of the first signal and the driving of the second signal is in sequential order.

33. The method of any preceding claim, in which the applying of the first signal overlaps with the driving of the second signal.

34. The method of any preceding claim, in which the applying of the first signal comprises directing an alternating signal to the sample so that a physical characteristic of the sample is determined from an output of the alternating signal.

35. The method of any preceding claim, in which the applying of the first signal comprises directing an optical signal to the sample so that a physical characteristic of the sample is determined from an output of the optical signal.

36. The method of any preceding claim, in which the physical characteristic comprises at least

one of viscosity, hematocrit, temperature or density of the sample.

37. The method of any preceding claim, in which the physical characteristic comprises hematocrit and the analyte comprises glucose.

38. The method of claim 34, in which the directing comprises driving first and second alternating signals at different respective frequencies in which a first frequency comprises a frequency than the second frequency.

39. The method of claim 39, in which the first frequency is at least one order of magnitude lower than the second frequency.

40. The method of claim 38 or claim 39, in which the first frequency comprises any frequency in the range of about 10kHz to about 250kHz.

41. The method of claim 1, in which the obtaining comprises extracting from the first transient signal a second transient signal referenced with respect to the second sampling time duration.

42. The method of claim 1 or claim 2, in which the obtaining comprises removing signals from the first transient signals that are outside of the second sampling time duration to leave the second transient signal within the second sampling time duration.

43. The method of claim 41 or claim 42, in which the deriving comprises storing magnitudes of the second transient signal for each discrete interval in the second sampling time duration.

44. An analyte measurement system comprising:

a test strip including:

a substrate;

a plurality of electrodes disposed on the substrate and connected to respective electrode connectors; and

an analyte meter including:

a housing;

a test strip port connector configured to connect to the respective electrode connectors of the test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from the plurality of electrodes during a test sequence,

the microprocessor is configured to:

(a) apply a first signal to the plurality of electrodes so that a physical characteristic of the sample is derived to provide a specific sampling time,

(b) apply a second signal to the plurality of electrodes,

(c) measure a first transient output signal from the plurality of electrodes;

(d) extract a second transient output signal from the first output signal;

(e) determine a magnitude of the second transient output signal over a plurality of discrete time intervals; and

(f) calculate the analyte concentration from the magnitudes of the second transient output signal at selected intervals of the plurality of discrete time intervals.

45. The system of claim 44, in which the microprocessor is further configured to annunciate the analyte concentration within about 10 seconds of a start of the test sequence.

46. The system of claim 44 or claim 45, in which the plurality of electrodes comprises at least two electrodes to measure the physical characteristic and at least two other electrodes to measure the analyte concentration.

47. The system of claim 46, in which the at least two electrodes and the at least two other electrodes are disposed in the same chamber provided on the substrate.

48. The system of claim 46, in which the at least two electrodes and the at least two other electrodes are disposed in different chambers provided on the substrate.

49. The system of claim 48, in which the different chambers are disposed adjacent to each

other on an edge of the substrate.

50. The system of claim 46, in which the at least two electrodes and the at least two other electrodes are disposed in a common chamber that receives a fluid sample.

51. The system of claim 44 or claim 45, in which the plurality of electrodes comprises two electrodes to measure the physical characteristic and the analyte concentration.

52. The system of one of claim 44-51, in which all of the electrodes are disposed on the same plane defined by the substrate.

53. The system of one of claim 46-50, in which a reagent is disposed proximate the at least two other electrodes and no reagent is disposed on the at least two electrodes.

54. The system of any one of claims 44-53, in which the specific sampling time is calculated using an equation of the form:

$$SpecificSamplingTime = x_1 H^{x_2} + x_3$$

where

"SpecificSamplingTime" is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

H represents physical characteristic of the sample;

xi represents about 4.3e5;

x_2 represents about (—)3.9; and

x_3 represents about 4.8.

55. The system of any one of claims 44-54, in which the plurality of discrete time intervals comprises at least 22 discrete time intervals.

56. The system of claim 55, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\frac{|I_3|}{|I_4|}\right)^{x_1} \times \left(\frac{|I_2| + x_4|I_5| - x_5|I_1|}{|I_2| + x_4|I_5|}|I_5|\right) - x_2}{x_3}$$

where:

G is representative of analyte concentration;

I_1 ≈ magnitude of second transient signal at interval 17;

I_2 ~ magnitude of second transient signal at interval 13;

I_3 ~ magnitude of second transient signal at interval 5;

I_4 ≈ magnitude of second transient signal at interval 3;

Is ≈ magnitude of second transient signal at interval 22;

x_i «0.75;

xi ≈337.27;

x_3 ≈ (—)16.81;

x_4 ≈l .41; and

x_5 -2.67.

57. The system of claim 55, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_1(|I_1|)^{\left(x_2 - \frac{x_3}{|I_2|}\right)} - x_4}{x_5}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 11;

I_2 ≈ magnitude of second transient signal at interval 7;

x_i -0.59;

x_2 ≈2.5l;

x_3 ≈(—)12.74;

x_4~{—) 188.31; and

x_5~9.2.

58. The system of claim 55, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_1 ln\left(x_2 \frac{|I_1|}{|I_2|}\right)^{x_3} |I_3|^{x_4 - x_5}}{x_6}$$

where

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 20;

I_2 ≈ magnitude of second transient signal at interval 22;

I_3 ~ magnitude of second transient signal at interval 19;

x,~20.15;

x^l.0446;

x_3-0.95;

x_4~1.39;

x_5~(—)0.71; and

x_6~0.1 1.

59. The system of claim 55, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_3 \left|\frac{I_1}{I_2}\right|^{\left(x_1 - x_2\left|\frac{I_3}{I_4}\right|\right)} \times |I_5| - x_5}{x_4}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 5;

I_2 ≈ magnitude of second transient signal at interval 1;

I_3 ~ magnitude of second transient signal at interval 2;

I_4 ≈ magnitude of second transient signal at interval 10;

I_5 ≈ magnitude of second transient signal at interval 22;

x_i -0.70,

x^0.49,

x_3 -28.59,

x_4 -*0.7*, and

x_5 ~15.51.

60. The system of claim 55, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^2 + x_3|I_3| + x_4}{x_5|I_4| + x_6}\right) - x_7}{x_8}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 19;

I_2 ≈ magnitude of second transient signal at interval 16;

1_3 ~ magnitude of second transient signal at interval 11;

1_4 ~ magnitude of second transient signal at interval 5;

x_{1} « (—)1.68;

x_2 -0.95;

x_3 ≈(—)4.97;

x_4 ≈*6.29*;

x_5~3.08;

x_6~(—)5.84;

x_7~(—)0.47; and

xs~0.01.

61. The system of claim 55, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^3 + x_3|I_3|^2 + x_4|I_3| + x_5}{x_6|I_4|^2 + x_7|I_4| + x_8}\right) - x_9}{X_{10}}$$

where:

G is representative of analyte concentration;

I_1 ~ magnitude of second transient signal at interval 16;

I_2 ~ magnitude of second transient signal at interval 5;

I_3 ~ magnitude of second transient signal at interval 12;

I_4 ~ magnitude of second transient signal at interval 14;

Xi~1.18;

x^0.97;

x_3~(—)11.32;

x_4-38.76;

x_5~(—)39.32;

x_6~0.0928;

x_7~(—)0.85;

xs~1.75;

x_9~(—)9.38; and

x_{10}~0.25.

62. The system of any one of claims 44-61 , in which the magnitude of the second transient signal at each of the plurality of discrete time intervals comprises an average magnitude of the signal sampled throughout each interval.

63. The system of any one of claims 54-61, in which an error between a plurality of analyte concentrations calculated by the microprocessor is less than ±15% as compared to referential value at 30% hematocrits.

64. The system of any one of claims 54-61, in which an error between the plurality of analyte concentrations calculated by the microprocessor is less than ± 15% as compared to referential value at 42% hematocrits.

65. The system of any one of claims 54-61, in which an error between a plurality of analyte concentrations calculated by the microprocessor is less than ±15% as compared to referential value at 55% hematocrits.

66. An analyte meter including:

a housing;

a test strip port connector configured to connect to respective electrode connectors of a test strip; and

a microprocessor in electrical communication with the test strip port connector to apply electrical signals or sense electrical signals from a plurality of electrodes of the test strip connected to the respective electrode connectors of the test strip during a test sequence,

the microprocessor is configured to:

(a) apply a first signal to the plurality of electrodes so that a physical characteristic of a sample deposited on the plurality of electrodes is derived to provide a specific sampling time,

(b) apply a second signal to the plurality of electrodes,

(c) measure a first transient output signal from the plurality of electrodes;

(d) extract a second transient output signal from the first output signal;

(e) determine a magnitude of the second transient output signal over a plurality of discrete time intervals; and

(f) calculate the analyte concentration from the magnitudes of the second transient output signal at selected intervals of the plurality of discrete time intervals.

67. The meter of claim 66, in which the microprocessor is further configured to annunciate the analyte concentration within about 10 seconds of a start of the test sequence

68. The meter of claim 66 or claim 67, in which the specific sampling time is calculated using an equation of the form:

$$SpecificSamplingTime = x_1 H^{x_2} + x_3$$

where

"SpecificSamplingTime" is designated as a time point from the start of the test sequence at which to sample the output signal of the test strip,

H represents physical characteristic of the sample;

xi represents about 4.3e5;

x_2 represents about (—)3.9; and

x_3 represents about 4.8.

69. The meter of any one of claims 66-68, in which the plurality of discrete time intervals comprises at least 22 discrete time intervals.

70. The meter of claim 69, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\frac{|I_3|}{|I_4|}\right)^{x_1} \times \left(\frac{|I_2| + x_4|I_5| - x_5|I_1|}{|I_2| + x_4|I_5|}|I_5|\right) - x_2}{x_3}$$

where:

G is representative of analyte concentration;

I_1 ~ magnitude of second transient signal at interval 17;

I_2 ~ magnitude of second transient signal at interval 13;

I_3 ~ magnitude of second transient signal at interval 5;

I_4 ~ magnitude of second transient signal at interval 3;

I_s ≈ magnitude of second transient signal at interval 22;

x_i «0.75;

xi ≈337.27;

x_3 ≈ (—)16.81;

x_4 ≈l .41; and

x_5 -2.67.

71. The meter of claim 69, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_1(|I_1|)^{\left(x_2 - \frac{x_3}{|I_2|}\right)} - x_4}{x_5}$$

where:

G is representative of analyte concentration;

I_i ≈ magnitude of second transient signal at interval 11;

I_2 ~ magnitude of second transient signal at interval 7;

x_i -0.59;

x_2 ≈2.5l;

x_3 ≈(—)12.74;

x_4 ~(—) 188.31; and

x_5 ~9.2.

72. The meter of claim 69, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_1 ln\left(x_2 \frac{|I_1|}{|I_2|}\right)^{x_3} |I_3|^{x_4 - x_5}}{x_6}$$

where

G is representative of analyte concentration;

$Ii \approx$ magnitude of second transient signal at interval 20;

$I_2 \approx$ magnitude of second transient signal at interval 22;

$I_3 \approx$ magnitude of second transient signal at interval 19;

x,~20.15;

x^l.0446;

x_3-0.95;

x_4~1.39;

x_5~(—)0.71; and

x_6~0.1 1.

73. The meter of claim 69, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{x_3 \left|\frac{I_1}{I_2}\right|^{\left(x_1 - x_2 \left|\frac{I_3}{I_4}\right|\right)} \times |I_5| - x_5}{x_4}$$

where:

G is representative of analyte concentration;

$Ii \approx$ magnitude of second transient signal at interval 5;

$I_2 \approx$ magnitude of second transient signal at interval 1;

$I3 \approx$ magnitude of second transient signal at interval 2;

I_4 ~ magnitude of second transient signal at interval 10;

I_5 ≈ magnitude of second transient signal at interval 22;

x_1 -0.70,

x_2 ≈0.49,

x_3 ~28.59,

x_4 -0.7, and

x_5 -15.51.

74. The meter of claim 69, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^2 + x_3|I_3| + x_4}{x_5|I_4| + x_6}\right) - x_7}{x_8}$$

where:

G is representative of analyte concentration;

I_1 ≈ magnitude of second transient signal at interval 19;

I_2 ~ magnitude of second transient signal at interval 16;

I_3 ~ magnitude of second transient signal at interval 11;

I_4 ~ magnitude of second transient signal at interval 5;

x_1 « (—)1·68;

x_2 -0.95;

x_3 ≈(—)4.97;

x_4 -6.29;

x_5 «3.08;

x_6 ≈(—)5.84;

x_7 ~(—)0.47; and

xs~0.01.

75. The meter of claim 69, in which the microprocessor calculates the analyte concentration with an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^3 + x_3|I_3|^2 + x_4|I_3| + x_5}{x_6|I_4|^2 + x_7|I_4| + x_8}\right) - x_9}{x_{10}}$$

where:

G is representative of analyte concentration;

I_1 ≈ magnitude of second transient signal at interval 16;

I_2 ≈ magnitude of second transient signal at interval 5;

I_3 ≈ magnitude of second transient signal at interval 12;

I_4 ≈ magnitude of second transient signal at interval 14;

x_i~1.18;

x^0.97;

x_3~(—)11.32;

x_4~38.76;

x_5~(—)39.32;

x_6~0.0928;

x_7~(—)0.85;

x_8~1.75;

x_9~(—)9.38; and

x_{10}~0.25.

76. The meter of any one of claims 66-75, in which the magnitude of the second transient signal at each of the plurality of discrete time intervals comprises an average magnitude of the signal sampled throughout each interval.

77. The meter of any one of claims 70-75, in which an error between a plurality of analyte concentrations calculated by the microprocessor is less than ±15% as compared to referential value at 30% hematocrits.

78. The meter of any one of claims 70-75, in which an error between the plurality of analyte concentrations calculated by the microprocessor is less than ±15% as compared to referential value at 42% hematocrits.

79. The meter of any one of claims 70-75, in which an error between a plurality of analyte concentrations calculated by the microprocessor is less than ±15% as compared to referential value at 55% hematocrits.

80. An analyte meter comprising:

a housing;

a test strip port connector configured to connect to respective plurality of electrode connectors of a test strip when the test strip is coupled to the test strip port connector; and

means for:

(a) determining a specified sampling time based on a sensed or estimated physical characteristic of a sample deposited on a plurality of electrodes of the test strip, the specified sampling time being at least one time point or interval referenced from a start of a test sequence upon deposition of a sample on the test strip;

(b) applying a second signal to the plurality of electrodes to measure a first transient output signal from the plurality of electrodes due to application of the second signal to the plurality of electrodes;

(c) extracting a second transient output signal from the first output signal;

(d) determining a magnitude of the second transient output signal over a plurality of discrete time intervals; and

(e) calculating the analyte concentration from the magnitudes of the second transient output signal at selected intervals of the plurality of discrete time intervals.

81. The meter of claim 80, in which the means for calculating comprises a microprocessor configured to calculate the analyte concentration with an equation of the form:

$$G = \frac{\left(\frac{|I_3|}{|I_4|}\right)^{x_1} \times \left(\frac{|I_2| + x_4|I_5| - x_5|I_1|}{|I_2| + x_4|I_5|}|I_5|\right) - x_2}{x_3}$$

where:

G is representative of analyte concentration;

I_1 ~ magnitude of second transient signal at interval 17;

I_2 ~ magnitude of second transient signal at interval 13;

I_3 ~ magnitude of second transient signal at interval 5;

I_4 ~ magnitude of second transient signal at interval 3;

I_5 ~ magnitude of second transient signal at interval 22;

xi«0.75;

xi≈337.27;

x_3≈ (—)16.81;

x_4≈l .41; and

x5-2.67.

82. The meter of claim 80, in which the means for calculating comprises a microprocessor configured to calculate the analyte concentration with an equation of the form:

$$G = \frac{x_1(|I_1|)^{\left(x_2 - \frac{x_3}{|I_2|}\right)} - x_4}{x_5}$$

where:

G is representative of analyte concentration;

I_i ~ magnitude of second transient signal at interval 11;

I_2 ~ magnitude of second transient signal at interval 7;

x_1 -0.59;

x_2 ≈2.51;

x_3 ≈(—)12.74;

x_4 ~(—) 188.31; and

x_5 ~9.2.

83. The meter of claim 80, in which the means for calculating comprises a microprocessor configured to calculate the analyte concentration with an equation of the form:

$$G = \frac{x_1 ln\left(x_2 \frac{|I_1|}{|I_2|}\right)^{x_3} |I_3|^{x_4} - x_5}{x_6}$$

where

G is representative of analyte concentration;

I_i ≈ magnitude of second transient signal at interval 20;

I_2 ~ magnitude of second transient signal at interval 22;

I_3 ~ magnitude of second transient signal at interval 19;

x,~20.15;

x^l.0446;

x_3 -0.95;

x_4 ~1.39;

x_5 ~(—)0.71; and

x_6 ~0.1 1.

84. The meter of claim 80, in which the means for calculating comprises a microprocessor configured to calculate the analyte concentration with an equation of the form:

$$G = \frac{x_3 \left|\frac{I_1}{I_2}\right|^{\left(x_1 - x_2\left|\frac{I_3}{I_4}\right|\right)} \times |I_5| - x_5}{x_4}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 5;

I_2 ~ magnitude of second transient signal at interval 1;

I_3 ~ magnitude of second transient signal at interval 2;

I_4 ≈ magnitude of second transient signal at interval 10;

I_5 ~ magnitude of second transient signal at interval 22;

xi -0.70,

x^O.49,

x_3-28.59,

x4≈0.1 , and

x_5~15.51.

85. The meter of claim 80, in which the means for calculating comprises a microprocessor configured to calculate the analyte concentration with an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^2 + x_3|I_3| + x_4}{x_5|I_4| + x_6}\right) - x_7}{x_8}$$

where:

G is representative of analyte concentration;

Ii ≈ magnitude of second transient signal at interval 19;

I_2 ~ magnitude of second transient signal at interval 16;

13 ~ magnitude of second transient signal at interval 11;

14 ~ magnitude of second transient signal at interval 5;

x_1≈(—)1.68;

x_2-0.95;

x_3≈(—)4.97;

x_4~6.29;

x_5~3.08;

x_6≈(—)5.84;

x_7~(—)0.47; and

xs~0.01.

86. The meter of claim 80, in which the means for calculating comprises a microprocessor configured to calculate the analyte concentration with an equation of the form:

$$G = \frac{\left(\left|\frac{I_1}{I_2}\right|^{x_1} \times \frac{x_2|I_3|^3 + x_3|I_3|^2 + x_4|I_3| + x_5}{x_6|I_4|^2 + x_7|I_4| + x_8}\right) - x_9}{X_{10}}$$

where:

G is representative of analyte concentration;

I_1 ≈ magnitude of second transient signal at interval 16;

I_2 ≈ magnitude of second transient signal at interval 5;

I_3 ≈ magnitude of second transient signal at interval 12;

I_4 ≈ magnitude of second transient signal at interval 14;

Xi~1.18;

x^0.97;

x_3≈(—)11.32;

x_4~38.76;

x_5~(—)39.32;

x_6~0.0928;

x_7≈(—)0.85;

xs~1.75;

x_9~(—)9.38; and

x_{10}~0.25.

87. The meter of any one of claims 81-86, in which the magnitude of the second transient signal at each of the plurality of discrete time intervals comprises an average magnitude of the signal sampled throughout each interval.

