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(54) **DEVICE FOR DETERMINING THE CONCENTRATION OF GLUCOSE IN BODY LIQUID**

VORRICHTUNG ZUR BESTIMMUNG DER GLUKOSEKONZENTRATION IN KÖRPERFLÜSSIGKEIT
DISPOSITIF DESTINES A DETERMINER LA CONCENTRATION DE GLUCOSE DANS UN LIQUIDE
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(56) References cited:
EP-A- 0 298 441 **EP-A- 0 309 085**
WO-A-00/43759 **WO-A-01/36952**
WO-A-85/04481 **WO-A-93/18395**
DE-A- 3 017 168 **US-A- 4 509 531**
US-A- 5 792 668

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Description

Technical Field

[0001] The invention relates to a device for determining the concentration of glucose in an in-vitro or in-vivo specimen containing body liquid according to the preamble of the independent claims.

Background Art

[0002] Radio wave spectroscopy has been known to provide promising potential in the in-vitro and in-vivo determination of the concentration of glucose and other substances in body fluids. In particular, this technology is of substantial interest for the determination of glucose concentration in blood and/or inter- or intracellular liquid. A device for measuring blood level glucose is disclosed in US 5 792 668, where two electrodes are brought into direct contact with the human body and the impedance is measured between them.

[0003] Despite its potential, the technology has not yet been used in commercial devices, which is attributed to the limited accuracy of the presently known solutions.

Disclosure of the Invention

[0004] Hence, it is the goal of the invention to provide a device that allows to increase the reliability of this type of measurement.

[0005] This goal is reached by claim 1.

[0006] Accordingly, the first electrode is electrically insulated from the specimen. Hence, the measured parameter does not depend on the surface conditions of the specimen. Rather, the signal is capacitively coupled to the specimen and the measured parameter depends therefore primarily on the conditions within the specimen. The parameter measured in this way can then be converted to the desired concentration, e.g. by using calibration data.

[0007] In addition, the first electrode is arranged on an insulating substrate between the substrate and the insulating cover layer. Hence, the substrate can provide mechanical stability to the electrode while the cover layer can be thin, which allows the electrode to be placed close to the specimen.

[0008] Preferably, at least two electrodes are provided, wherein the modulated voltage is applied between them. By using two electrodes, a defined field can be established within the specimen. For best signals, it has been found advantageous to place the second electrode in electric contact with the specimen.

[0009] The measured parameter preferably depends on the electrical impedance at the electrode(s). It has been found that the concentration of various substances, in particular glucose, affects the real or imaginary part of this impedance because it changes the loss and/or dielectric constant of body fluid.

[0010] Preferably, the electrode forms part of a resonant circuit, which is operated at or close to its resonance frequency. Under such conditions, a change of the dielectric or loss properties of the specimen leads to substantial shifts in the parameters of the resonant circuit and can therefore be measured with high sensitivity.

[0011] The device of the present invention has been found to be especially suited for measuring the glucose concentration in body fluid.

Brief Description of the Drawings

[0012] The invention will be better understood and objects other than those set forth above will become apparent when consideration is given to the following detailed description thereof. Such description makes reference to the annexed drawings, wherein:

Fig. 1 is a block circuit diagram of a preferred device for carrying out the invention,

Fig. 2 is a view onto a possible embodiment of the device,

Fig. 3 is a section along line III-III of Fig. 2,

Fig. 4 is the device of Fig. 3 with a wristband,

Fig. 5 shows the behavior of the relative amplitude A as a function of frequency,

Fig. 6 is a second embodiment of the circuit,

Fig. 7 is an alternative electrode geometry,

Fig. 8 shows measurements at varying glucose concentrations (mmol/liter) in physiologic solution and

Fig. 9 a third embodiment of the circuit.

Modes for Carrying Out the Invention

[0013] Fig. 1 shows a block circuit diagram of a preferred device for carrying out the invention. It comprises a voltage controlled oscillator (VCO) 1 as a signal source for generating a sine wave signal. This signal is fed to two amplifiers 2, 3. The output of first amplifier 2 is connected via a resistor R1 to a first signal path 4. A resonant circuit 5 comprising an inductance L and a capacitor C in series is connected between first signal path 4 and ground. The output of second amplifier 3 is connected via a resistor R2 to a second signal path 6. Second signal path 6 is substantially identical to first signal path 4 but comprises a resistor R3 as a reference load instead of resonant circuit 5.

[0014] Both signal paths 4, 6 are fed to a measuring circuit 7, which determines the relative amplitude A of both signals as well as, optionally, their mutual phase shift phi. Relative amplitude A can e.g. be the amplitude of first signal path 4 in units of the amplitude of second signal path 6 (wherein the amplitudes are the peak values of the sine waves).

[0015] The output signal of measuring circuit 7 is fed to a microprocessor 8, which also controls the operation of VCO 1.

[0016] As can be seen from Fig. 1, the device in the

present embodiment further comprises a temperature sensor 10, a display 11 and an input device 12 with user operatable controls, all of which are controlled by microprocessor 8.

[0017] Inductance L of the device of Fig. 1 can be generated by a coil and/or by the leads and electrodes of capacitor C. Its value is generally known with reasonable accuracy.

[0018] Capacitor C of the device of Fig. 1 is used as an antenna for probing a specimen. For this purpose, it is formed by electrodes that are arranged near the specimen. The geometry of the electrodes is selected such that the electric field generated by them extends into the specimen and the body liquid to be measured. Suitable geometries are discussed below. As mentioned above, at least one of the electrodes of the capacitor is electrically isolated such that capacitor C is primarily a capacitive load, the capacitance and loss of which depends on the electrical properties (i.e. the response) of the specimen at the frequency of VCO 1.

[0019] To measure the concentration of a substance in the body fluid of the specimen, microprocessor 8 can e.g. initiate a measurement cycle consisting of a frequency sweep of VCO 1. The sweep should start at a frequency f_{min} below the expected resonance frequency f_0 of the resonant circuit 5 and extend to a frequency f_{max} above resonance frequency f . During this sweep, the electrical properties of signal path 4 will change substantially, while those of signal path 6 will vary only slightly. The amplitude determined by measuring circuit A will therefore fall to a minimum A_0 at f_0 , as shown in Fig. 5. At the same time, phase shift ϕ crosses zero.

