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(54) **METHOD FOR MEASURING THE MOISTURE CONTENT OF SKIN AND APPARATUS FOR APPLYING THE METHOD**

VERFAHREN ZUR MESSUNG DES FEUCHTIGKEITSGEHALTES DER HAUT UND VORRICHTUNG ZUR ANWENDUNG DES VERFAHRENS

PROCEDE POUR MESURER LA TENEUR EN EAU DE LA PEAU ET APPAREIL POUR L'APPLICATION DU PROCEDE

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Description

[0001] The present invention relates to a method for measuring the moisture content of skin with an apparatus, in which method a probe of the apparatus is placed on the skin for measuring the capacitance of the skin, a wave signal is transmitted into the probe, the capacitance of the probe is measured by comparing the phases of the transmitted and reflected wave. The invention relates also to the apparatus for applying the method.

[0002] The skin consists of three layers, which are, from the surface inwards, stratum corneum, epidermis and dermis. The water content is low in the stratum corneum and high in the dermis. The water content increases gradually from the surface of epidermis to deeper parts of epidermis. The hydration of skin is determined by the properties of the stratum corneum. Dry skin feels rough and will become wrinkled faster than normal skin. People living in dry weather conditions suffer from dry skin more than others and have to apply cosmetic products for moisturizing the skin.

[0003] There exist devices for skin moisture measurement used for the assessment of skin condition. These devices can also be used for evaluating the efficacy of skin moisturizing products. Innumerable devices have been developed for the measurement of parameters sensitive to the moisture of skin. Some of the devices are expensive and complicated to use, but some are relatively cheap and easy to use, e.g. ohmmeters measuring the electric resistance of the skin. However, they have many shortcomings: the distance between the electrodes varies and the devices are sensitive to the electrolyte content of the intercellular space and to the skin contact.

[0004] The principle of the present moisture meters based on the measurement of the skin capacitance is that the skin is a capacitive part of a resonance circuit, either an RC-circuit or a monostable multivibrator. A device containing an RC-circuit is introduced in the US-patent publication 4,860,753. A monostable multivibrator is introduced in the US-patent publication 4,711,244. The skin causes a change in the resonance frequency of the circuit. The resonance frequency that indicates the properties of the skin is for instance calculated with a counter. One weakness of these devices is that the frequency of the measurement circuit depends on the properties of the skin. However, the dielectric properties of the skin change in relation to the frequency due to the influence of different types of dispersions. The dielectric properties determine the capacitance of the skin, which is the reason why a device measuring capacitance is not working reliably when its frequency changes. Another weakness of mentioned devices is that they are sensitive also to the resistivity of the skin, which means that, for example, the relative content of the electrolytes, which is independent of the water content of the stratum corneum, affects the measurement result.

[0005] In GB-patent 2194340 has been described an apparatus for measuring the moisture content of homo-

geneous materials. This is based on well-known measuring techniques where an open-ended coaxial line is placed on the surface of the material under test, and where electromagnetic field penetrates in the depth determined by the geometry of the probe. The frequency of the electromagnetic field is high. The measurements shown in the document are done at 1,000 MHz.

[0006] US-patent 5,086,279 discloses a method for measuring the moisture content of hygroscopic commodity, such as shredded tobacco. The method applies two separate techniques: microwaves and infrared waves.

[0007] DE-patent 196 52 679 C1 discloses a method and equipment for evaluation of the moisture content in porous building material. The method applies dielectrical method to determine moisture content of building material. The measuring frequency is 100-500 MHz

[0008] The object of the present invention is to provide a method and an apparatus, which obviate the shortcomings of the present methods and apparatuses. It is a particular object of the invention to provide a method and an apparatus for measuring the moisture content of skin reliably, and that the resistivity of the skin does not affect the measurement result. It is a further object of the invention to provide an apparatus which is simple in its structure and economical to manufacture and to use.