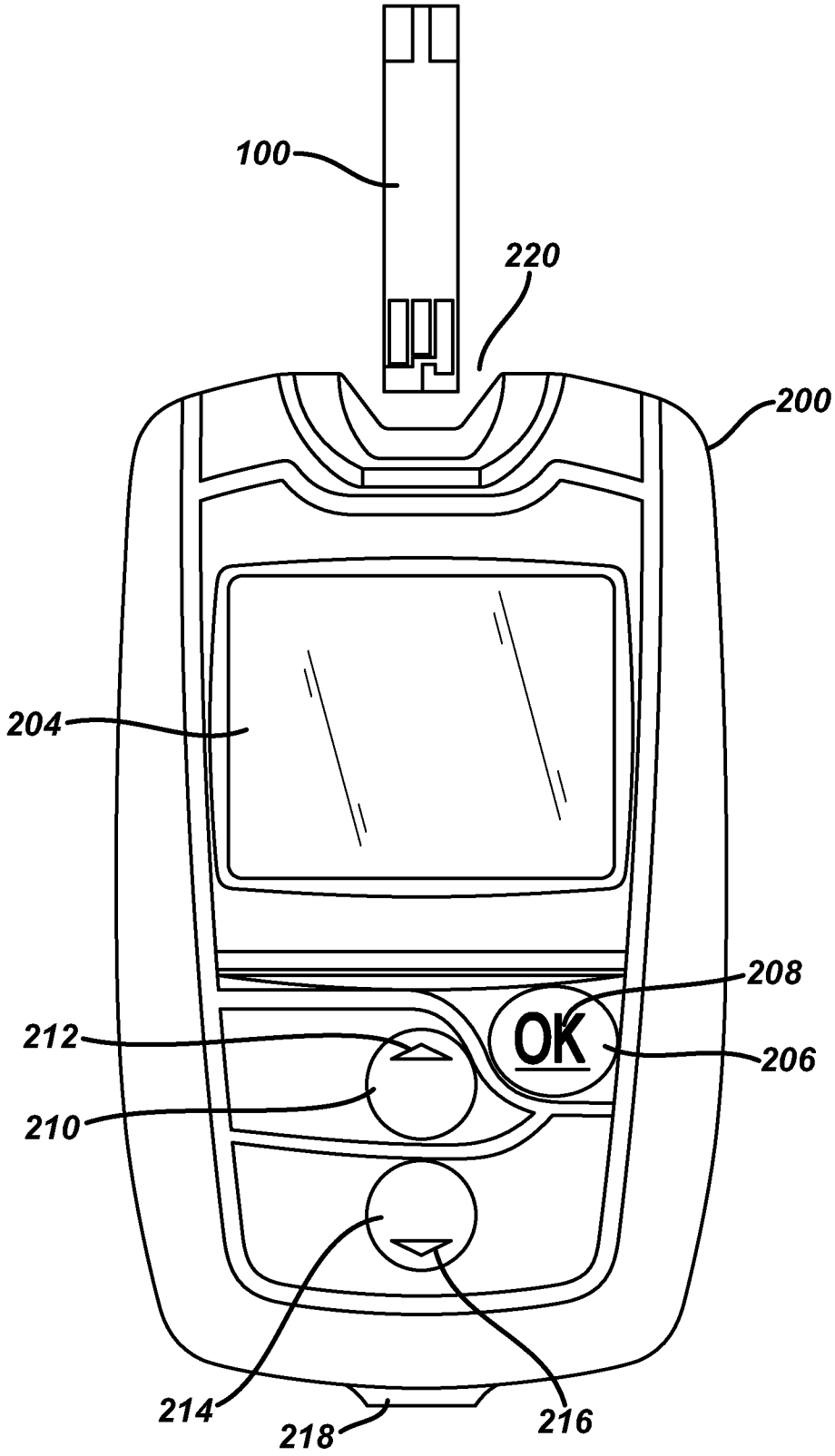

FIG. 1

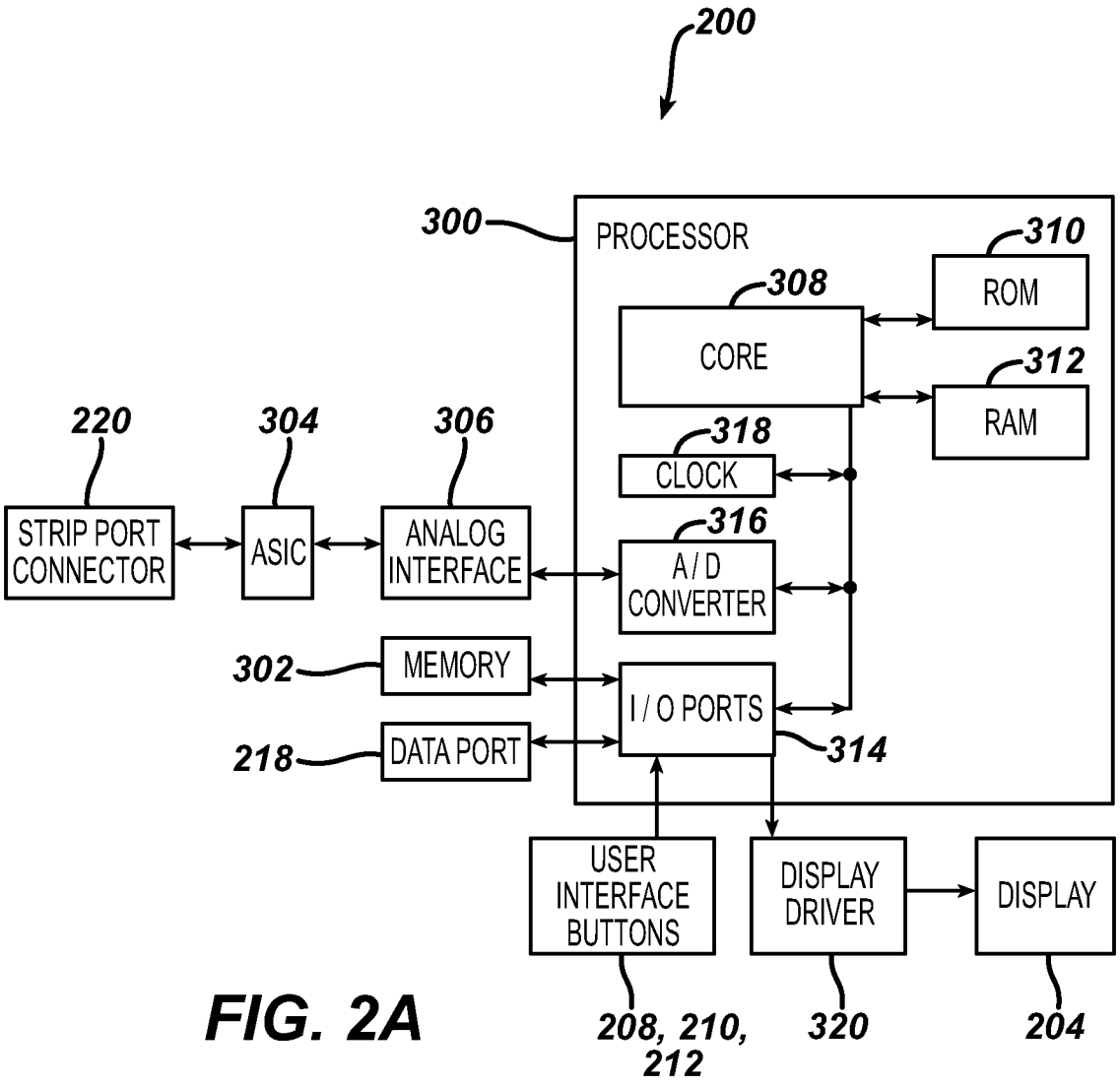
200
300
PROCESSOR
310
ROM
308
CORE
312
RAM
318
CLOCK
316
A / D
CONVERTER
220
304
306
STRIP PORT
CONNECTOR
ASIC
ANALOG
INTERFACE
302
MEMORY
218
DATA PORT
I / O PORTS
314
USER
INTERFACE
BUTTONS
DISPLAY
DRIVER
DISPLAY
208, 210,
212
320
204

FIG. 2A

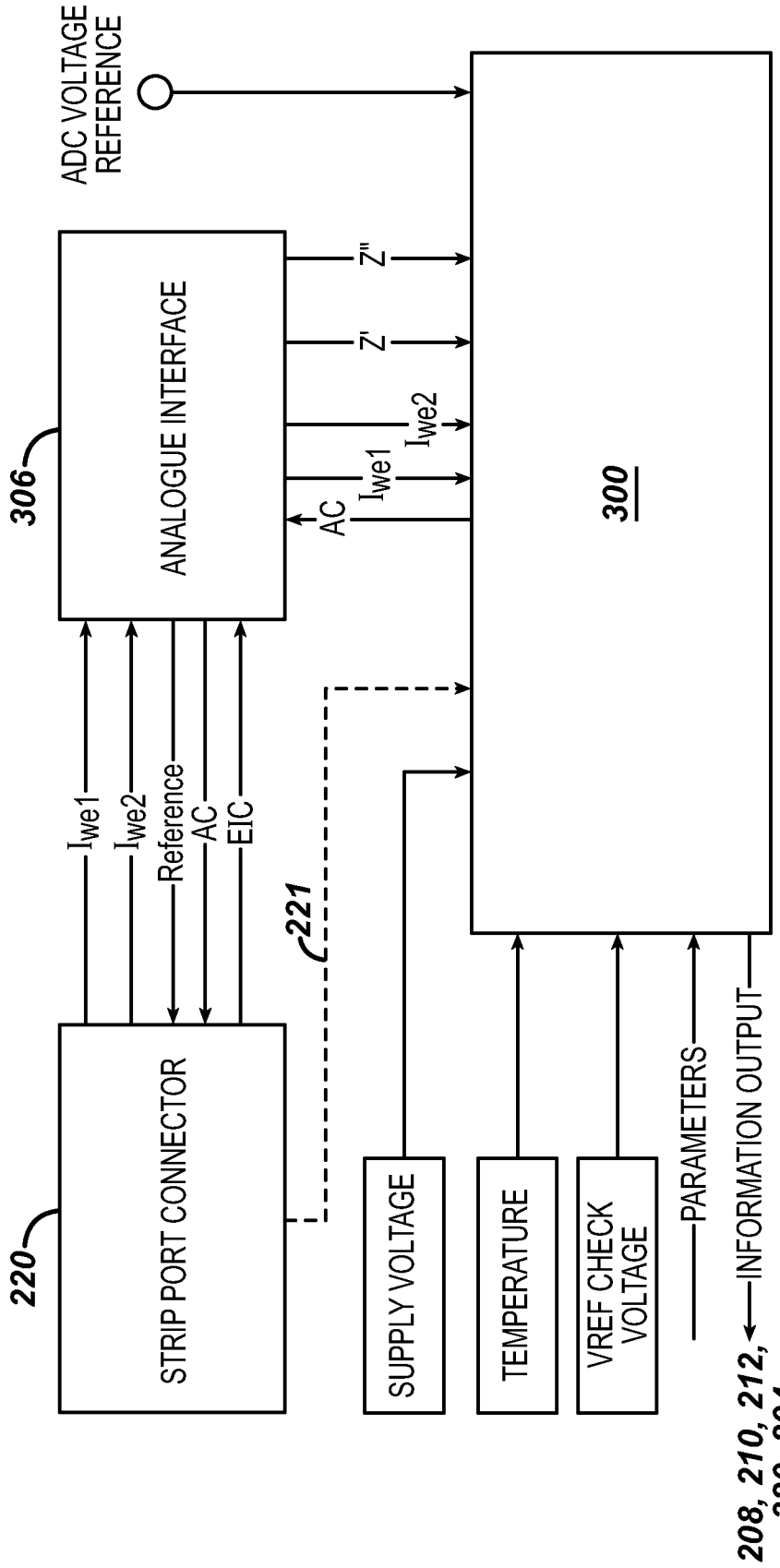
ADC VOLTAGE REFERENCE
ANALOGUE INTERFACE
306
Z"
Z'
I_{we2}
I_{we1}
AC
300
I_{we1}
I_{we2}
Reference
AC
EIC
221
STRIP PORT CONNECTOR
220
SUPPLY VOLTAGE
TEMPERATURE
VREF CHECK VOLTAGE
PARAMETERS
INFORMATION OUTPUT
208, 210, 212, 320, 204

FIG. 2B

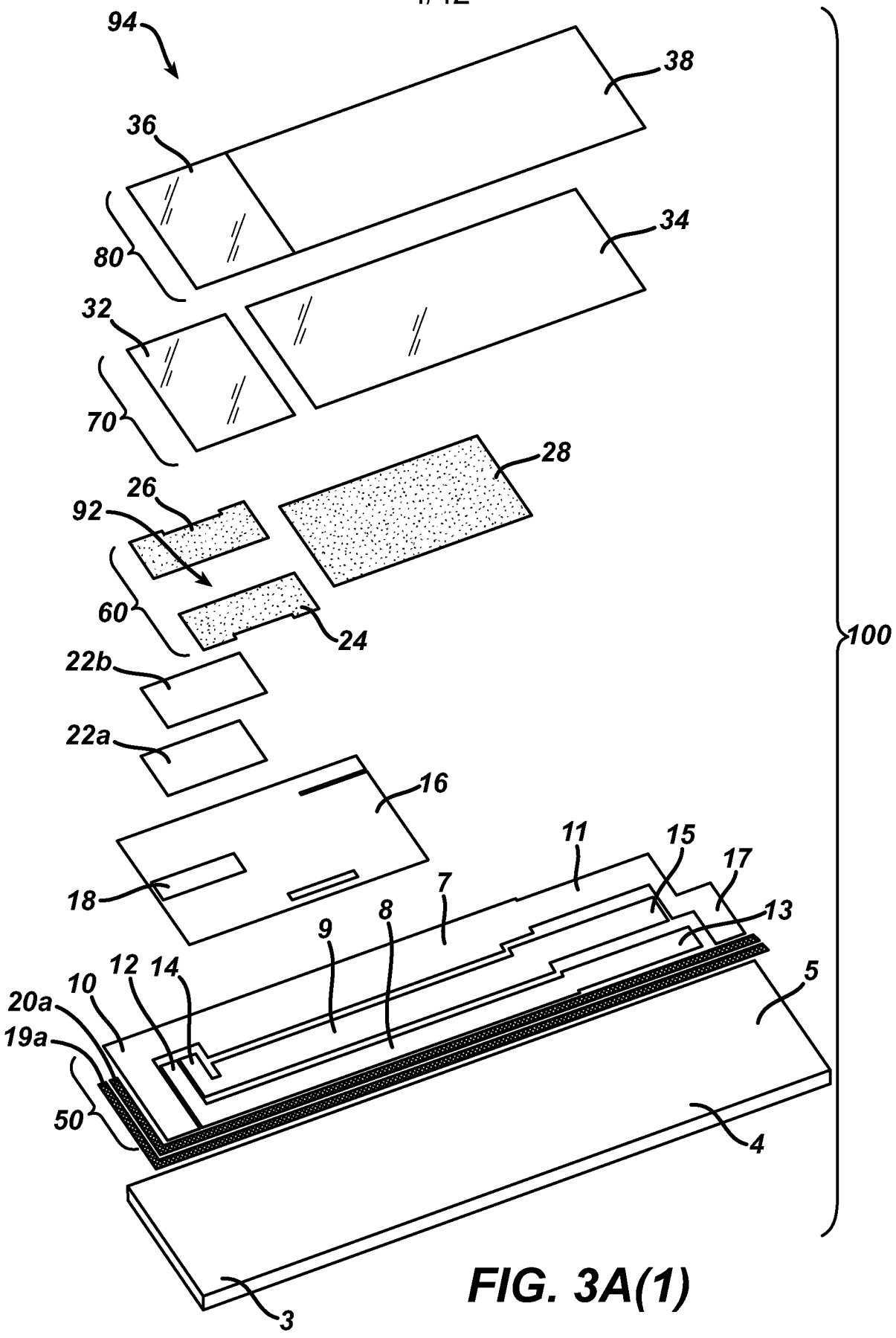
94
38
36
34
80
32
70
28
26
92
60
24
22b
22a
16
18
11
15
17
7
13
9
8
12
14
10
20a
19a
5
50
4
3
100

FIG. 3A(1)

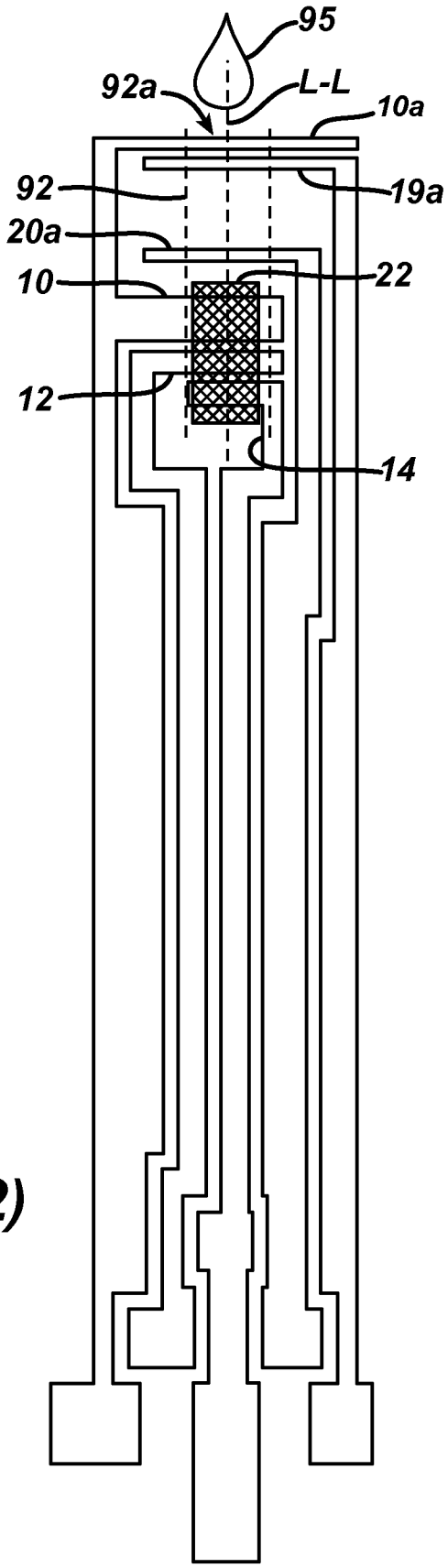

FIG. 3A(2)

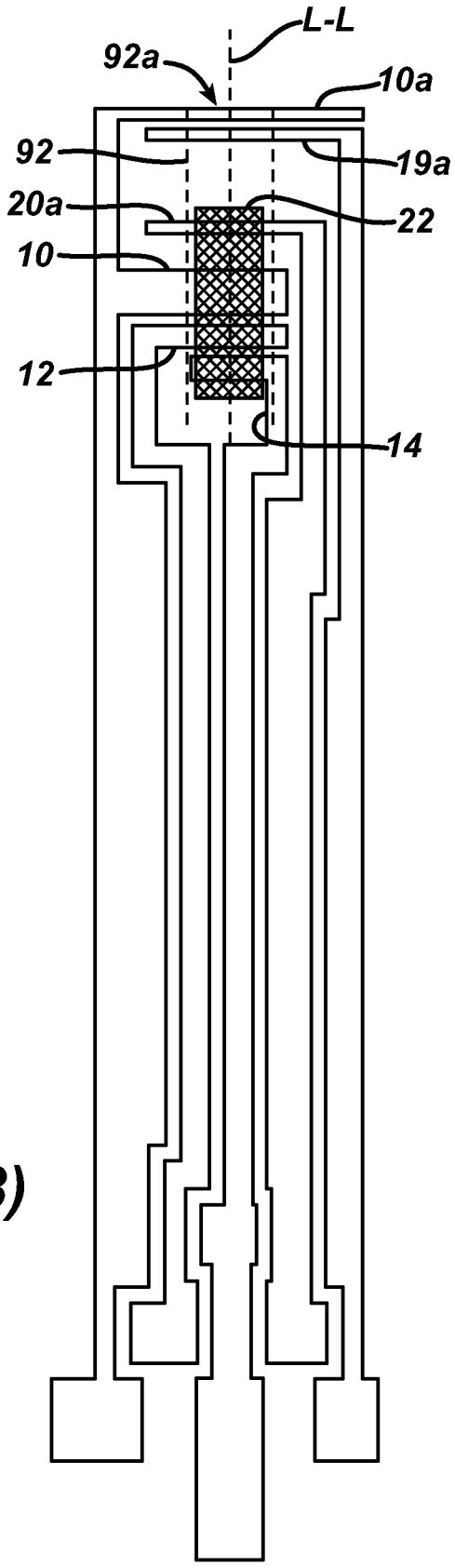

FIG. 3A(3)

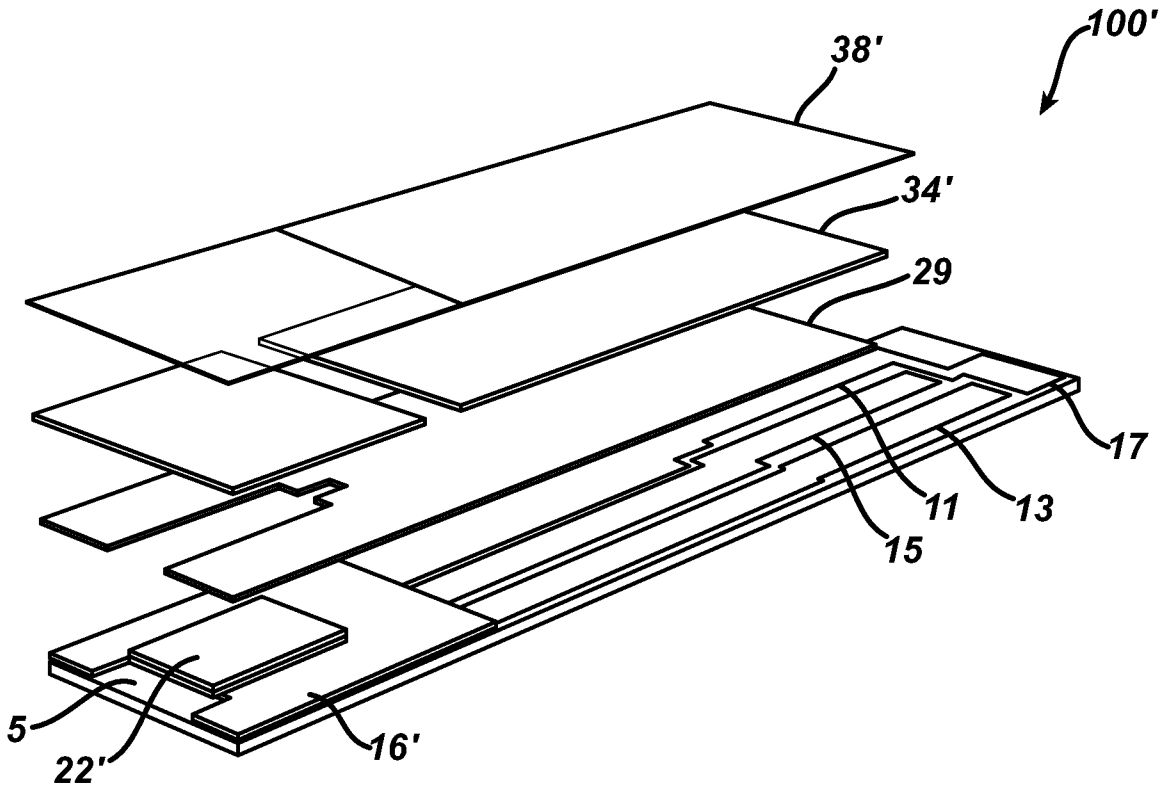

FIG. 3A(4)