[0020] As can be shown, the dependence of A_0 on the dielectric constant $s(f)$ and, in particular, on the loss or conductance $p(f)$ of the fluid in the specimen is stronger than at off-resonance frequencies, which allows a sensitive measurement of the liquid's response to the electric field.

[0021] This is shown in Fig. 8, which represents measurements of the type shown in Fig. 5 at glucose concentrations between 0 and 17.5 mmol/l. The vertical axis represents the ratio in dB of the signals from first signal path 4 and second signal path 6. The resonance frequency is around 35.5 MHz.

[0022] It is presently believed that the specific impedance of the body fluid, i.e. the specific conductivity $p(f)$ and the dielectric constant $\epsilon(f)$ in a frequency range between 10 MHz and 2000 MHz, and in particular between 20 MHz and 70 MHz, are a function of the properties and concentration of the salty (ionic) components of the human body. These salty components primarily include solvated sodium, potassium, calcium and other minor ions and their counter ions, the primary counter ion being chloride. Other non-ionic solvated substances, in particular substances having a similar range of size as the ion complexes, can have an impact on the impedance pattern of the salty body fluid components, provided these substances occur in sufficient concentration. In particular,

glucose has a similar range of size and is present in concentrations giving rise to a well detectable variation of the amplitude A_0 at resonance frequency.

[0023] In a simple embodiment, only amplitude A_0 is measured as a parameter for the determination of the concentration. Suitable calibration data stored in microprocessor 8 is used to convert amplitude A_0 into the desired concentration level.

[0024] The effects exploited for the measurement are temperature dependent. In order to obtain high accuracy over a wide temperature range, temperature sensor 10 is brought into thermal contact with the specimen to be measured. The signals from temperature sensor 10 are used to correct the obtained result, again using calibration data obtain from calibration measurements.

[0025] A proper design of the electrodes of capacitor C allows to optimize the accuracy and sensitivity of the present device in a given application. A preferred geometry of the device for in-vivo measurements in a living body is shown in Figs. 2 and 3.

[0026] The device comprises a housing 13 closed on one side by an electrode plate 14. The display 11 is arranged opposite electrode plate 14. The electronic circuits 16 are arranged between electrode plate 14 and display 11.

[0027] Electrode plate 14 comprises an electrically insulating substrate 17 with a strip electrode 18 and a top or ring electrode 19 arranged on an outer side 20 thereof. An inner side 21 of insulating substrate 17 is covered by a bottom electrode 22. A plurality of through-contacts 23 are provided to connect ring electrode 19 to bottom electrode 22. A further through-contact 24 connects one end of strip electrode 18 to a small bond pad 25 arranged in an opening 26 of bottom electrode 22 on inner side 21.

[0028] Temperature sensor 10 is mounted to bottom electrode 22. The large number of through-contacts 23 ensure that bottom electrode 22 follows the temperature of ring electrode 18 and therefore the temperature of the specimen closely.

[0029] A typical size of electrode plate 14 is 32 mm x 21 mm. Bottom electrode 22 covers all of inner side 21 except for the small opening 26 and is therefore much larger than strip electrode 18.

[0030] Leads 28 are provided to connect bottom electrode 22, contact pad 26 and temperature sensor 10 to the electronic circuits 16.

[0031] While bottom electrode 22 and ring electrode 19 are connected to ground, strip electrode 18 is connected to inductance L of resonant circuit 5. Therefore, the capacitor C is formed between strip electrode 18 as a first electrode and ring electrode 19 and bottom electrode 22 as a second electrode. In other words, the second electrode consists of two electrode layers: a top electrode layer formed by ring electrode 19 and a bottom electrode layer formed by bottom electrode 22.

[0032] An electrically insulating cover layer 29 covers all of strip electrode 18 but not ring electrode 19. In other words, strip electrode 18 is arranged between substrate

17 and cover layer 29. Cover layer 29 is preferably of a hard, moisture- and salt-impervious material such as glass, ceramics, a polycarbonate or diamondlike carbon (DLC) of a thickness preferably between 50 and 100 μm .

[0033] As can be seen in Fig. 4, a holder or wristband 31 is attached to housing 13 for fixing the device to an arm or a leg of a human body with cover layer 29 facing the body and a longitudinal axis of strip electrode 18 parallel to the arm or leg. In this way, ring electrode 19 comes into contact with the user's skin and sets the same to ground reference potential. The electric field generated by strip electrode 18 extends into the body tissue. Since strip electrode 18 is elongate and has a width much smaller than its length and extends along the arm or leg, a comparatively large region of the body is reached by the field. This allows to obtain more sensitive and accurate measurements.

[0034] As described above, a pure sine voltage has been found to be sufficient for obtaining accurate measurements. However, other types for modulated voltages, such as square-wave voltages or pulses can be used as well. In this case, measuring circuit 7 is preferably provided with suitable filters for selectively sampling one or more frequency components. At least one measured frequency component is preferably close to the resonance frequency of resonant circuit 5 for exploiting the circuit's high sensitivity to the specimen's properties at that frequency.

[0035] The electrode geometry can be varied for adapting it to a given application. While the design of Fig. 2 is optimized for a measurement on an arm or leg, a circular design can be used for measurement on a flatter body part or an in-vitro sample.

[0036] Ring electrode 19 does not necessarily have to form a closed ring as long as it provides sufficient grounding of the body part to be measured. It can e.g. also have U-shape or consist of two stripes parallel to and laterally enclosing strip electrode 18. Ring electrode 19 can also be omitted completely or be covered by cover layer 29, in particular for in-vitro measurements where noise is low.

[0037] Part of a further embodiment of the circuit is shown in Fig. 6. Here, no direct connection between resonant circuit 5 and measuring circuit 7 is used. Rather, an antenna electrode 33 is located in proximity to the electrodes of capacitor C, and measuring circuit 7 measures the signal returned by antenna electrode 33.

[0038] A possible arrangement of the electrodes is shown in Fig. 7. As can be seen, antenna electrode 33 is strip shaped and arranged in parallel to strip electrode 18. Both, antenna electrode 33 and strip electrode 18 are covered by cover layer 29 and therefore electrically insulated from the specimen.

[0039] The device of Figs. 6 and 7 is again sweeping VCO 1 between a frequency f_{min} below the resonance frequency f_0 of resonant circuit 5 and a frequency f_{max} above it. In contrast to Fig. 5, measuring circuit 7 now detects a maximum amplitude A_0 at f_0 , wherein the value of A_0 depends on the response, i.e. the electrical prop-

erties of the specimen at the resonance frequency f_0 . The parameter A_0 can now again be processed using calibration data as described above.