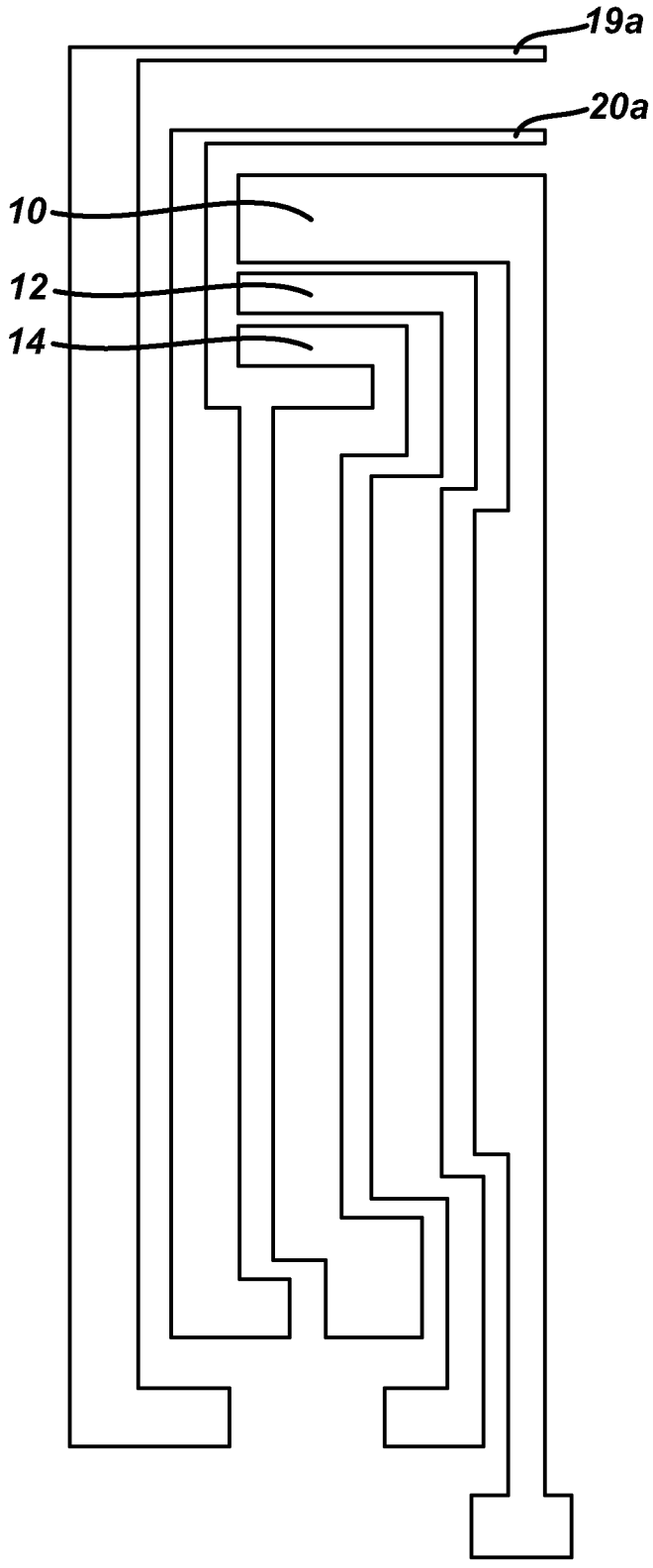

FIG. 3A(5)

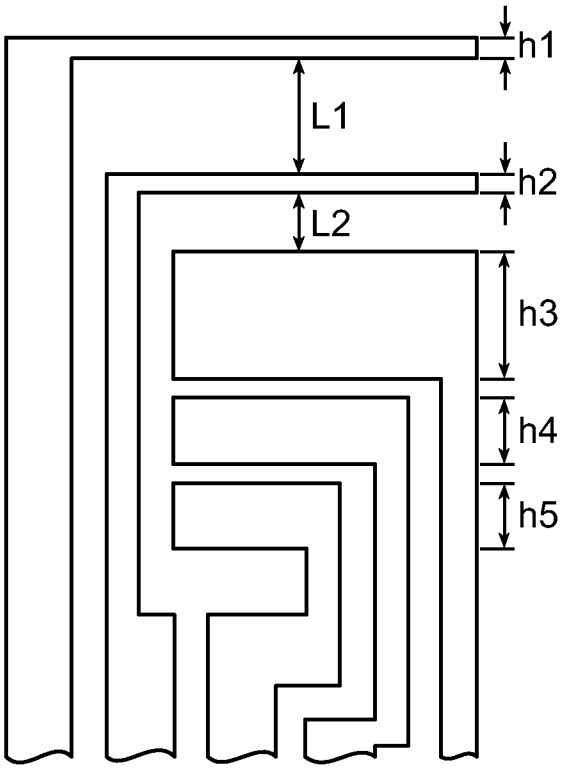

FIG. 3A(6)