[0040] A comparison of the device of Figs. 1 and 2 with the device of Figs. 6 and 7 shows that the first embodiment measures the response of the specimen from the signal reflected to strip electrode 18. The second embodiment measures the response of the specimen from the signal transmitted from strip electrode 18 to antenna electrode 33.

[0041] It is found that the transmission and reflection show different dependencies on the concentrations of various compounds of the body fluid. Hence, a combined measurement of reflection and transmission allows a further refinement of the measurement by elimination of the influence of compounds not of interest for the quantity to be measured.

[0042] A third embodiment of a circuit is shown in Fig. 9. Here, the capacitor C formed by the electrodes is part of the resonant tank circuit of an active, self-oscillating oscillator 40. The amplitude A and frequency f_0 of the output signal of oscillator 40 depend on the capacitance and losses in capacitor C. The corresponding signal is fed to measuring circuit 7, which evaluates the parameters A and f_0 . Measuring the corresponding parameters A and f_0 again allows a sensitive measurement of the desired concentration using calibration data.

[0043] In the examples shown so far, the invention was used in a device for qualitatively or quantitatively displaying the concentration a substance (such as glucose) in body liquid. The invention can, however, e.g. also be used in devices that automatically administer medication to a body, such as an insulin pump, where the amount and/or time for administering the medication depends on the measured concentration. It can also be used in any other type of device that requires the measurement of the concentration of a substance in body fluid.

[0044] While there are shown and described presently preferred embodiments of the invention, it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied and practiced within the scope of the following claims.

45 Claims

1. A device for determining the concentration of glucose in a in-vitro or in-vivo specimen containing body liquid comprising
 - a first electrode (18),
 - an electrically insulating substrate (17), wherein the first electrode (18) is arranged on a first side (20) of the substrate (17),
 - a signal source (1) having an oscillator, said signal source connected to the first electrode (18) for applying a modulated electrical voltage to the first electrode (18) for generating an electric field in the specimen,

- a measuring circuit (7) for measuring at least one parameter depending on a response of the specimen to the field,
 calibration data for converting the parameter (A, ϕ , f_0) to the concentration
 a data processor (8) determining the concentration from the parameter using the calibration data,
characterised in that the first electrode (18) is covered by a cover layer (29) of insulating material for electrically insulating the first electrode (18) from the specimen, wherein the first electrode is arranged between the substrate (17) and the cover layer (29).
2. The device of claim 1 comprising a holder (31) for fixing the first electrode (18) to a part of a body with the cover layer (29) facing the body.
 3. The device of any of the preceding claims further comprising a second electrode (19, 22) arranged on the substrate, wherein the signal source (2) is connected to apply the modulated electrical voltage between the first (18) and the second (19, 22) electrode.
 4. The device of claim 3, wherein the second electrode (19, 22) comprises a bottom electrode layer (22) arranged on a second side (21) of the substrate (17), said bottom electrode layer (22) having a larger extension than said top electrode layer (18).
 5. The device of one of the claims 3 or 4, wherein the second electrode (19, 22) comprises a top electrode layer (19) arranged on the first side (20) of the substrate (17), said top electrode layer (19) being arranged around at least part, in particular substantially all, of the first electrode (18).
 6. The device of any of the claims 3 to 5, wherein the second electrode is not covered by the cover layer such that it is suited to be brought into electric contact with the specimen.
 7. The device of one of the preceding claims, wherein the first electrode (18) is elongate having a width much smaller than a length.
 8. The device of one of the preceding claims comprising a first (4) and a second (6) signal path between the signal source (1) and the measuring circuit (7), wherein the first electrode (18) is arranged in the first signal path (4) and a reference load (R3) is arranged in the second signal path (6), and wherein the measuring circuit (7) is adapted to measure a relative amplitude (A) and/or phase (ϕ) of signals from the first and second paths.
 9. The device of one of the preceding claims wherein the first electrode (18) is part of a capacitor (C) of a resonant circuit (5) comprising the capacitor (C) and an inductance (L) connected to the signal source (1).
 10. The device of claim 9 wherein the capacitor (C) and the inductance (L) are arranged in series.
 11. The device of one of the claims 9 or 10 wherein the measuring circuit (7) is adapted to measure a voltage over the resonant circuit (5).
 12. The device of one of the claims 9 to 11 further comprising an antenna electrode (33) arranged in proximity to the first electrode (18), wherein the measuring circuit (7) is adapted to measure a signal transmitted from the first electrode (18) to the antenna electrode (33).
 13. The device of one of the preceding claims comprising a temperature sensor (10) for measuring a temperature (T), wherein said data processor is adapted to use the temperature (T) when determining said concentration.
 14. The device of one of the preceding claims wherein the modulated electrical voltage is a sine voltage.
 15. The device of one of the preceding claims wherein the modulated electrical voltage has a frequency between 10 MHz and 2 GHz, in particular between 20 MHz and 70 MHz.
 16. The device of one of the preceding claims wherein the parameter (A, ϕ , f_0) depends on the electrical impedance at the first electrode.
 17. The device of one of the preceding claims wherein the measuring circuit (7) is adapted for measuring a signal reflected from the first electrode.
 18. The device of one of the preceding claims further comprising an antenna electrode (33) for being arranged at the specimen in proximity to the first electrode (18) and wherein the measuring circuit (7) is adapted for measuring a signal transmitted from the first electrode (18) to the antenna electrode (33).
 19. The device of one of the preceding claims wherein the first electrode forms part of a resonant circuit (5) having a resonance frequency (f_0) and wherein the device is adapted to operate the resonant circuit (5) substantially at the resonance frequency.
 20. The device of claim 19 wherein the resonant circuit is at least part of a tank circuit of an active oscillator (40) and wherein the parameter is an amplitude (A) and/or a frequency (f_0) of a signal generated by said oscillator (40).
 21. The device of claim 19 wherein the device is adapted

to frequency-sweep the modulated voltage from a frequency (f_{\min}) below the resonance frequency (f_0) to a frequency (f_{\max}) above the resonance frequency, and in particular wherein the parameter is a signal reflected to the first electrode (18) or transmitted to an antenna electrode (33) at the resonance frequency (f_0).

Patentansprüche

1. Vorrichtung zur Bestimmung der Konzentration von Glucose in einer in-vitro oder in-vivo Probe, welche Körperflüssigkeit enthält, umfassend eine erste Elektrode (18), ein elektrisch isolierendes Substrat (17), wobei die erste Elektrode (18) auf einer ersten Seite (20) des Substrats (17) angeordnet ist, eine Signalquelle (1), welche eine Oszillator aufweist, wobei die Signalquelle mit der ersten Elektrode (18) verbunden ist um eine modulierte elektrische Spannung an die erste Elektrode (18) anzulegen zur Erzeugung eines elektrischen Felds in der Probe, eine Messschaltung (7) zum Messen mindestens eines Parameters, der von einer Antwort der Probe auf das Feld abhängt, Eichdaten zum Umwandeln des Parameters (A, ϕ , f_0) in die Konzentration, einen Datenprozessor (8), der die Konzentration aus dem Parameter unter Verwendung der Eichdaten bestimmt, **dadurch gekennzeichnet, dass** die erste Elektrode (18) von einer Deckschicht (29) aus isolierendem Material bedeckt ist um die erste Elektrode (18) elektrisch von der Probe zu isolieren, wobei die erste Elektrode zwischen dem Substrat (17) und der Deckschicht (29) angeordnet ist.
2. Vorrichtung nach Anspruch 1, aufweisend einen Halter (31) zum Befestigen der ersten Elektrode (18) an einem Teil eines Körpers mit zum Körper ausgerichteter Deckschicht (29).
3. Vorrichtung nach einem der vorangehenden Ansprüche, weiter umfassend eine zweite Elektrode (19, 22) angeordnet auf dem Substrat, wobei die Signalquelle (2) verbunden ist um die modulierte elektrische Spannung zwischen der ersten (18) und der zweiten (19, 22) Elektrode anzulegen.
4. Vorrichtung nach Anspruch 3, wobei die zweite Elektrode (19, 22) eine untere Elektrodenschicht (22) angeordnet auf einer zweiten Seite (21) des Substrats (17) aufweist, wobei die untere Elektrodenschicht (22) eine grössere Ausdehnung als die obere Elektrodenschicht (18) aufweist.
5. Vorrichtung nach einem der vorangehenden Ansprüche, 3 oder 4, wobei die zweite Elektrode (19, 22) eine obere Elektrodenschicht (19) angeordnet auf der ersten Seite (20) des Substrats (17) aufweist, wobei obere Elektrodenschicht (19) um mindestens einen Teil der ersten Elektrode (18), insbesondere im wesentlichen die ganze erste Elektrode (18) angeordnet ist.
6. Vorrichtung nach einem der Ansprüche 3 bis 5, wobei die zweite Elektrode nicht von der Deckschicht bedeckt ist, so dass sie dazu geeignet ist, mit der Probe in elektrischen Kontakt gebracht zu werden.
7. Vorrichtung nach einem der vorangehenden Ansprüche, wobei die erste Elektrode (18) länglich ist und eine Breite sehr viel kleiner als ihre Länge besitzt.
8. Vorrichtung nach einem der vorangehenden Ansprüche, umfassend einen ersten (4) und einen zweiten (6) Signalpfad zwischen der Signalquelle (1) und der Messschaltung (7), wobei die erste Elektrode (18) im ersten Messpfad (4) und eine Referenzlast (R3) im zweiten Signalpfad (6) angeordnet sind, und wobei die Messschaltung (7) dazu ausgestaltet ist, die relative Amplitude (A) und/oder Phase (ϕ) der Signale vom ersten und zweiten Pfad zu messen.
9. Vorrichtung nach einem der vorangehenden Ansprüche, wobei die erste Elektrode (18) Teil der Kapazität (C) eines Schwingkreises (5) umfassend die Kapazität (C) und eine Induktivität (L) verbunden mit der Signalquelle (1) ist.
10. Vorrichtung nach Anspruch 9, wobei die Kapazität (C) und die Induktivität (L) in Serie angeordnet sind.
11. Vorrichtung nach einem der Ansprüche 9 oder 10, wobei die Messschaltung (7) dazu ausgestaltet ist, eine Spannung über dem Schwingkreis (5) zu messen.
12. Vorrichtung nach einem der Ansprüche 9 bis 11 weiter umfassend eine Antennenelektrode (33) angeordnet in der Nähe der ersten Elektrode (18), wobei die Messschaltung (7) dazu ausgestaltet ist, ein von der ersten Elektrode (18) an die Antennenelektrode (33) übertragenes Signal zu messen.
13. Vorrichtung nach einem der vorangehenden Ansprüche, umfassend einen Temperatursensor (10) zum Messen einer Temperatur (T), wobei der Datenprozessor ausgestaltet ist, die Temperatur (T) beim Bestimmen der Konzentration zu verwenden.
14. Vorrichtung nach einem der vorangehenden Ansprüche, wobei die modulierte elektrische Spannung eine Sinusspannung ist.

15. Vorrichtung nach einem der vorangehenden Ansprüche, wobei die modulierte elektrische Spannung eine Frequenz zwischen 10 MHz und 2 GHz, insbesondere zwischen 20 MHz und 70 MHz aufweist.
16. Vorrichtung nach einem der vorangehenden Ansprüche, wobei der Parameter (A, phi, f0) von der elektrischen Impedanz an der ersten Elektrode abhängt.
17. Vorrichtung nach einem der vorangehenden Ansprüche, wobei die Messschaltung (7) ausgestaltet ist zum Messen eines von der ersten Elektrode reflektierten Signals.
18. Vorrichtung nach einem der vorangehenden Ansprüche, weiter umfassend eine Antennenelektrode (33) zur Anordnung an der Probe in der Nähe der ersten Elektrode (19), und wobei die Messschaltung (7) dazu ausgestaltet ist, ein von der ersten Elektrode (18) an die Antennenelektrode (33) übertragenes Signal zu messen.
19. Vorrichtung nach einem der vorangehenden Ansprüche, wobei die erste Elektrode Teil eines Schwingkreises (5) mit einer Resonanzfrequenz (f0) bildet und wobei die Vorrichtung dazu ausgestaltet ist, den Schwingkreis (5) im wesentlichen auf der Resonanzfrequenz zu betreiben.
20. Vorrichtung nach Anspruch 19, wobei der Schwingkreis mindestens Teil einer Tankschaltung eines aktiven Oszillators (40) ist und wobei der Parameter eine Amplitude (A) und/oder eine Frequenz (f0) eines vom Oszillator (40) erzeugten Signals ist.
21. Vorrichtung nach Anspruch 19, wobei die Vorrichtung dazu ausgestaltet ist, die modulierte Spannung von einer Frequenz (fmin) unterhalb der Resonanzfrequenz (f0) zu einer Frequenz (fmax) oberhalb der Resonanzfrequenz durchzustimmen, und insbesondere wobei der Parameter ein an die erste Elektrode (18) reflektiertes Signal oder ein an eine Antennenelektrode (33) übertragenes Signal bei der Resonanzfrequenz ist.