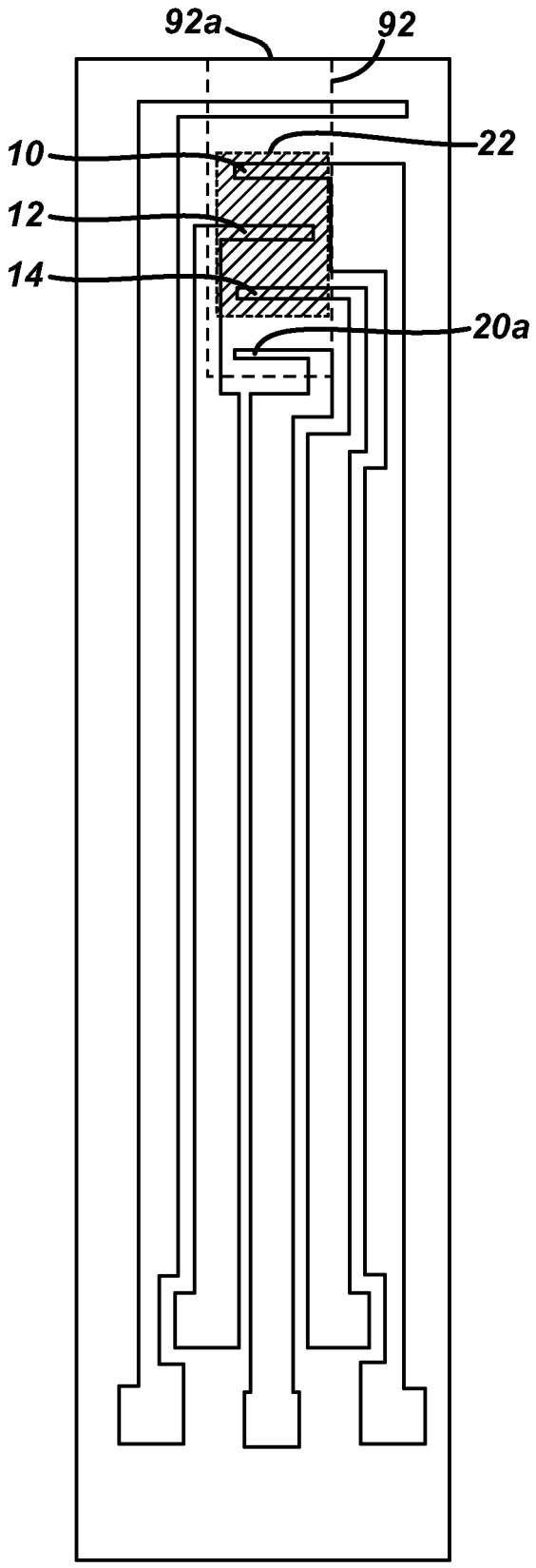

FIG. 3B

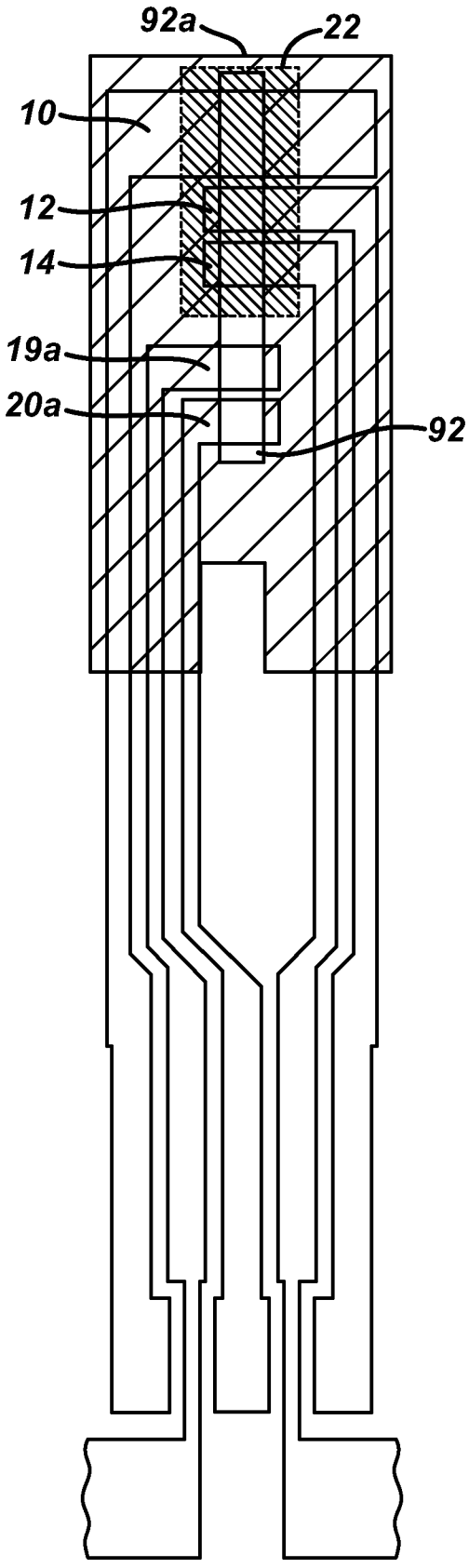

FIG. 3C

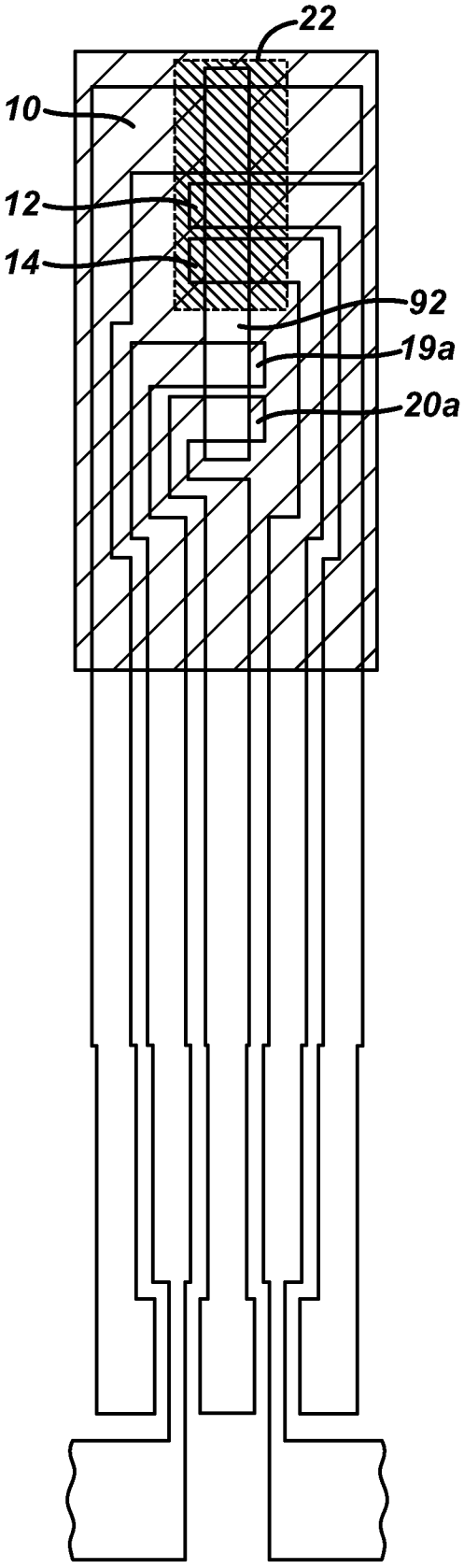

FIG. 3D

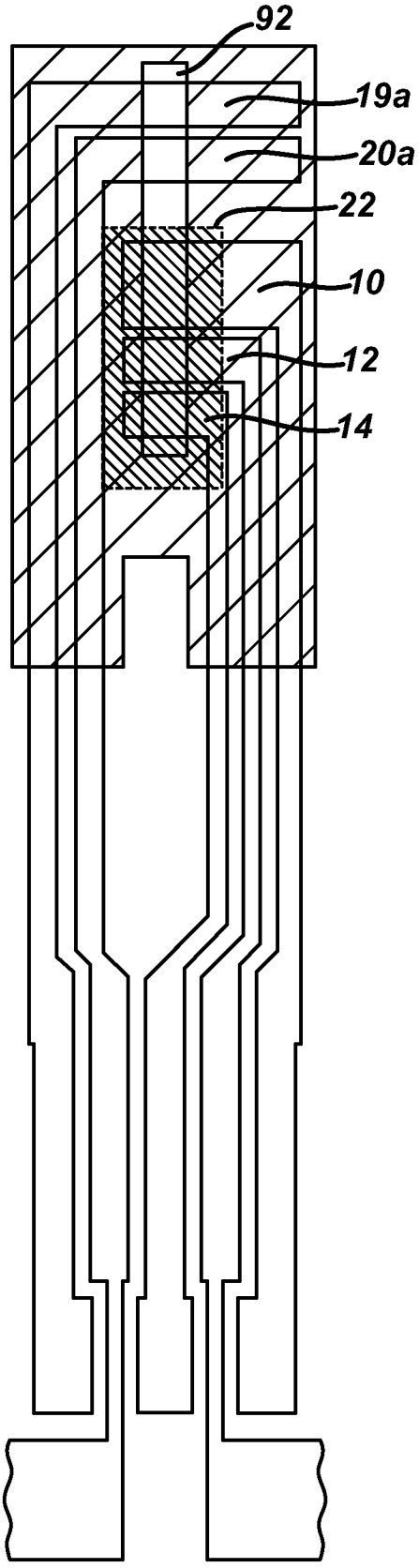

FIG. 3E

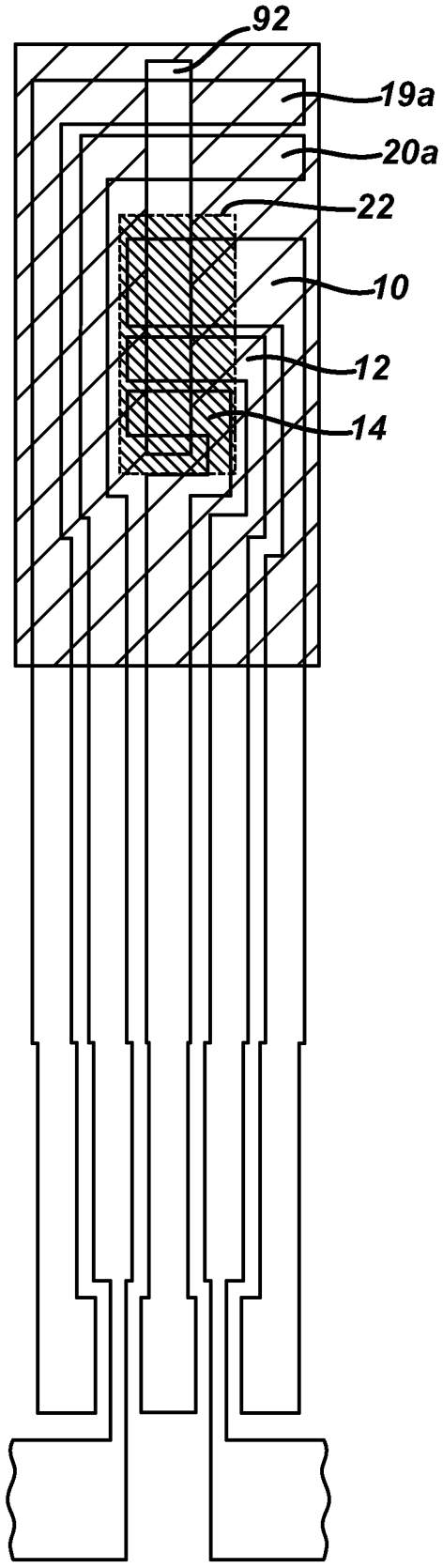

FIG. 3F

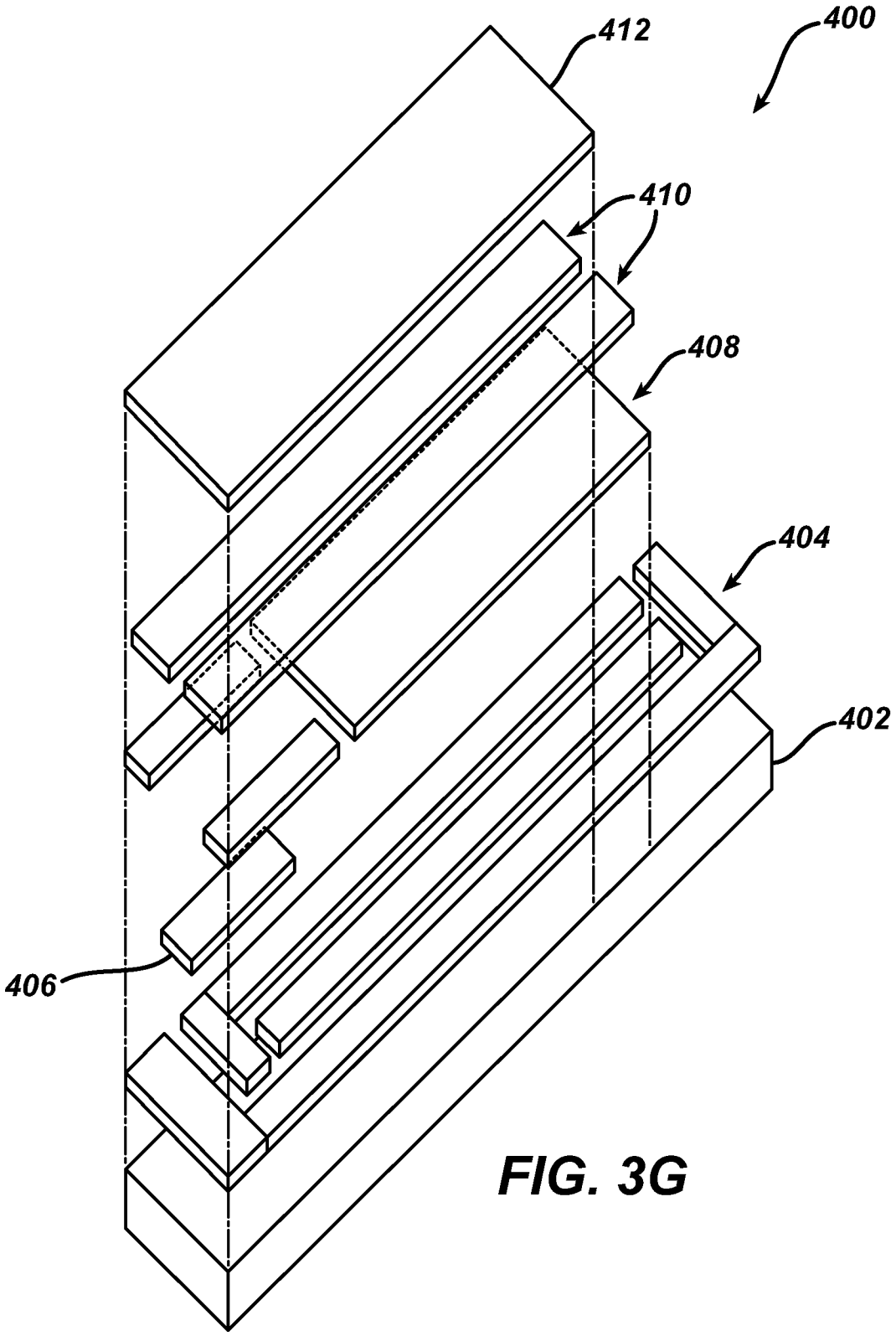

FIG. 3G

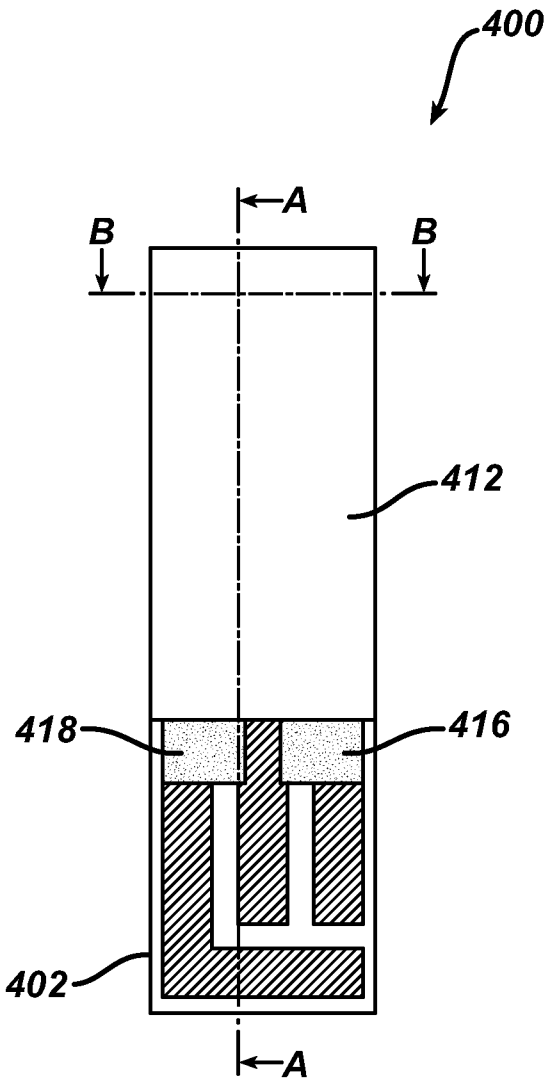

FIG. 3H

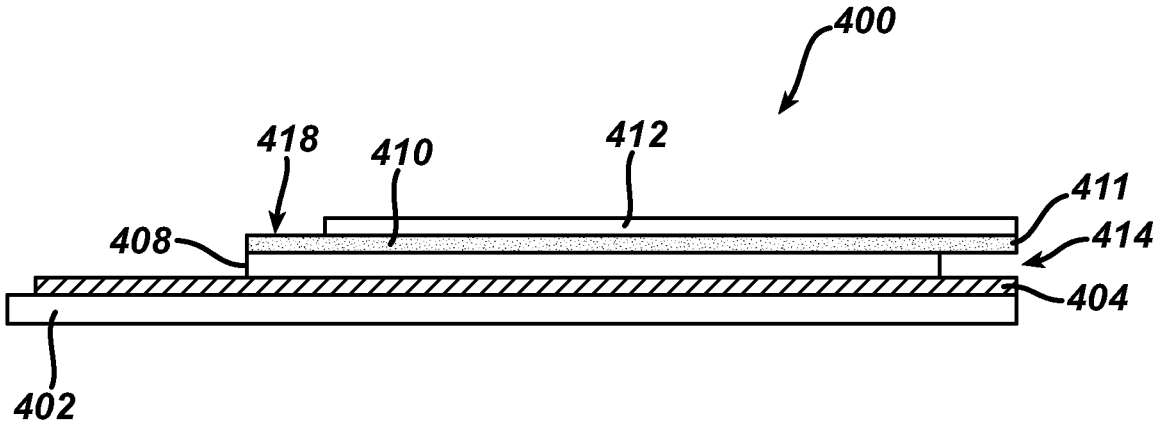
400
418
410
412
411
408
414
404
402

FIG. 3I

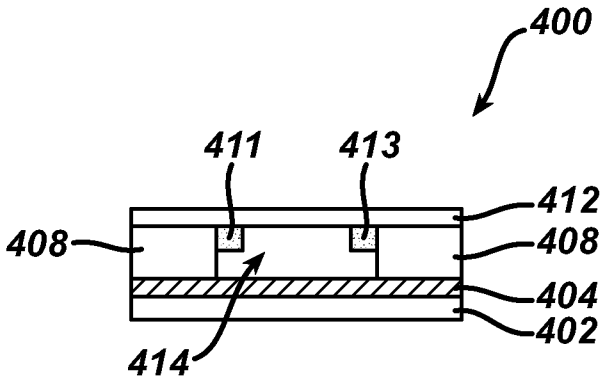
400
411
413
412
408
408
404
402
414

FIG. 3J

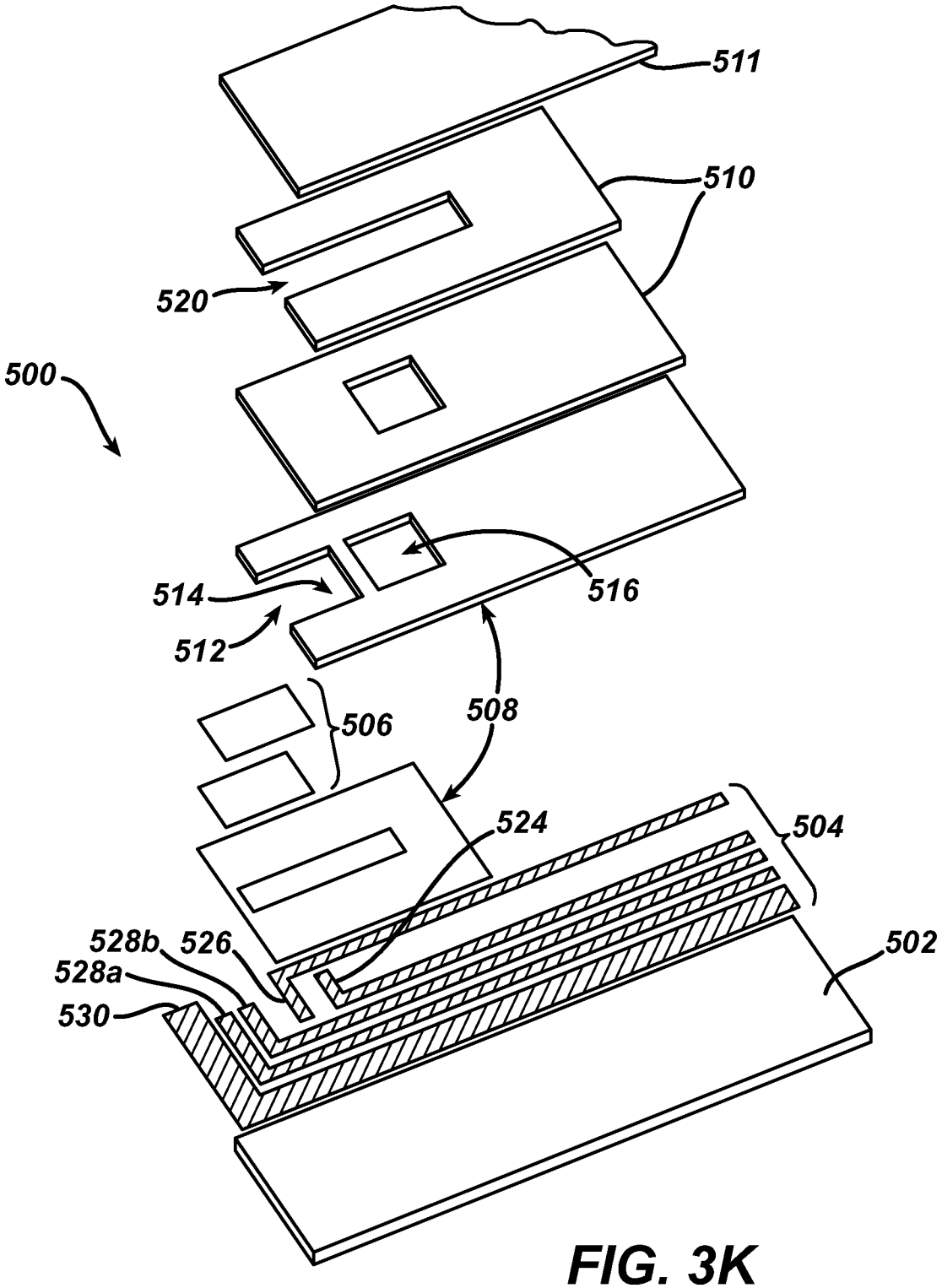
511
510
520
500
514
516
512
506
508
524
504
528b
526
528a
530
502

FIG. 3K

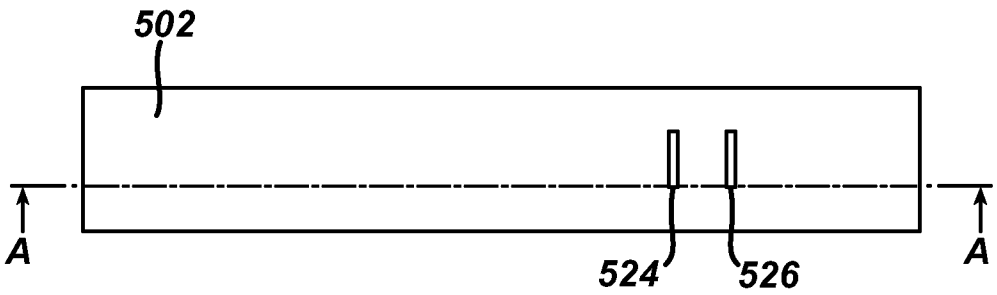

FIG. 3L

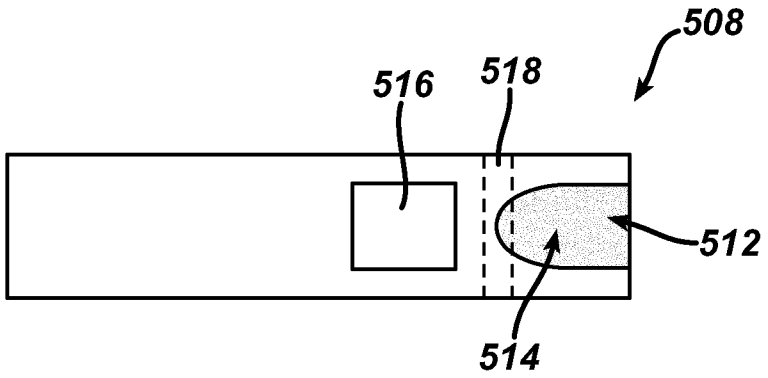

FIG. 3M

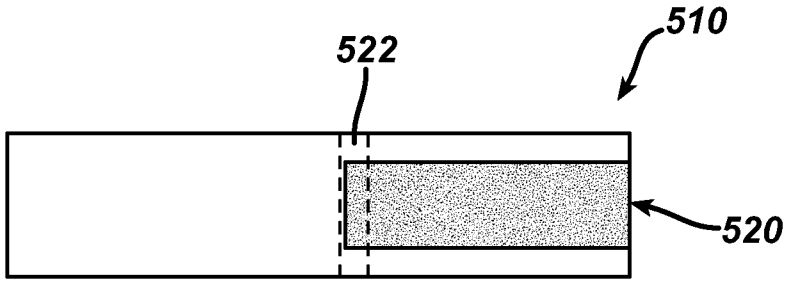

FIG. 3N

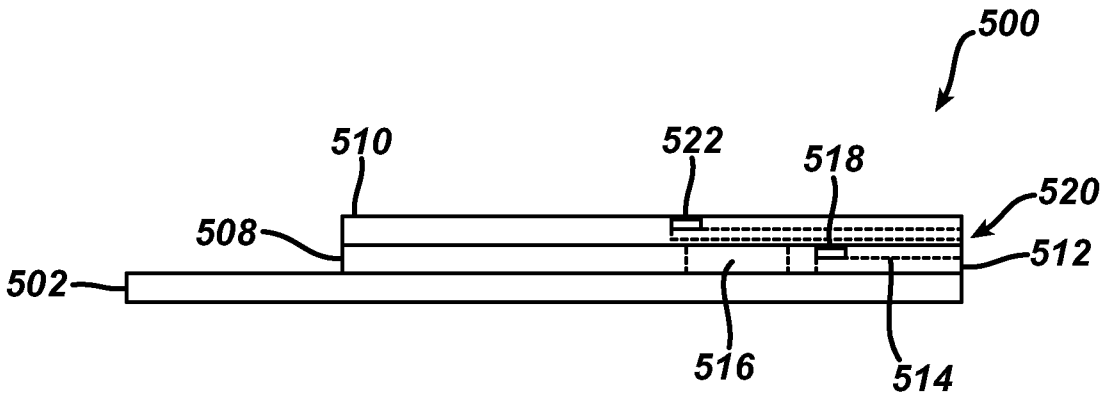

FIG. 3O

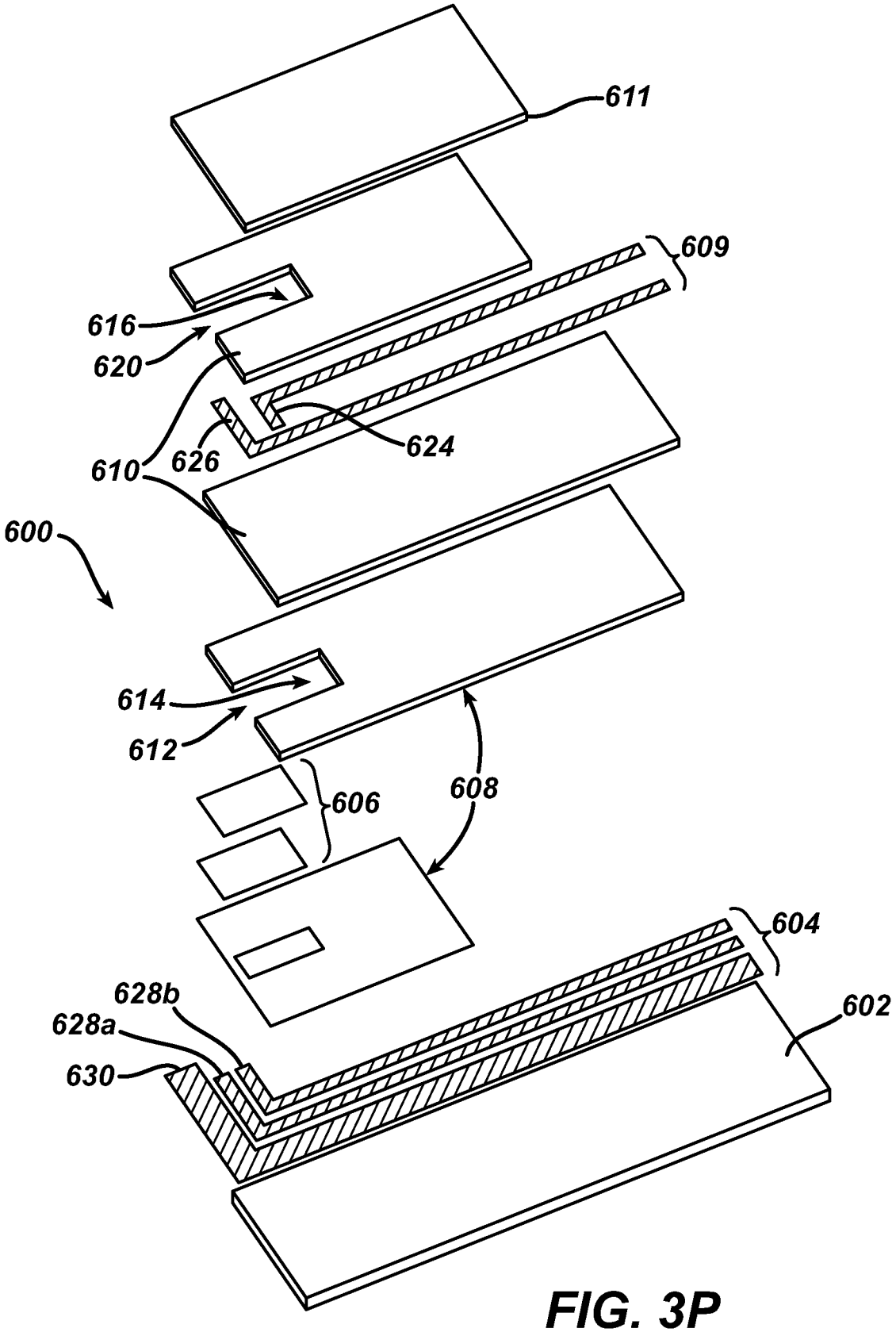
611
609
616
620
610
626
624
600
614
612
606
608
604
628b
628a
630
602

FIG. 3P

FIG. 3Q

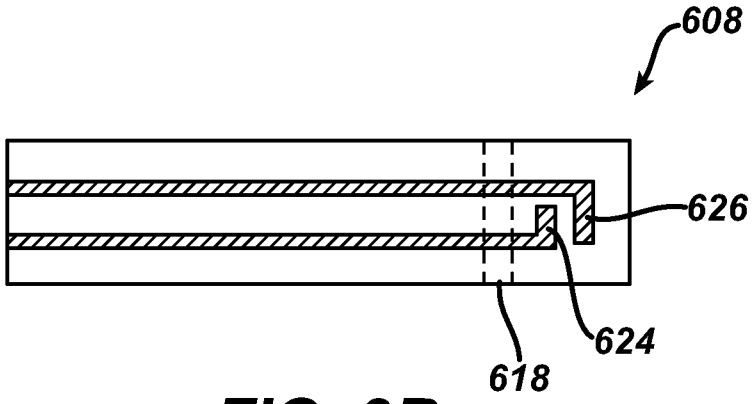

FIG. 3R

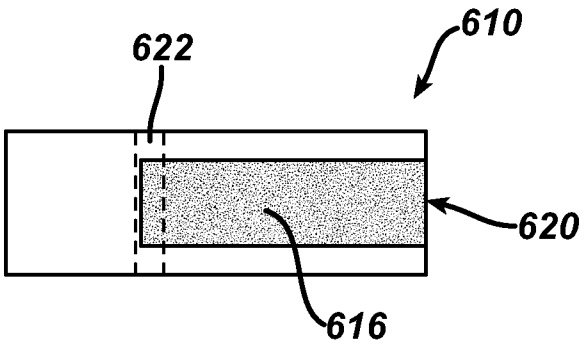

FIG. 3S

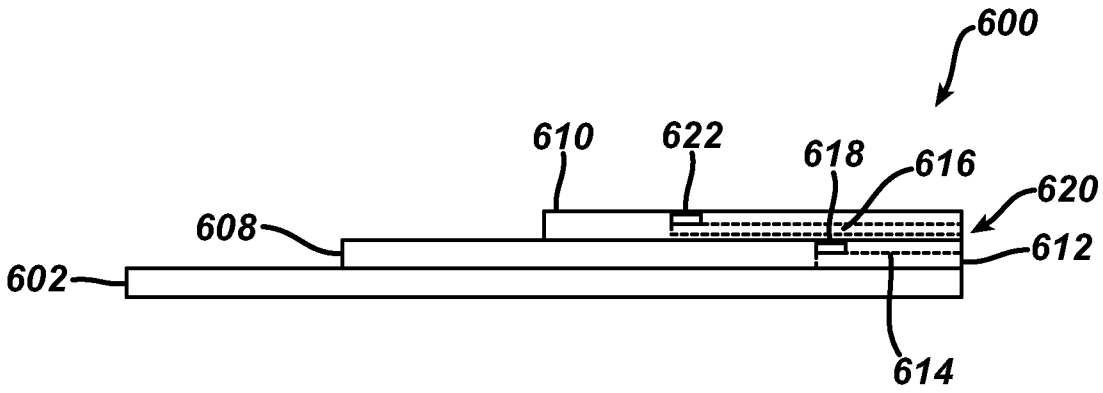

FIG. 3T

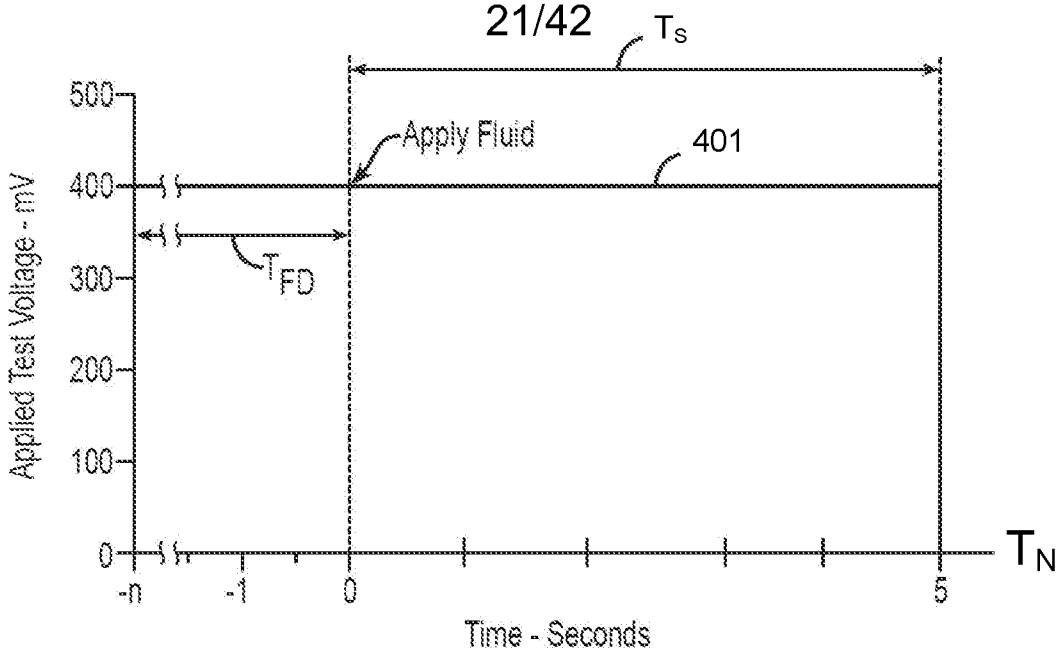
T_S
500
400
300
200
100
0
Apply Fluid
401
T_{FD}
Applied Test Voltage - mV
-n
-1
0
5
T_N
Time - Seconds