Revendications

1. Dispositif destiné à déterminer la concentration en glucose dans une éprouvette *in vitro* ou *in vivo* contenant un liquide corporel comprenant une première électrode (18), un substrat électriquement isolant (17), dans lequel la première électrode (18) est agencée sur un premier côté (20) du substrat (17), une source de signal (1) comportant un oscillateur, ladite source de signal étant connectée à la première

électrode (18) pour appliquer une tension électrique modulée à la première électrode (18) pour générer un champ électrique dans l'éprouvette, un circuit de mesure (7) destiné à mesurer au moins un paramètre en fonction d'une réponse de l'éprouvette au champ, des données d'étalonnage destinées à convertir le paramètre (A, phi, f0) en la concentration un processeur de données (8) déterminant la concentration à partir du paramètre en utilisant les données d'étalonnage, **caractérisé en ce que** la première électrode (18) est recouverte par une couche de couverture (29) de matériau isolant destinée à isoler électriquement la première électrode (18) de l'éprouvette, dans lequel la première électrode est agencée entre le substrat (17) et la couche de couverture (29).

2. Dispositif selon la revendication 1, comprenant un support (31) destiné à fixer la première électrode (18) à une partie d'un corps, la couche de couverture (29) faisant face au corps.
3. Dispositif selon l'une quelconque des revendications précédentes, comprenant en outre une seconde électrode (19, 22) agencée sur le substrat, dans lequel la source de signal (2) est connectée pour appliquer la tension électrique modulée entre la première (18) et la seconde (19, 22) électrode.
4. Dispositif selon la revendication 3, dans lequel la seconde électrode (19, 22) comprend une couche d'électrode inférieure (22) agencée sur un second côté (21) du substrat (17), ladite couche d'électrode inférieure (22) ayant un allongement plus grand que ladite couche d'électrode supérieure (18).
5. Dispositif selon l'une des revendications 3 ou 4, dans lequel la seconde électrode (19, 22) comprend une couche d'électrode supérieure (19) agencée sur le premier côté (20) du substrat (17), ladite couche d'électrode supérieure (19) étant agencée autour d'au moins une partie, en particulier sensiblement la totalité, de la première électrode (18).
6. Dispositif selon l'une quelconque des revendications 3 à 5, dans lequel la seconde électrode n'est pas recouverte par la couche de couverture de telle sorte qu'elle est adaptée pour être amenée en contact électrique avec l'éprouvette.
7. Dispositif selon l'une des revendications précédentes, dans lequel la première électrode (18) est allongée ayant une largeur beaucoup plus petite qu'une longueur.
8. Dispositif selon l'une des revendications précédentes, comprenant un premier (4) et un second (6) trajet

- de signal entre la source de signal (1) et le circuit de mesure (7), dans lequel la première électrode (18) est agencée dans le premier trajet de signal (4) et une charge de référence (R3) est agencée dans le second trajet de signal (6), et dans lequel le circuit de mesure (7) est adapté pour mesurer une amplitude relative (A) et/ou une phase relative (ϕ) des signaux des premier et second trajets.
- 5
9. Dispositif selon l'une des revendications précédentes, dans lequel la première électrode (18) fait partie d'un condensateur (C) d'un circuit résonant (5) comprenant le condensateur (C) et une inductance (L) connectés à la source de signal (1).
10. Dispositif selon la revendication 9, dans lequel le condensateur (C) et l'inductance (L) sont agencés en série.
11. Dispositif selon l'une des revendications 9 ou 10, dans lequel le circuit de mesure (7) est adapté pour mesurer une tension sur le circuit résonant (5).
12. Dispositif selon l'une des revendications 9 à 11, comprenant en outre une électrode d'antenne (33) agencée à proximité de la première électrode (18), dans lequel le circuit de mesure (7) est adapté pour mesurer un signal transmis de la première électrode (18) à l'électrode d'antenne (33).
13. Dispositif selon l'une des revendications précédentes, comprenant un capteur de température (10) destiné à mesurer une température (T), dans lequel ledit processeur de données est adapté pour utiliser la température (T) lors de la détermination de ladite concentration.
14. Dispositif selon l'une des revendications précédentes, dans lequel la tension électrique modulée est une tension sinusoïdale.
15. Dispositif selon l'une des revendications précédentes, dans lequel la tension électrique modulée a une fréquence comprise entre 10 MHz et 2 GHz, en particulier entre 20 MHz et 70 MHz.
16. Dispositif selon l'une des revendications précédentes, dans lequel le paramètre (A, ϕ , f_0) dépend de l'impédance électrique au niveau de la première électrode.
17. Dispositif selon l'une des revendications précédentes, dans lequel le circuit de mesure (7) est adapté pour mesurer un signal réfléchi depuis la première électrode.
18. Dispositif selon l'une des revendications précédentes, comprenant en outre une électrode d'antenne (33) destinée à être agencée au niveau de l'éprouvette à proximité de la première électrode (18) et dans lequel le circuit de mesure (7) est adapté pour mesurer un signal transmis de la première électrode (18) à l'électrode d'antenne (33).
19. Dispositif selon l'une des revendications précédentes, dans lequel la première électrode fait partie d'un circuit résonant (5) ayant une fréquence de résonance (f_0) et dans lequel le dispositif est adapté pour faire fonctionner le circuit résonant (5) sensiblement à la fréquence de résonance.
20. Dispositif selon la revendication 19, dans lequel le circuit résonant est au moins une partie d'un circuit oscillant final d'un oscillateur actif (40) et dans lequel le paramètre est une amplitude (A) et/ou une fréquence (f_0) d'un signal généré par ledit oscillateur (40).
21. Dispositif selon la revendication 19, dans lequel le dispositif est adapté pour balayer en fréquence la tension modulée d'une fréquence (f_{min}) en dessous de la fréquence de résonance (f_0) à une fréquence (f_{max}) au-dessus de la fréquence de résonance, et en particulier dans lequel le paramètre est un signal réfléchi vers la première électrode (18) ou transmis à une électrode d'antenne (33) à la fréquence de résonance (f_0).