FIG. 4A

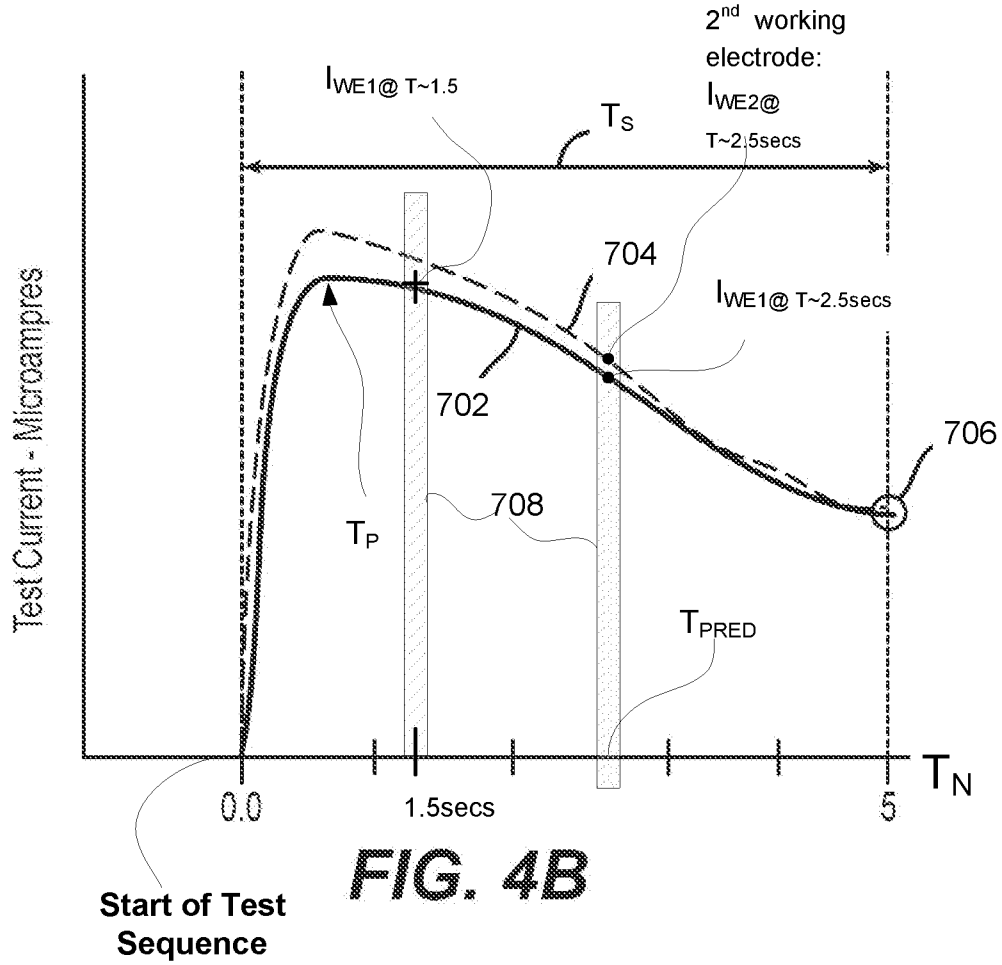
2nd working electrode: $I_{WE2@}$ T~2.5secs
$I_{WE1@\ T\sim1.5}$
T_S
704
$I_{WE1@\ T\sim2.5secs}$
702
706
708
T_P
T_{PRED}
Test Current - Microampres
0.0
1.5secs
5
T_N
Start of Test Sequence

FIG. 4B

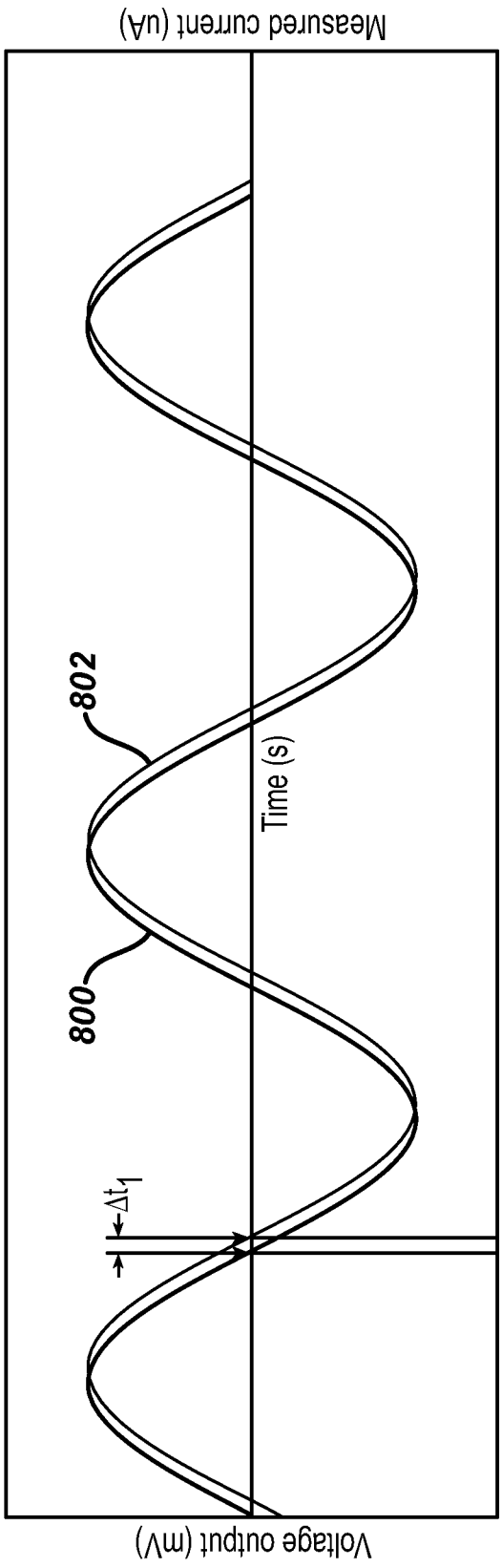
Measured current (uA)
802
800
Time (s)
Δt_1
Voltage output (mV)

FIG. 5

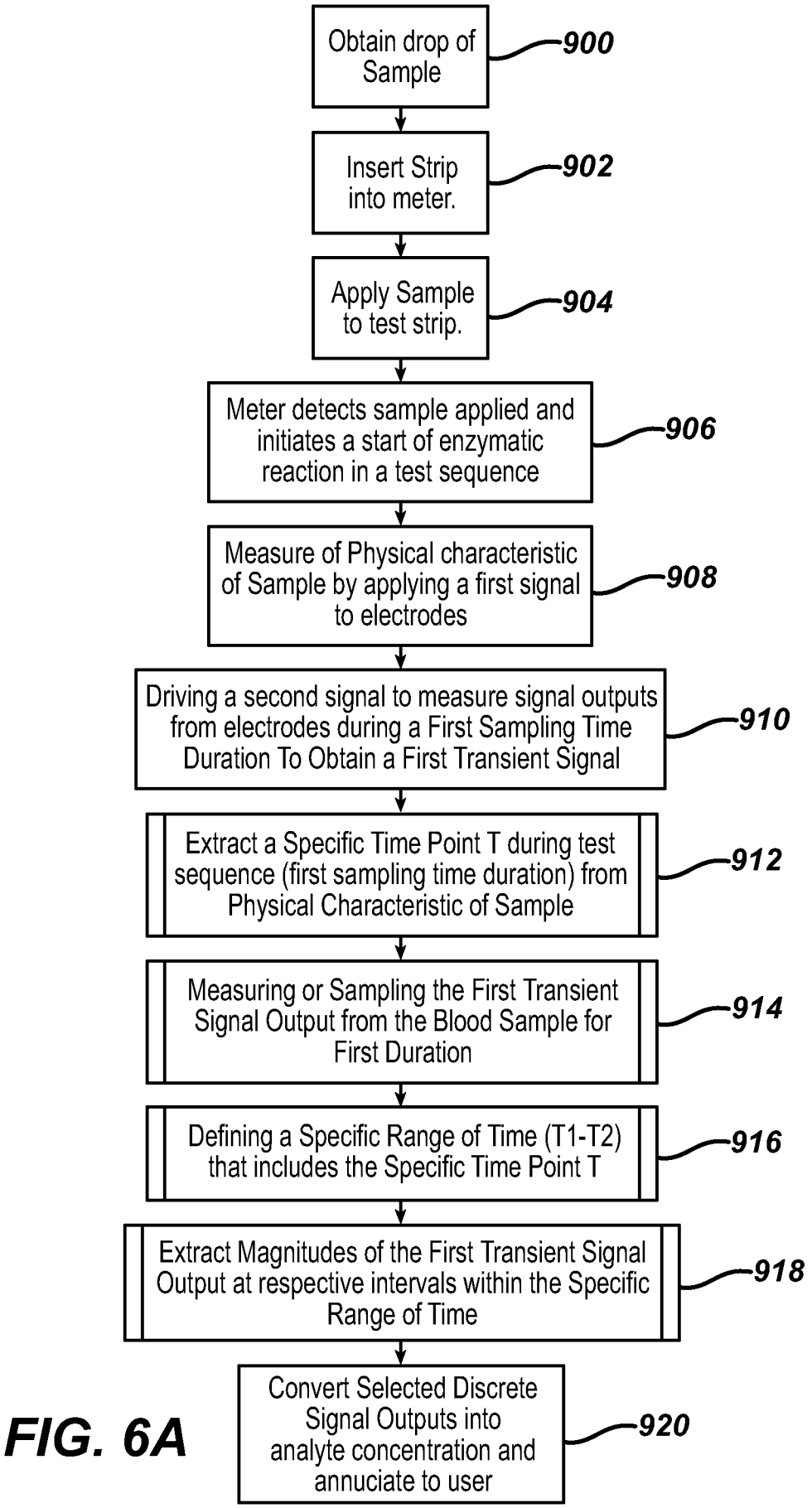
Obtain drop of Sample
900
Insert Strip into meter.
902
Apply Sample to test strip.
904
Meter detects sample applied and initiates a start of enzymatic reaction in a test sequence
906
Measure of Physical characteristic of Sample by applying a first signal to electrodes
908
Driving a second signal to measure signal outputs from electrodes during a First Sampling Time Duration To Obtain a First Transient Signal
910
Extract a Specific Time Point T during test sequence (first sampling time duration) from Physical Characteristic of Sample
912
Measuring or Sampling the First Transient Signal Output from the Blood Sample for First Duration
914
Defining a Specific Range of Time (T1-T2) that includes the Specific Time Point T
916
Extract Magnitudes of the First Transient Signal Output at respective intervals within the Specific Range of Time
918
Convert Selected Discrete Signal Outputs into analyte concentration and annuciate to user
920

FIG. 6A

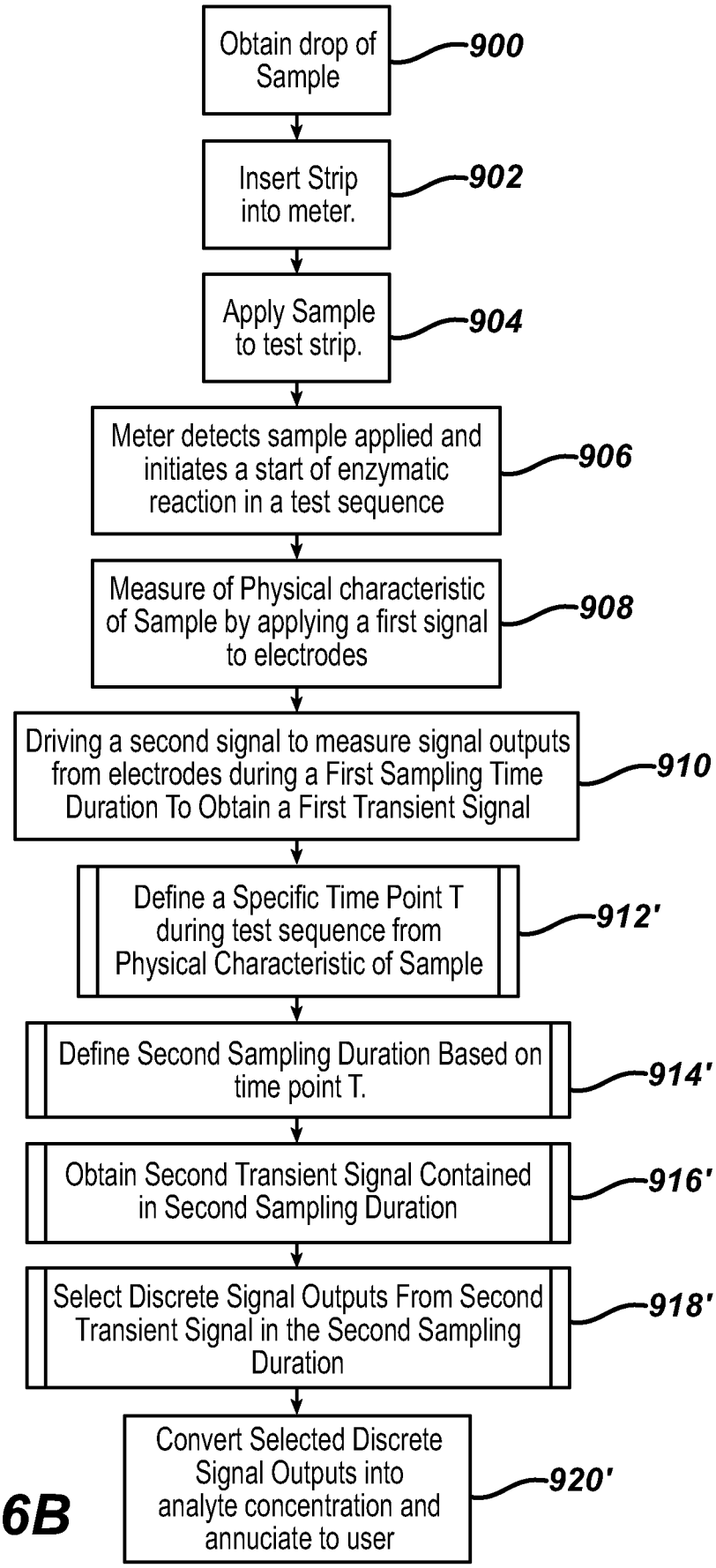
Obtain drop of Sample
900
Insert Strip into meter.
902
Apply Sample to test strip.
904
Meter detects sample applied and initiates a start of enzymatic reaction in a test sequence
906
Measure of Physical characteristic of Sample by applying a first signal to electrodes
908
Driving a second signal to measure signal outputs from electrodes during a First Sampling Time Duration To Obtain a First Transient Signal
910
Define a Specific Time Point T during test sequence from Physical Characteristic of Sample
912'
Define Second Sampling Duration Based on time point T.
914'
Obtain Second Transient Signal Contained in Second Sampling Duration
916'
Select Discrete Signal Outputs From Second Transient Signal in the Second Sampling Duration
918'
Convert Selected Discrete Signal Outputs into analyte concentration and annuciate to user
920'

FIG. 6B

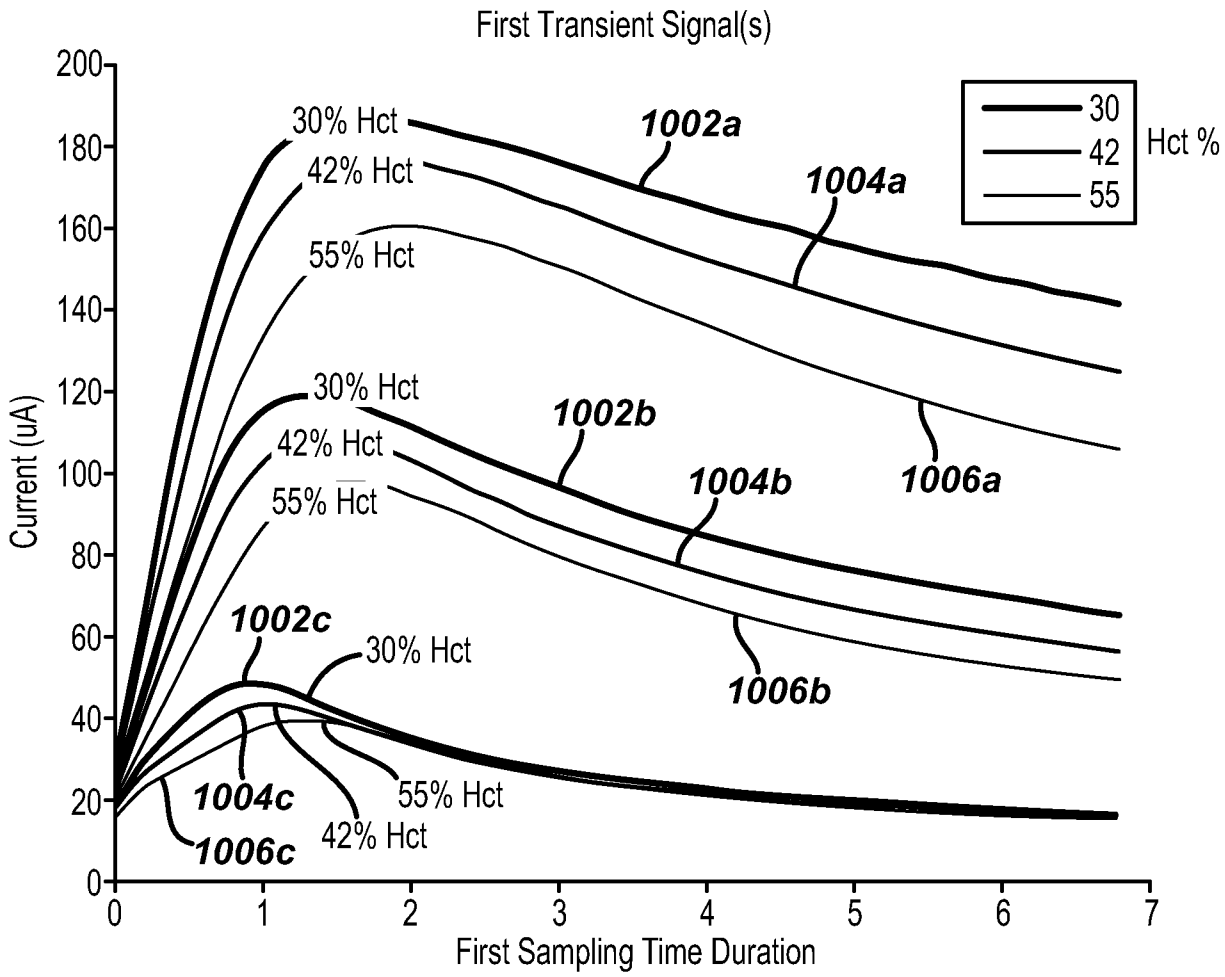
First Transient Signal(s)
Current (uA)
First Sampling Time Duration
30
42
55
Hct %
30% Hct
42% Hct
55% Hct
1002a
1004a
1006a
1002b
1004b
1006b
1002c
1004c
1006c
0
20
40
60
80
100
120
140
160
180
200
0
1
2
3
4
5
6
7