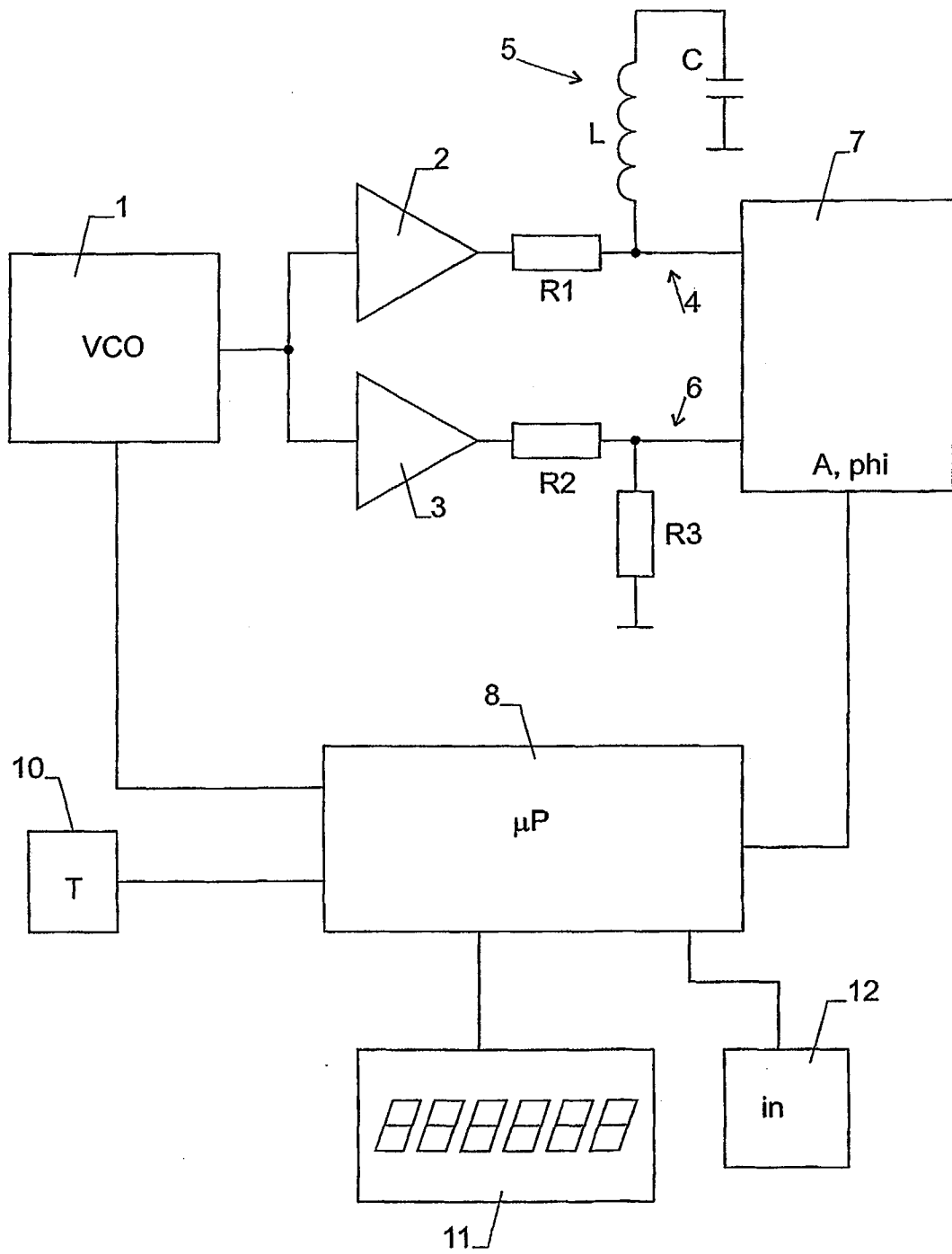
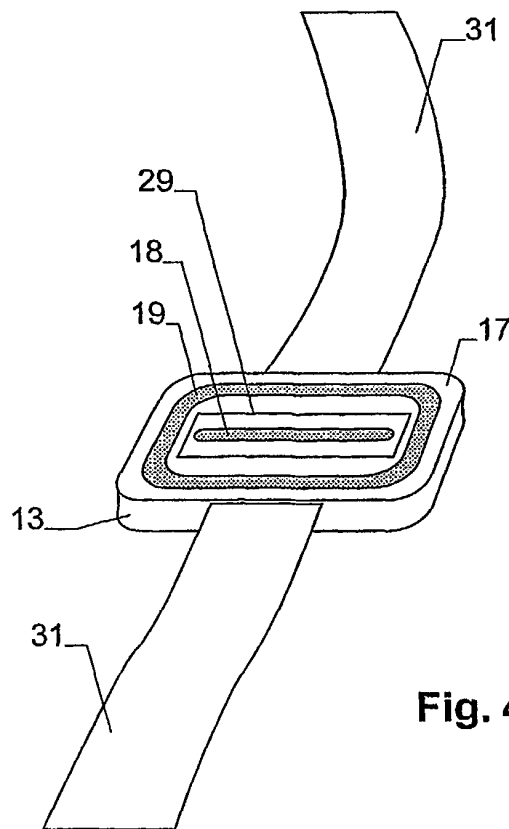
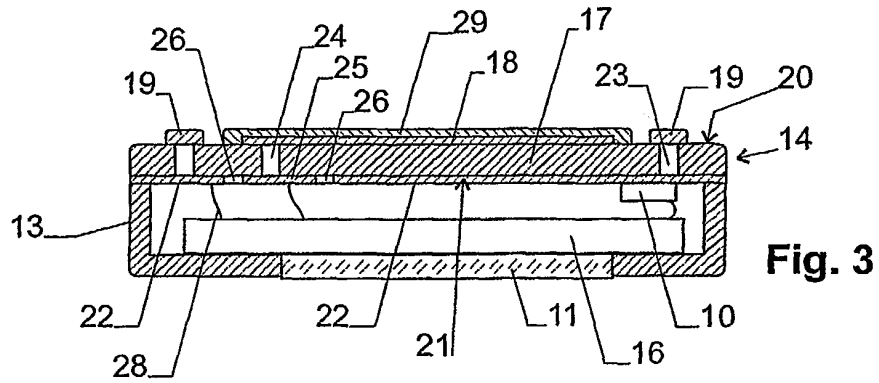
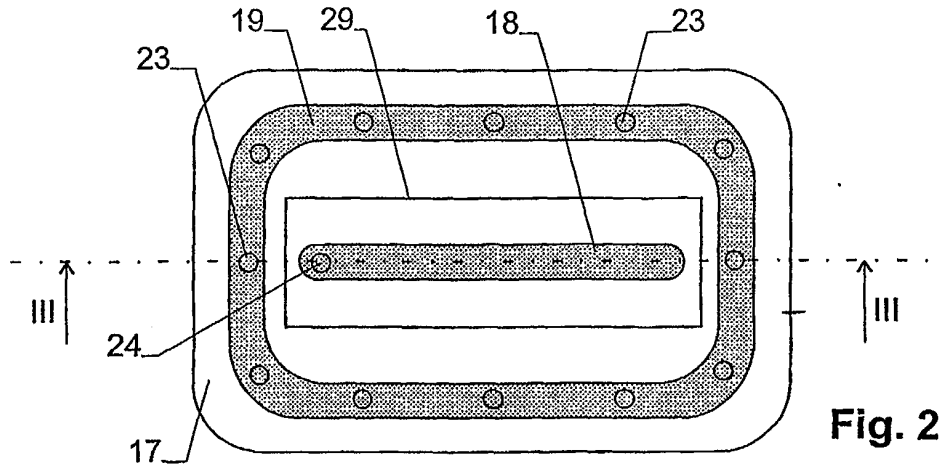