FIG. 7A

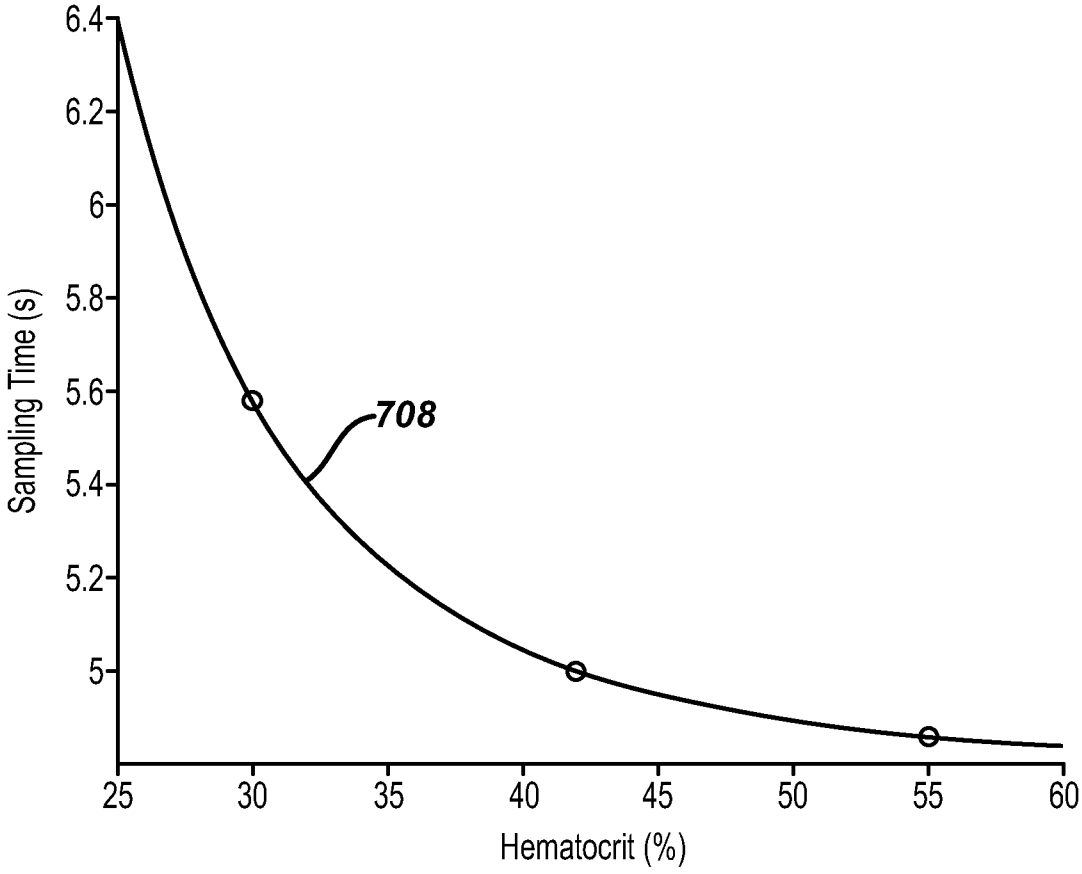
6.4
6.2
6
5.8
5.6
5.4
5.2
5
Sampling Time (s)
708
25
30
35
40
45
50
55
60
Hematocrit (%)

FIG. 7B

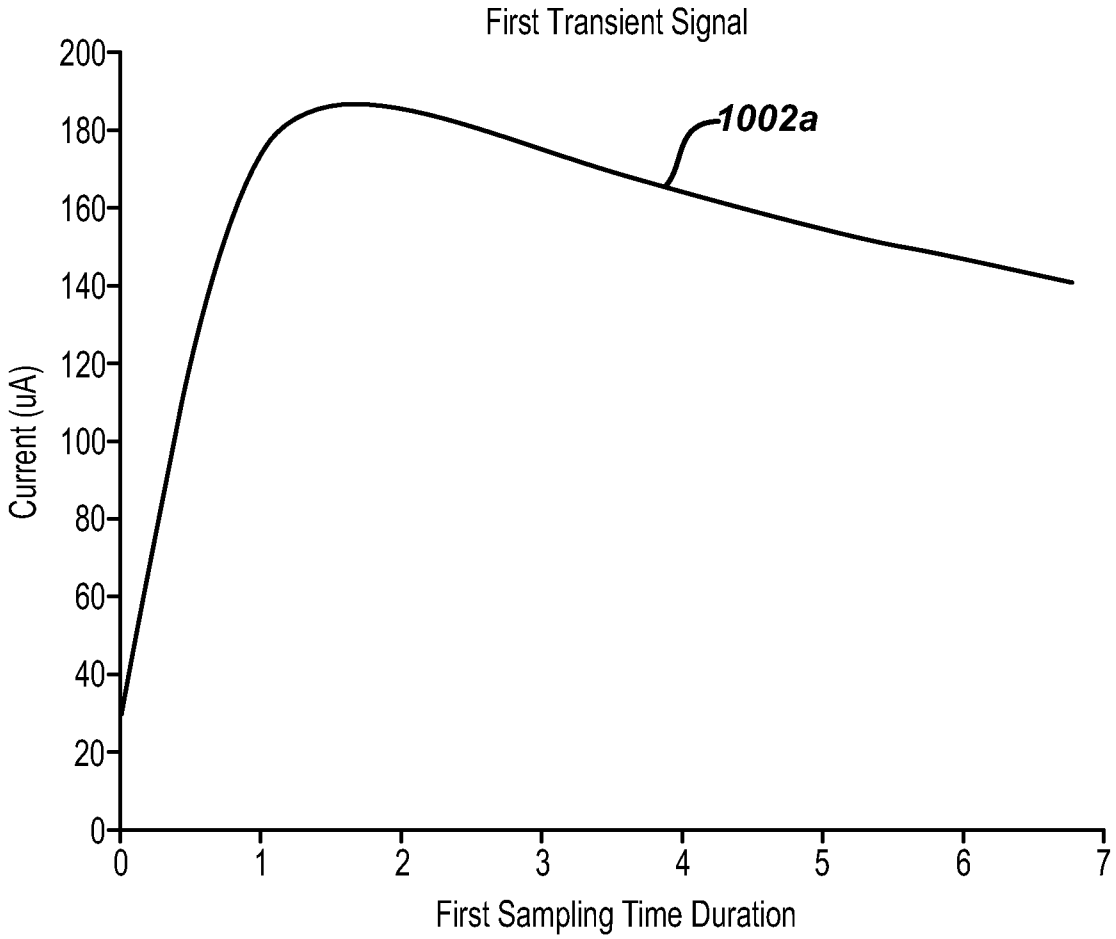
First Transient Signal
1002a
Current (uA)
200
180
160
140
120
100
80
60
40
20
0
0
1
2
3
4
5
6
7
First Sampling Time Duration

FIG. 7C

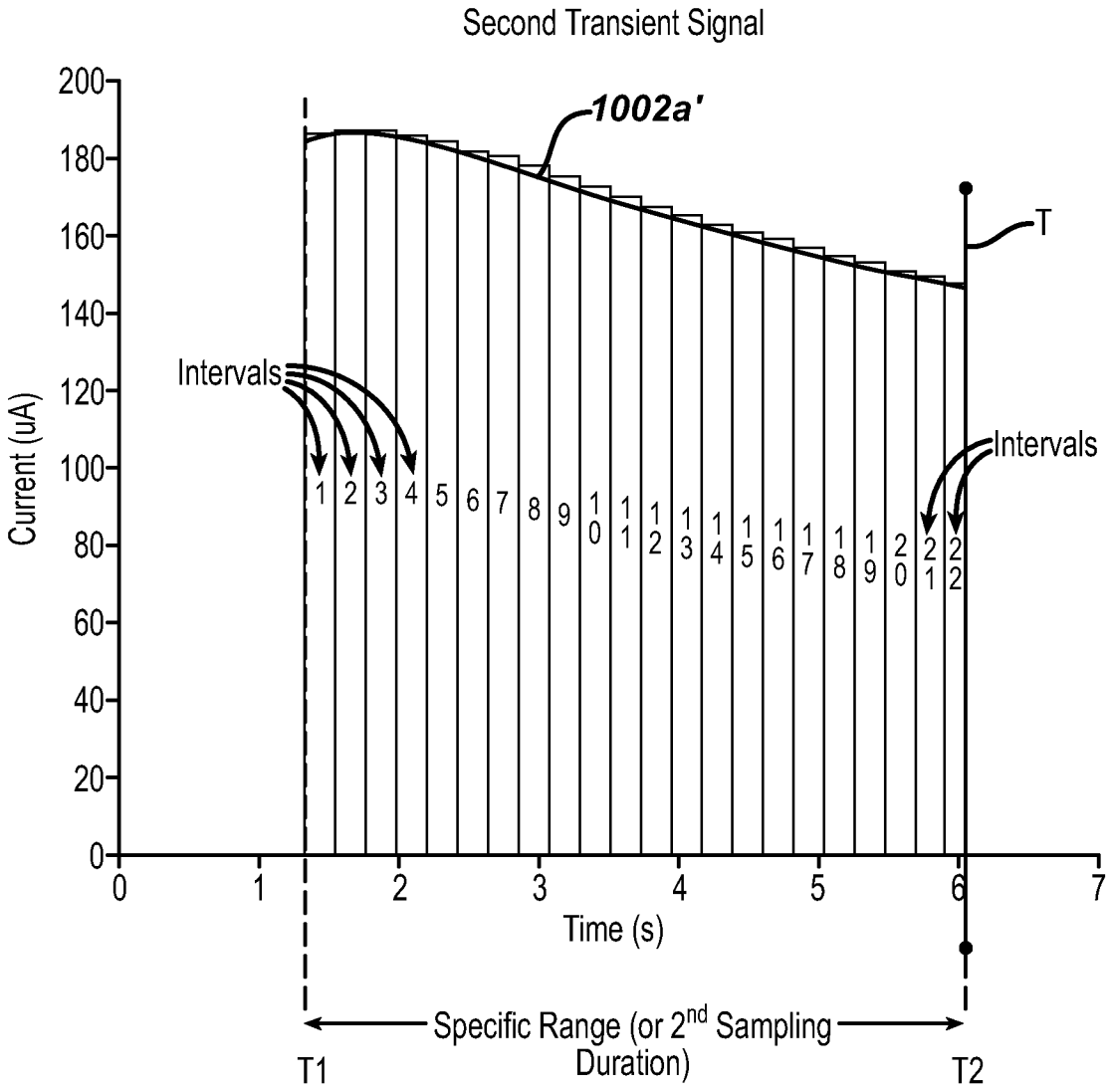
Second Transient Signal
1002a'
T
Intervals
Intervals
Current (uA)
200
180
160
140
120
100
80
60
40
20
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
0 1 2 3 4 5 6 7
Time (s)
Specific Range (or 2nd Sampling Duration)
T1
T2

FIG. 7D

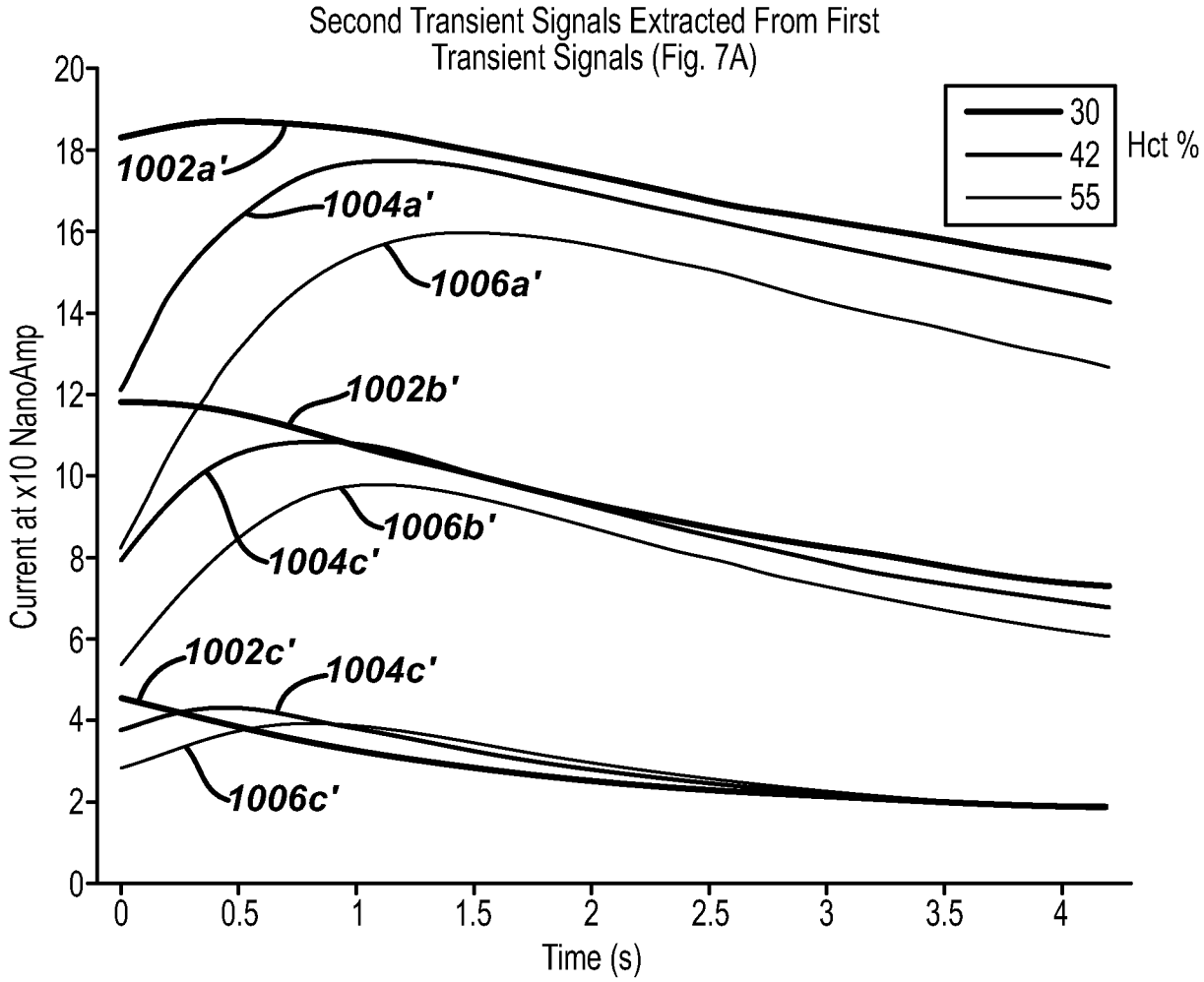
Second Transient Signals Extracted From First Transient Signals (Fig. 7A)
Current at x10 NanoAmp
Time (s)
Hct %
30
42
55
1002a'
1004a'
1006a'
1002b'
1006b'
1004c'
1002c'
1004c'
1006c'
0
2
4
6
8
10
12
14
16
18
20
0
0.5
1
1.5
2
2.5
3
3.5
4

FIG. 7E

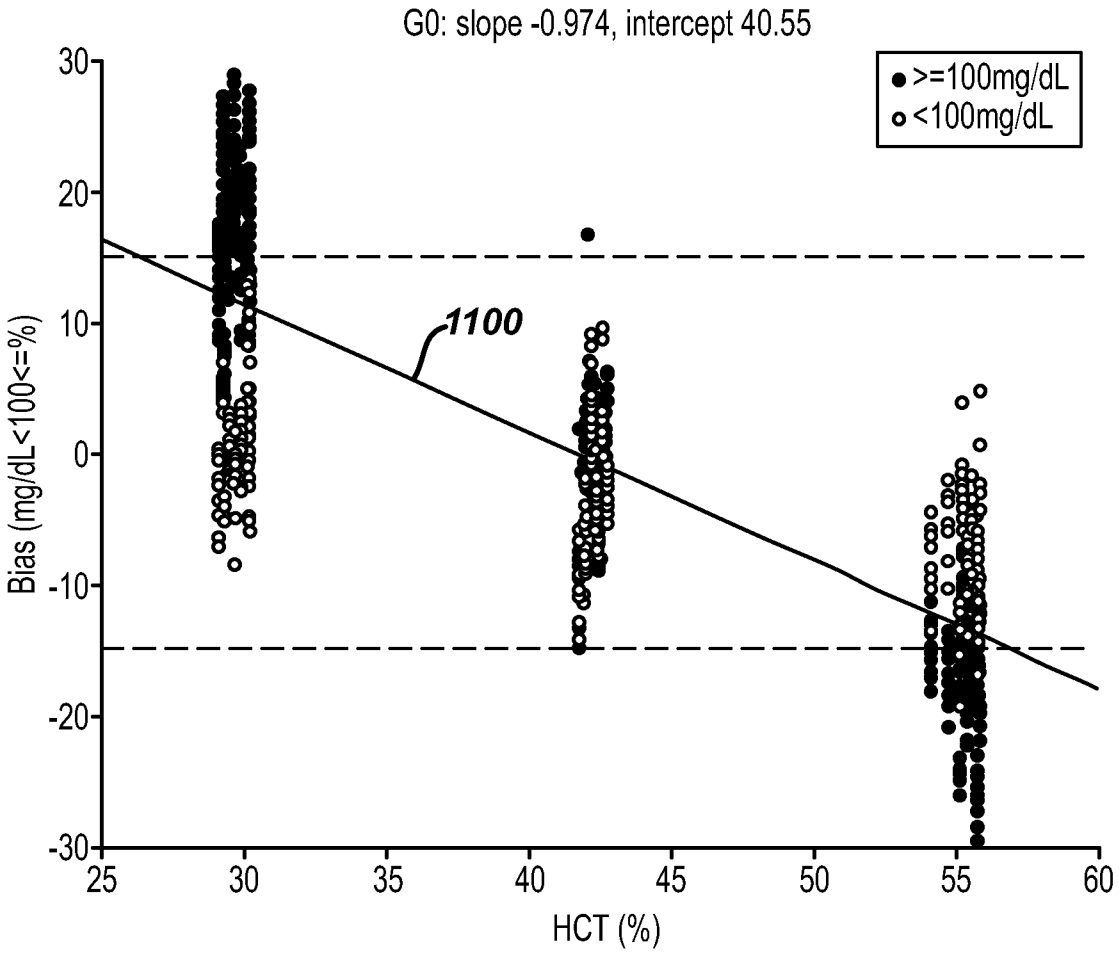

FIG. 8A PRIOR ART

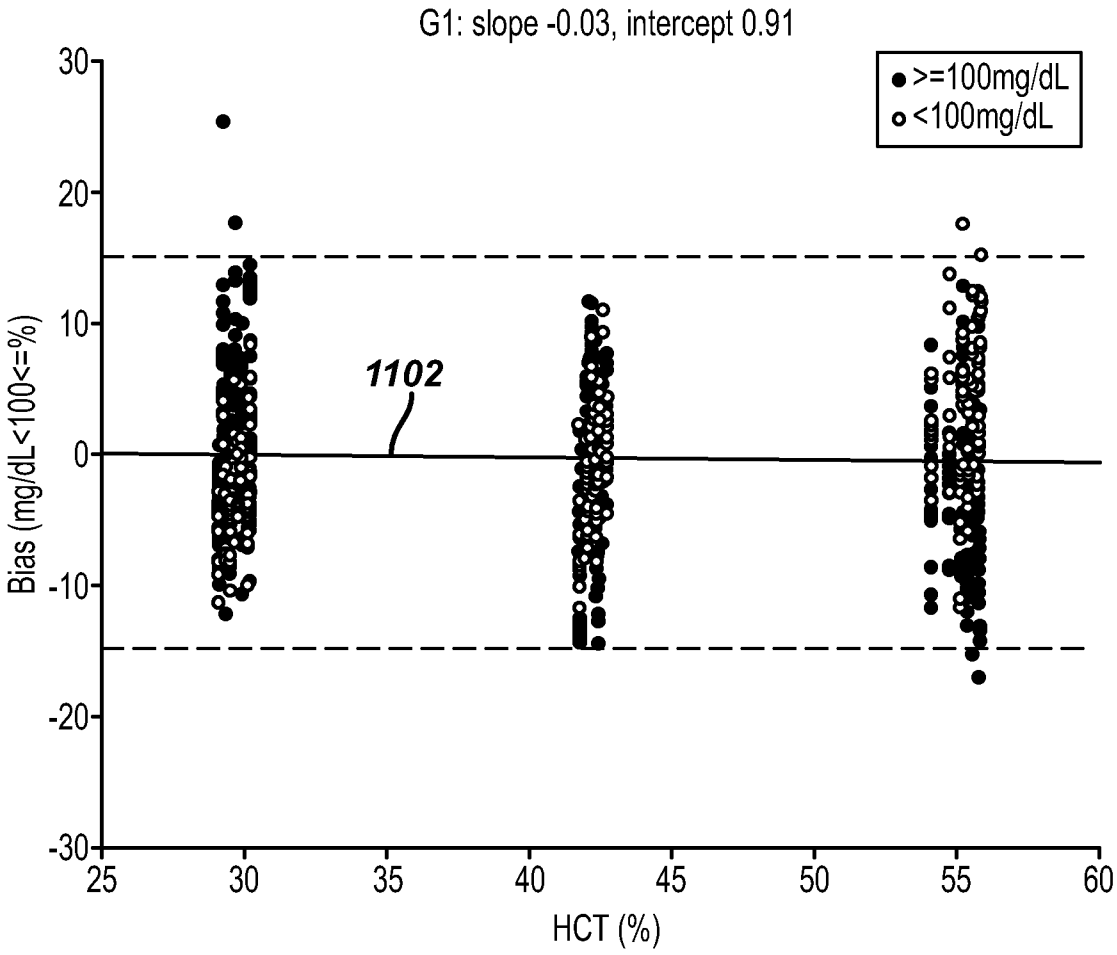
G1: slope -0.03, intercept 0.91
>=100mg/dL
<100mg/dL
1102
Bias (mg/dL<100<=%)
HCT (%)
30
20
10
0
-10
-20
-30
25
30
35
40
45
50
55
60