Fig. 1



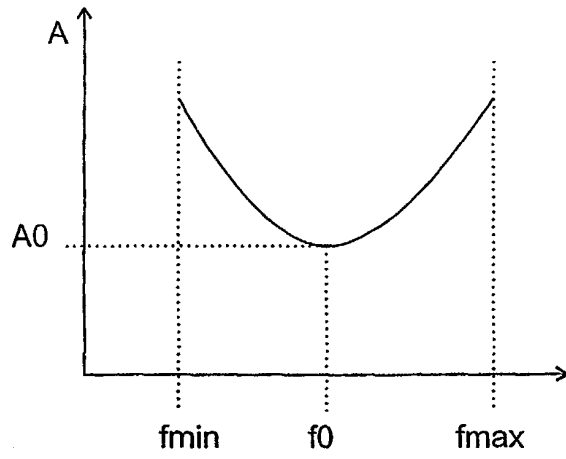


Fig. 5

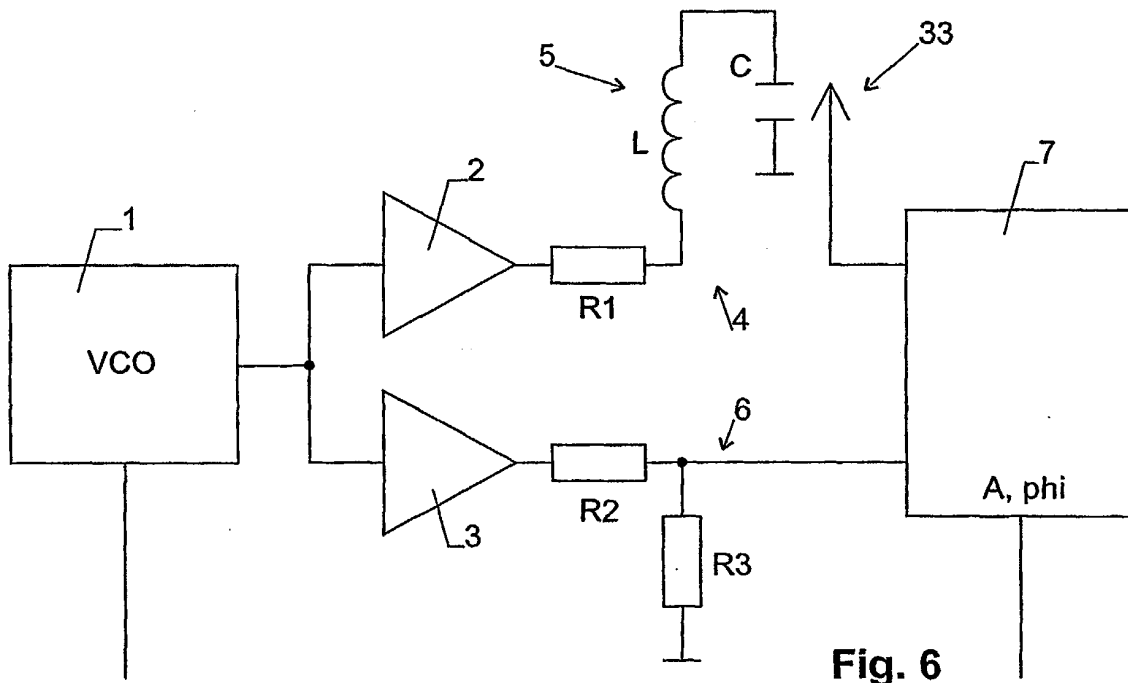


Fig. 6

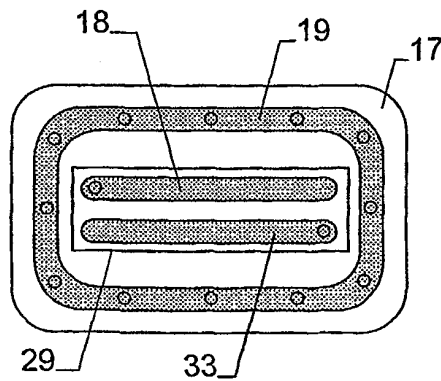


Fig. 7

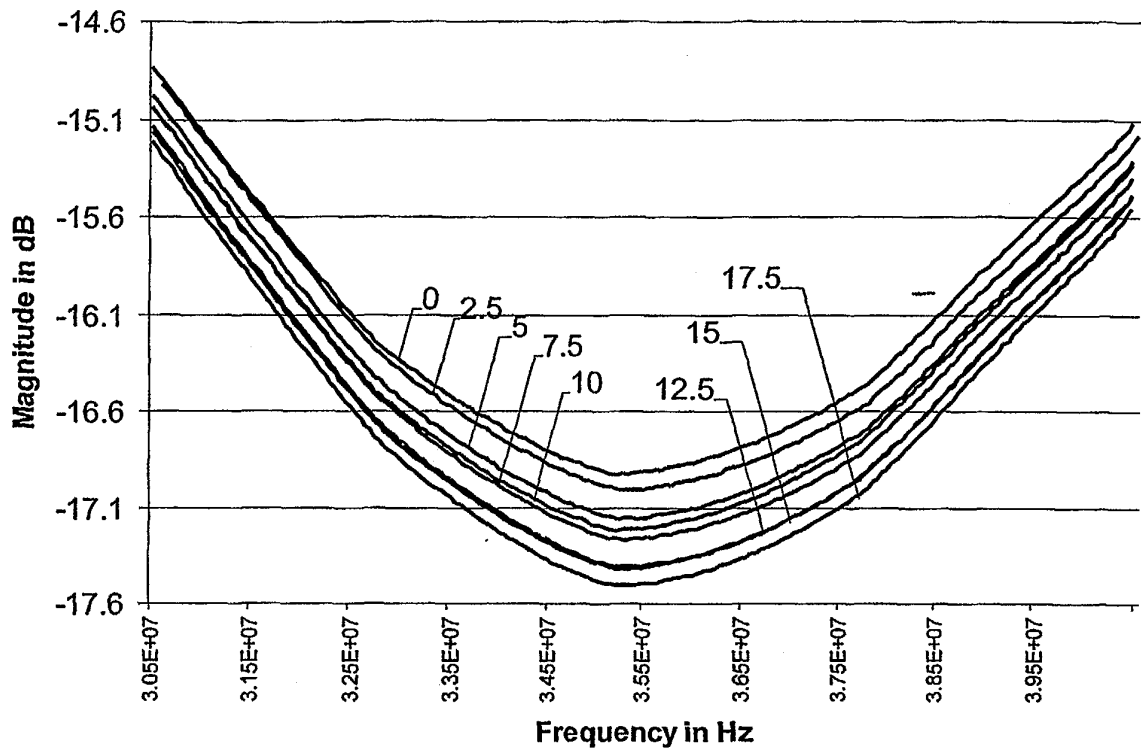


Fig. 8

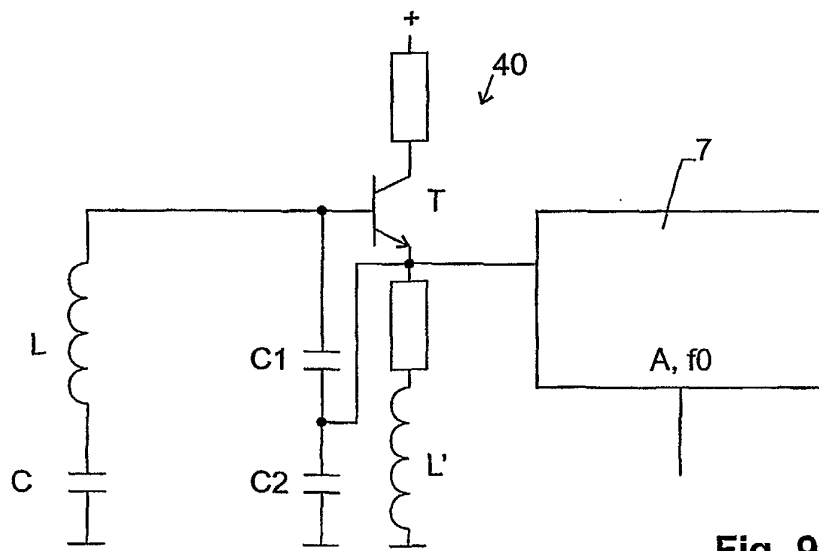


Fig. 9

专利名称(译)	用于确定体液中葡萄糖浓度的装置		
公开(公告)号	EP1299029B1	公开(公告)日	2006-11-22
申请号	EP2001914075	申请日	2001-03-06
[标]申请(专利权)人(译)	潘卓冈医学公司		
申请(专利权)人(译)	PENDRAGON MEDICAL LTD.		
当前申请(专利权)人(译)	SOLIANIS HOLDING AG		
[标]发明人	SCHREPFER THOMAS W CADUFF ANDREAS HIRT ETIENNE SUSSTRUNK HEINZ		