FIG. 8B

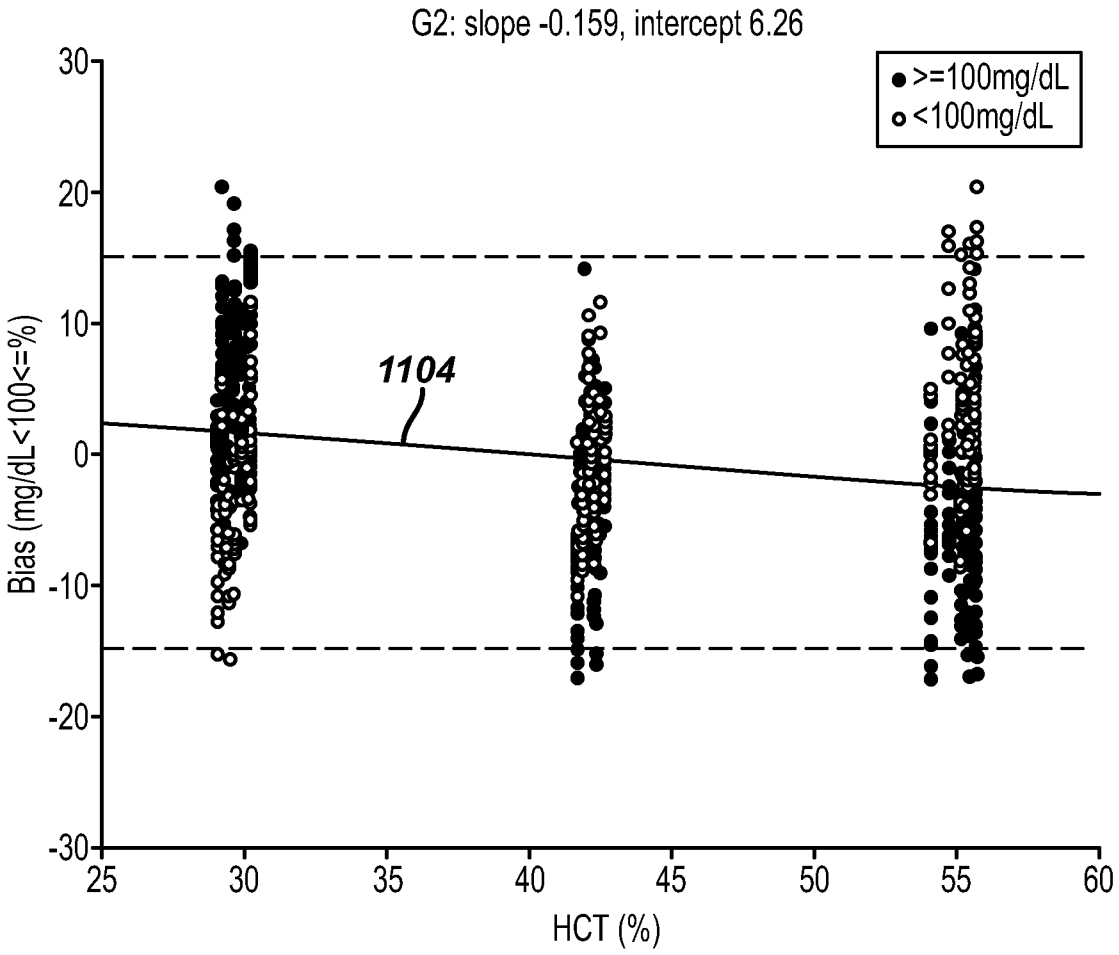
G2: slope -0.159, intercept 6.26
>=100mg/dL
<100mg/dL
1104
Bias (mg/dL<100<=%)
HCT (%)
30
20
10
0
-10
-20
-30
25
30
35
40
45
50
55
60

FIG. 8C

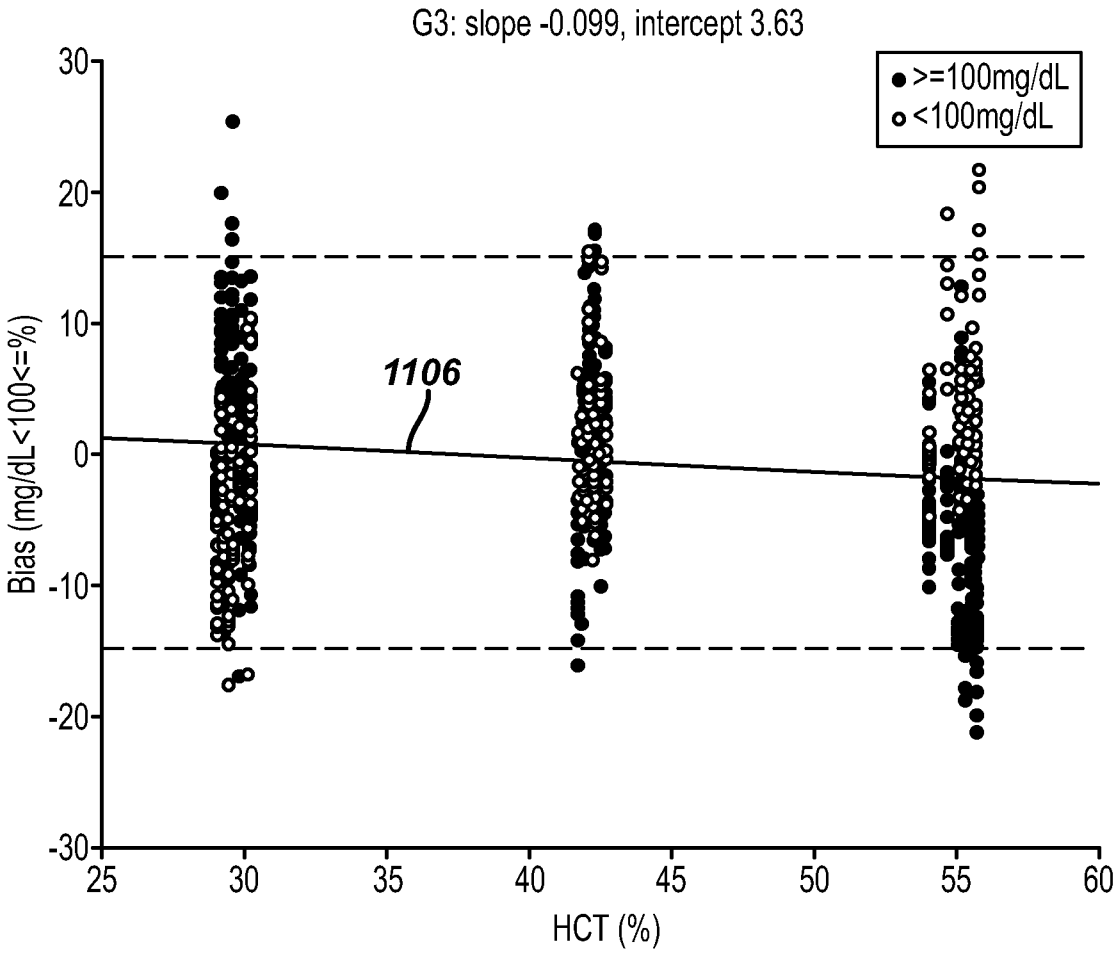
G3: slope -0.099, intercept 3.63
>=100mg/dL
<100mg/dL
1106
Bias (mg/dL<100<=%)
HCT (%)
30
20
10
0
-10
-20
-30
25
30
35
40
45
50
55
60

FIG. 8D

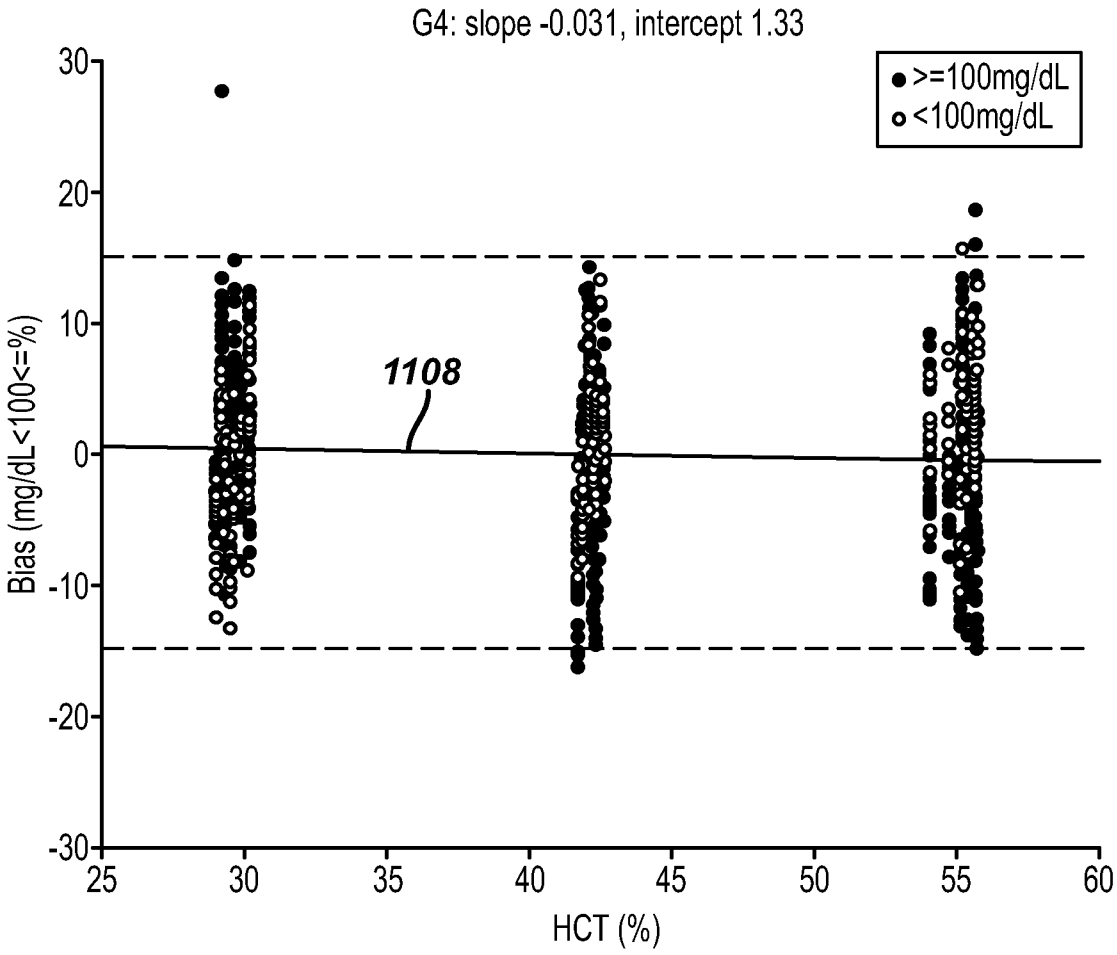
G4: slope -0.031, intercept 1.33
>=100mg/dL
<100mg/dL
1108
Bias (mg/dL<100<=%)
HCT (%)
30
20
10
0
-10
-20
-30
25
30
35
40
45
50
55
60

FIG. 8E

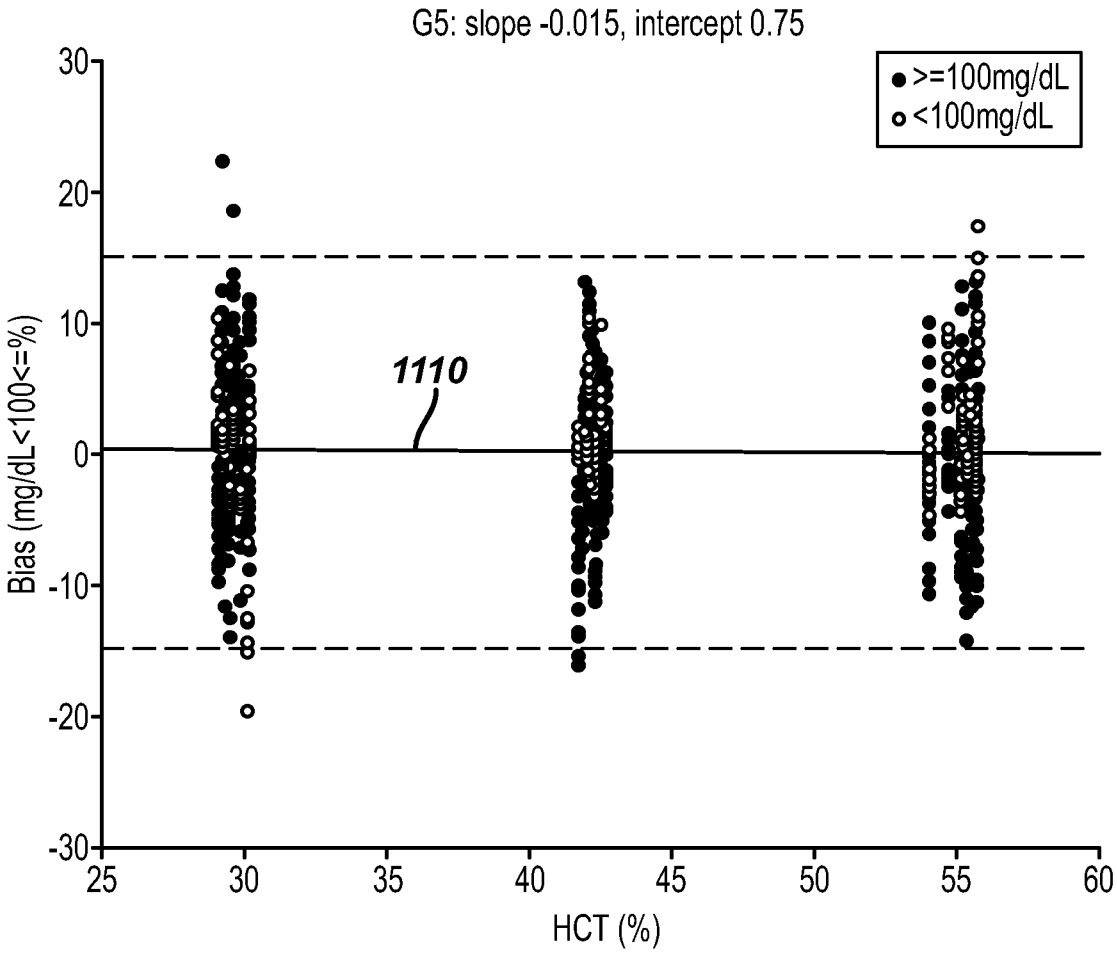
G5: slope -0.015, intercept 0.75
>=100mg/dL
<100mg/dL
1110
Bias (mg/dL<100<=%)
HCT (%)
30
20
10
0
-10
-20
-30
25
30
35
40
45
50
55
60

FIG. 8F

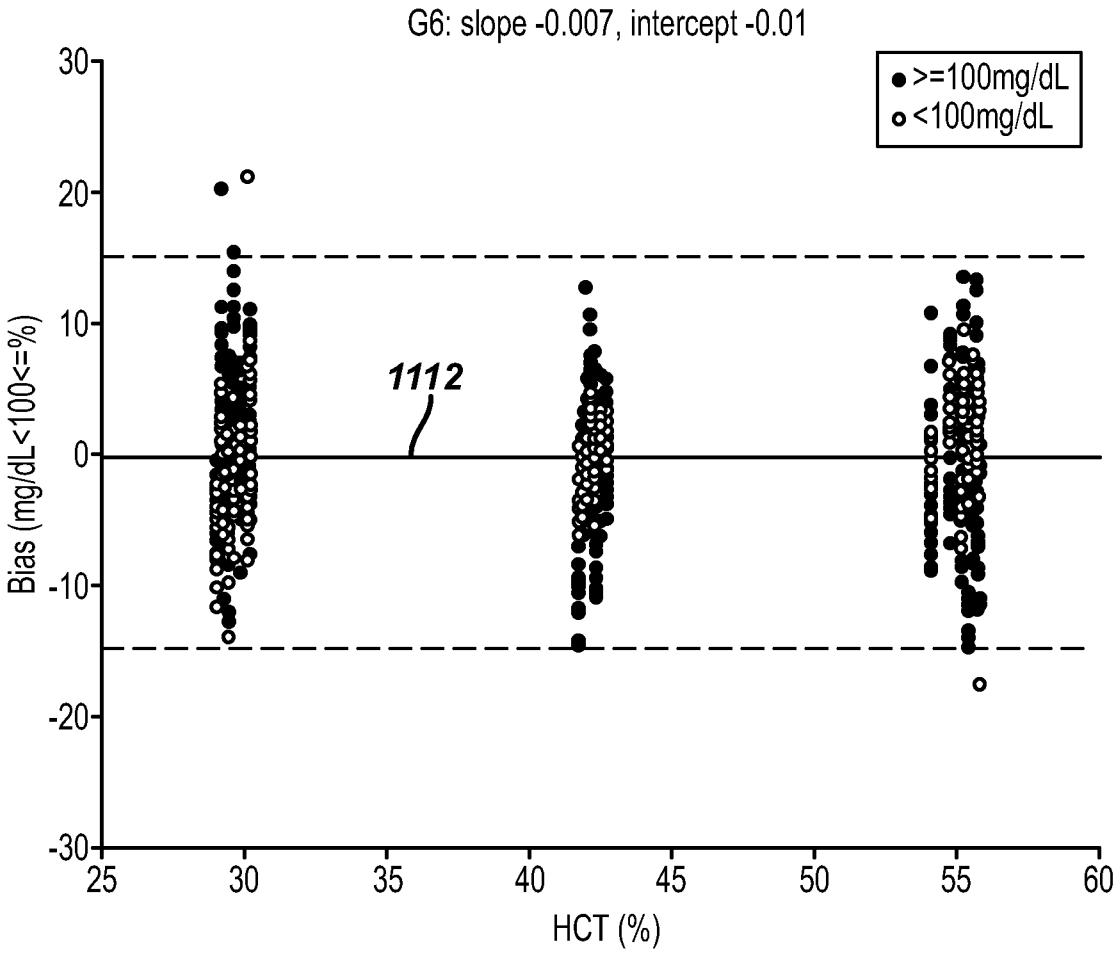
G6: slope -0.007, intercept -0.01
>=100mg/dL
<100mg/dL
1112
Bias (mg/dL<100<=%)
HCT (%)
30
20
10
0
-10
-20
-30
25
30
35
40
45
50
55
60

FIG. 8G

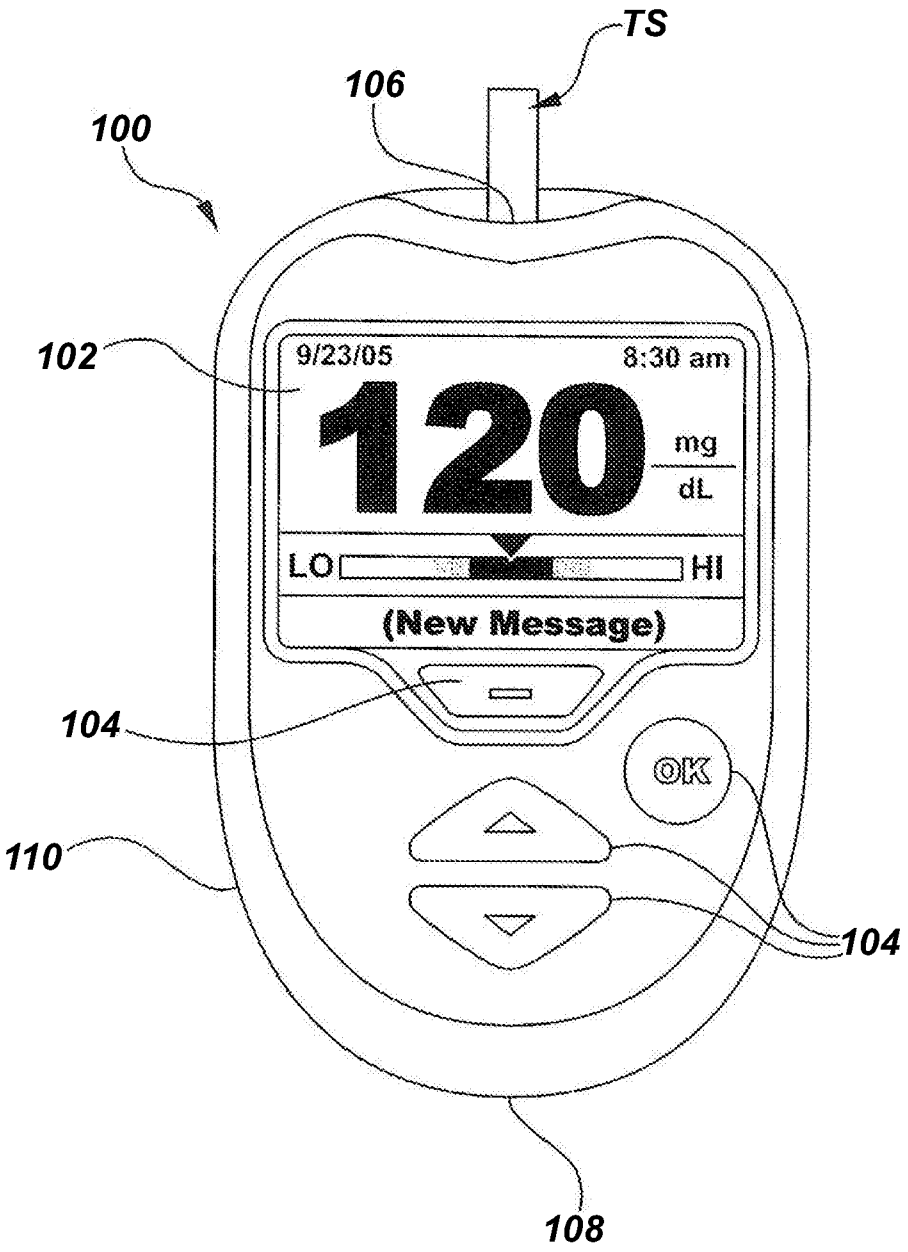
TS
106
100
102
9/23/05
8:30 am
120
mg
dL
LO
HI
(New Message)
104
OK
110
104
108

FIG. 9

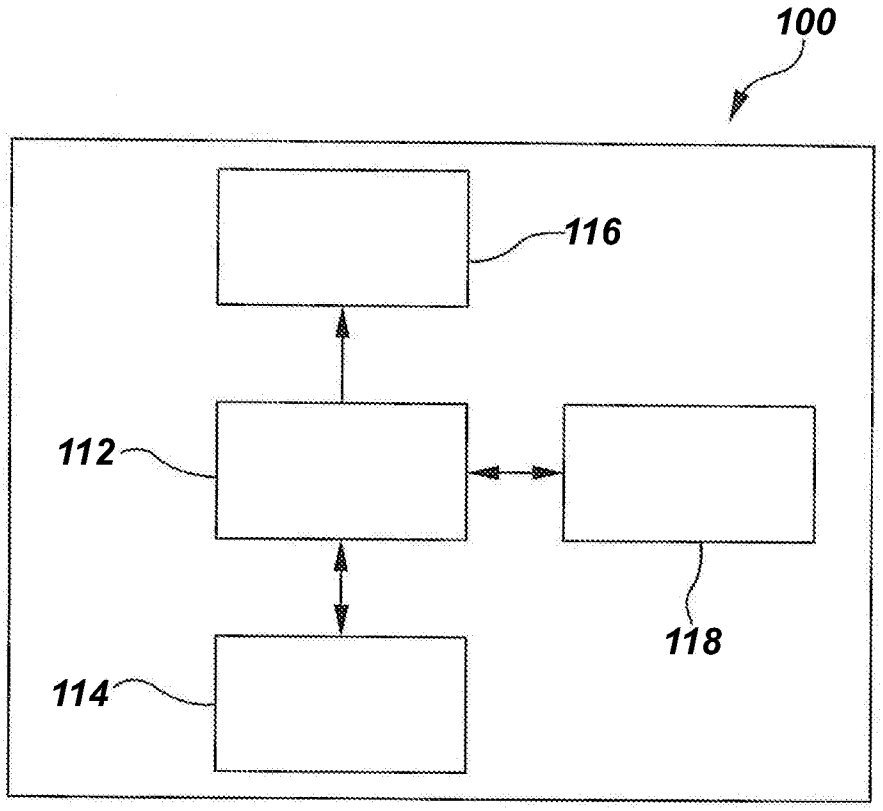
100
116
112
118
114

FIG. 10

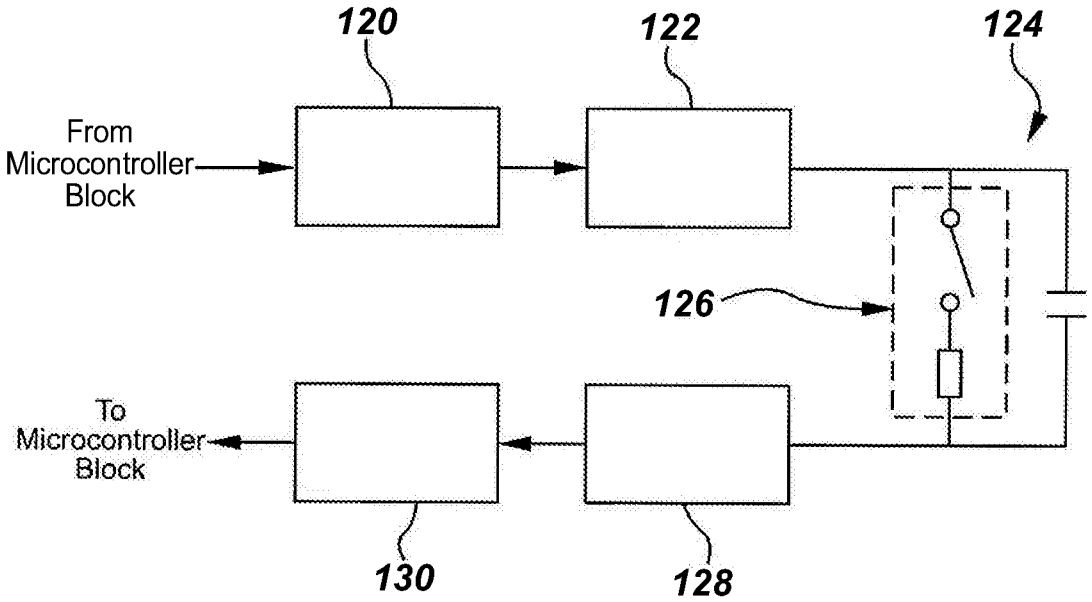
120
122
124
From Microcontroller Block
126
To Microcontroller Block
130
128

FIG. 11

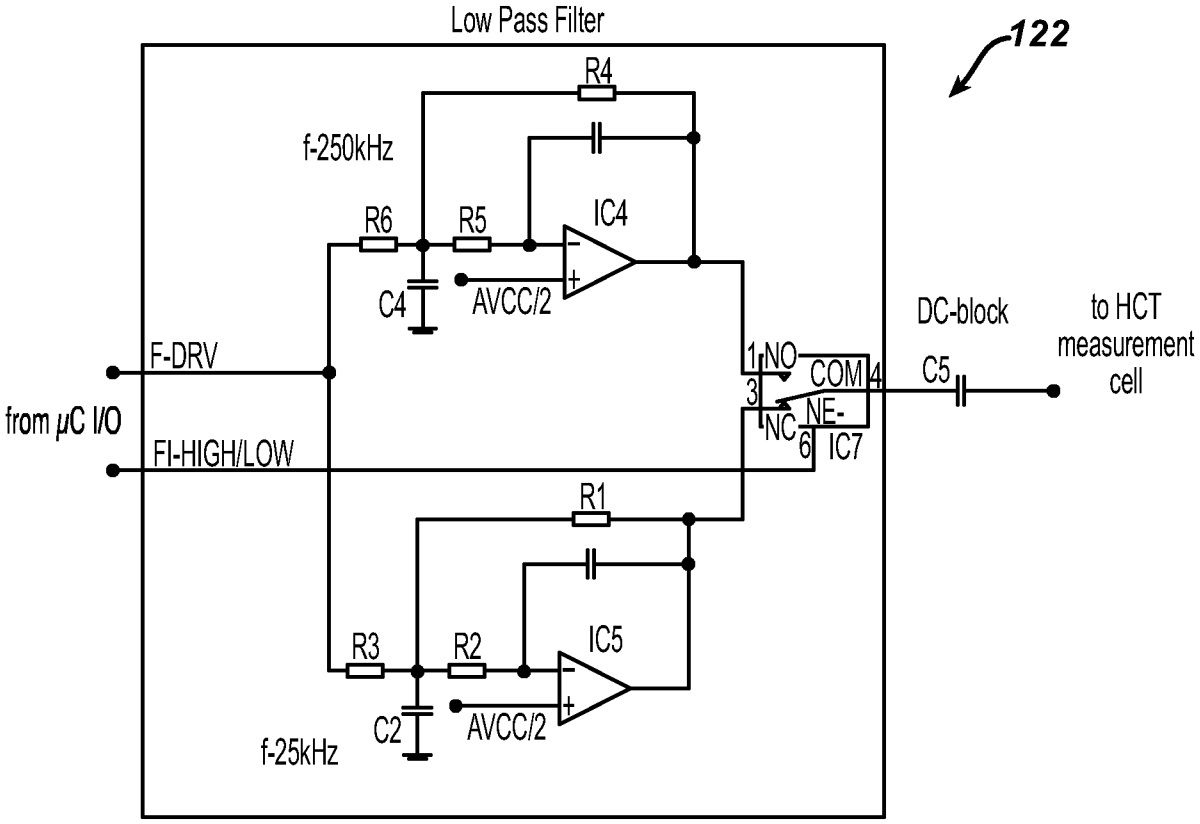
Low Pass Filter
122
R4
f-250kHz
R6
R5
IC4
C4
AVCC/2
F-DRV
from µC I/O
FI-HIGH/LOW
1 NO
3
COM 4
NC
NE-
6 IC7
DC-block
C5
to HCT measurement cell
R1
R3
R2
IC5
C2
AVCC/2
f-25kHz

FIG. 12

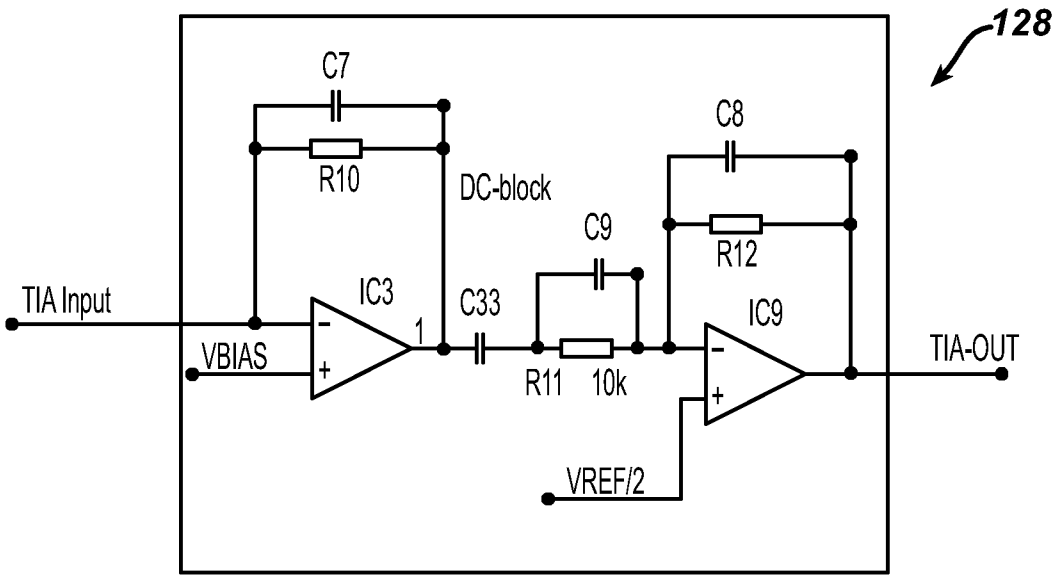
128
C7
R10
DC-block
C8
C9
R12
TIA Input
IC3
C33
IC9
VBIAS
1
R11
10k
TIA-OUT
VREF/2

FIG. 13

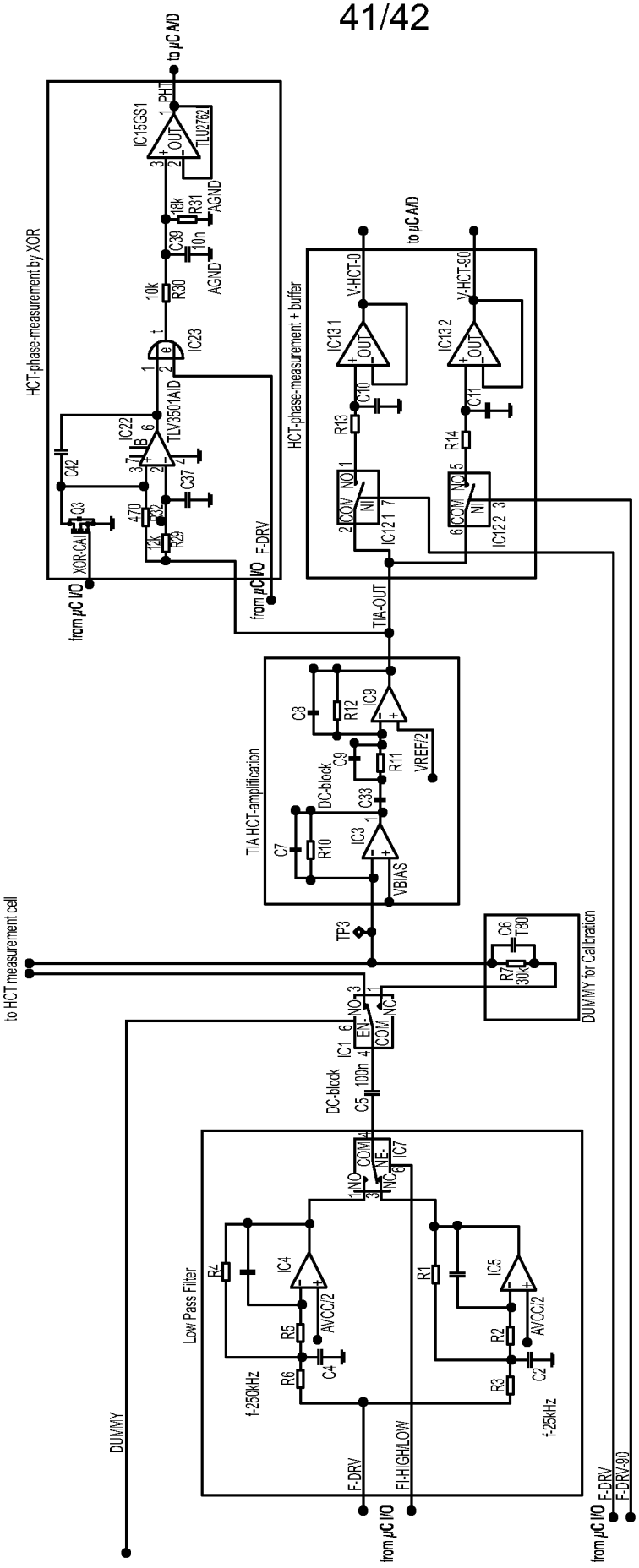
HCT-phase-measurement by XOR
HCT-phase-measurement + buffer
TIA HCT-amplification
Low Pass Filter
DUMMY for Calibration
to HCT measurement cell
to µC A/D
from µC I/O
TIA-OUT
F-DRV
F-DRV-90
F1-HIGH/LOW
DUMMY
VREF/2
VBIAS
AVCC/2
AGND
f-250kHz
f-25kHz
DC-block
V-HCT-0
V-HCT-90
XOR-CAL
TLV3501AID
TLV2762
TP3

FIG. 14

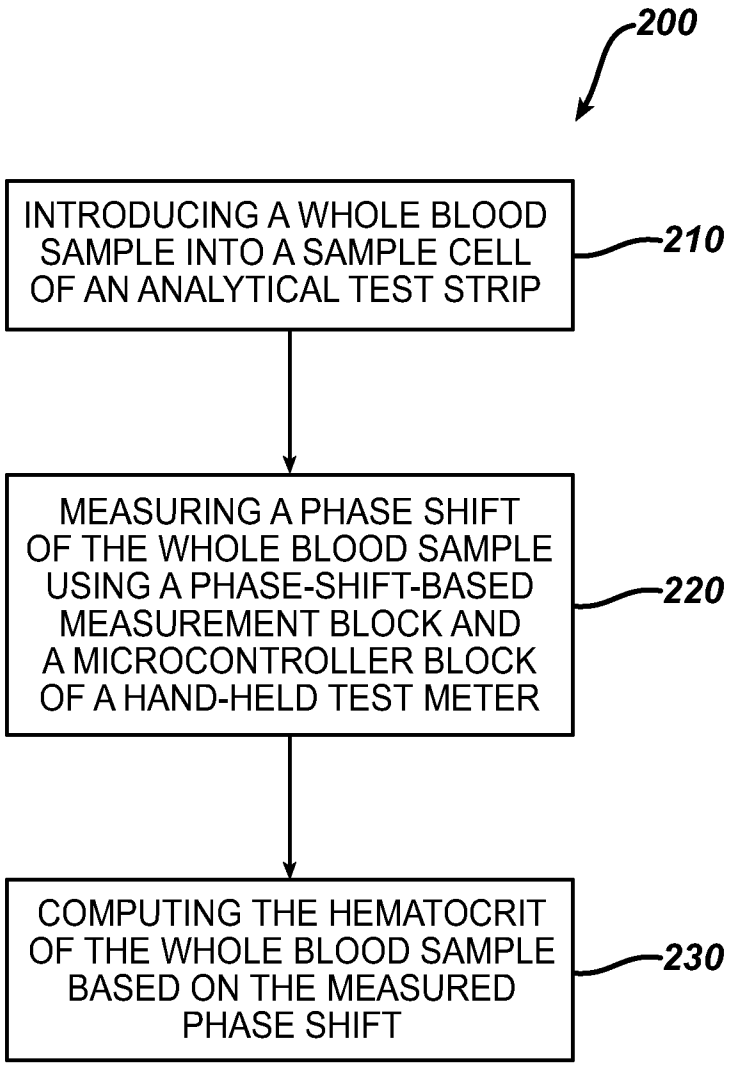
200
INTRODUCING A WHOLE BLOOD SAMPLE INTO A SAMPLE CELL OF AN ANALYTICAL TEST STRIP
210
MEASURING A PHASE SHIFT OF THE WHOLE BLOOD SAMPLE USING A PHASE-SHIFT-BASED MEASUREMENT BLOCK AND A MICROCONTROLLER BLOCK OF A HAND-HELD TEST METER
220
COMPUTING THE HEMATOCRIT OF THE WHOLE BLOOD SAMPLE BASED ON THE MEASURED PHASE SHIFT
230

FIG. 15

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2012/053277

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N27/327
ADD.

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

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 practicable, 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.
Y	US 2007/084734 A1 (ROBERTS NEIL [US] ET AL) 19 April 2007 (2007-04-19) cited in the application the whole document	1-5, 7-22, 24-43
X	US 2010/206749 A1 (CHOI IN HWAN [KR]) 19 August 2010 (2010-08-19) cited in the application	44-87
Y	the whole document	1-5, 7-22, 24-43
A	WO 2011/121292 A1 (LIFESCAN SCOTLAND LTD [GB]; MALECHA MICHAEL [GB]; CRAGGS ADAM [GB]) 6 October 2011 (2011-10-06) paragraph [0054]	15-20, 25-30, 56-61, 70-75, 81-86

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step 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
9 April 2013	03/05/2013

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, Fax: (+31-70) 340-3016	Purdie, Douglas

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/GB2012/053277

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007084734 Al	19-04-2007	CN 1991355 A	04-07-2007
		CN 102520045 A	27-06-2012
		EP 1783486 Al	09-05-2007
		EP 2261651 Al	15-12-2010
		JP 4859619 B2	25-01-2012
		JP 2007114197 A	10-05-2007
		US 2007084734 Al	19-04-2007
		US 2011174616 Al	21-07-2011
US 2010206749 Al	19-08-2010	EP 2193367 A2	09-06-2010
		KR 20090033065 A	01-04-2009
		US 2010206749 Al	19-08-2010
		WO 2009041782 A2	02-04-2009
WO 2011121292 Al	06-10-2011	AU 2011234255 Al	25-10-2012
		CA 2794978 Al	06-10-2011
		CN 102918388 A	06-02-2013
		EP 2553441 Al	06-02-2013
		EP 2565636 A2	06-03-2013
		EP 2565637 A2	06-03-2013
		EP 2565638 A2	06-03-2013
		KR 20130014053 A	06-02-2013
		WO 2011121292 Al	06-10-2011