发明人	SCHREPFER, THOMAS, W. CADUFF, ANDREAS HIRT, ETIENNE SÜSSTRUNK, HEINZ		
IPC分类号	A61B5/00 A61B5/05 G01N33/487 G01N22/00 G01N27/22 G01N27/02 A61B5/0408 A61B5/0478 A61B5/0492 A61B5/053 A61B5/145 A61B5/1477		
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其他公开文献	EP1299029A1		
外部链接	Espacenet		

摘要(译)

为了测量体液中物质的浓度，例如血液或组织中的葡萄糖水平，在样本处设置条形电极（18）和环形电极（19）。环形电极（19）与样品直接电接触，而条形电极（18）与样品电绝缘。条形电极（18）平行于臂或腿布置，以获得大的相互作用长度。电极（18,19）在谐振电路中形成电容器。将接近或处于共振频率的MHz范围内的调制电压施加到电极，并测量体液的响应。该设计允许高精度的测量。

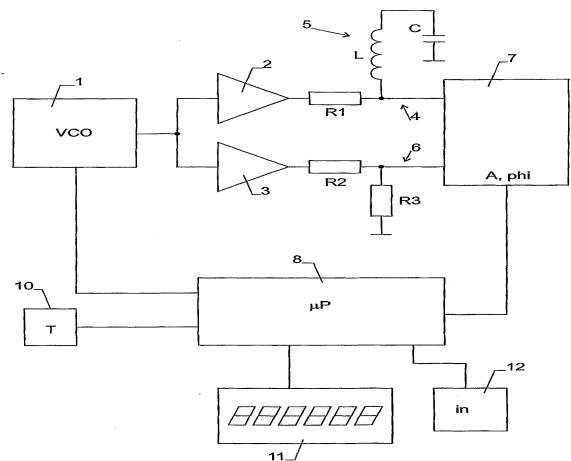


Fig. 1