[0009] The object of the invention is achieved with a method and an apparatus which are characterized by what is described in claims 1 and 6, respectively.

[0010] In the method in accordance with the invention the moisture content of the uppermost layer of the skin is measured with the apparatus, the apparatus operates only at one strictly predetermined frequency and the applied radio frequency is low, approximately 0,2-5 MHz. This comparison can be performed with an appropriate apparatus known as such.

[0011] This method enables accurate measurement of the capacitance of the probe even in the case when the conductance of the probe is much higher than the susceptance of the probe, which occurs always when the probe is in contact with the skin. In this arrangement the measurement result is independent of the conductance of the probe, which in practice means that the measurement result does not depend on the resistivity and further, for example, on the electrolyte content of the skin.

[0012] Operating frequency of the apparatus is an essential parameter of the method in accordance with the invention. The range used in the method is approximately 0,2-5 MHz. With lower frequencies than this, the susceptance of the probe decreases further and the difference between the conductance and the susceptance increases further. On the other hand, with frequencies higher than the specified range the measurement result contains information also from deeper layers of the skin. This is undesirable, because the water content of dermis does not affect what is commonly perceived as the moistness of the skin.

[0013] When this method is used the apparatus operates only at one precisely set frequency, and thus gives

a reliable result of the moisture content of skin. The capacitance of the skin is determined by its dielectric properties and therefore only such capacitance measuring apparatus which operates with a constant frequency, can be a reliable apparatus.

[0014] In a further advantageous application of the invention a wave signal is transmitted to the probe by an oscillator, and placing an attenuator on the signal path between the oscillator and the probe prohibits the reflections of the waves forming the signal between the oscillator and the probe. This means that the reflections do not affect the measurement result.

[0015] In a further application of the invention the phases of the wave transmitted to and reflected from the probe are deviated with a power splitter from each other by 90 degrees in addition to the minor phase difference caused by the probe. The resolution of the phase detector is then optimal and the accuracy of the measurement is better than when using a normal zero-degree power splitter.

[0016] In an additional application the phases of the wave transmitted to and reflected from the probe are compared by a phase detector. The phase detector is dependable and reliable but in other applications other devices can be used for this purpose.

[0017] Furthermore, in an advantageous additional application the propagating waves are amplified in the phase detector inputs so that the phase detector operates in a saturated state. Only then the phase detector or a similar device measures merely the phase shift of the incoming signals.

[0018] An apparatus in accordance with the invention comprises a device, preferably a phase detector, into the input of which the wave formed by the signal reflected from the probe is arranged to be led, and a wave forming the signal is arranged to be led into the other input of the device, then the capacitance can be measured by comparing the wave phases.

[0019] The invention will now be described in greater detail with reference to the accompanying drawings, where

Fig. 1 shows the general view of an apparatus in accordance with the invention seen from above,

Fig. 2 shows a block diagram showing the operation of the apparatus,

Fig. 3 shows the longitudinal view of a probe, and

Fig 4 shows the cross-section A-A of figure 3.

[0020] Figure 1 shows the case 10 of the apparatus and attached to it a display unit 11, a press button 12, an indicator light 13, a set of small LED lights 14 and a reset button 15. The shape of the case and the attached lights etc. can vary in different applications. From the case 10 outgoes a coaxial cable 16, in which a probe 17 is attached.

[0021] Figure 2 shows an oscillator 20, an attenuator 21, a 90-degree power splitter 22, a directional coupler 23, two amplifiers 24 and 25, a probe 17, a phase detector

26, a low pass filter 27 and a digital electronic unit 28. A display unit 11, a press button 12, an indicator light 13, a set of LED lights 14 and a reset button 15 are connected to this electronic unit.

[0022] Figure 3 shows a probe 17 comprising a brass-made outer electrode 31, a brass-made inner electrode 33 and a Teflon part 32. The inner electrode 33 is round and the ring-shaped outer electrode 31 surrounds it so that the Teflon part 32 is between them. The inner conductor 35 of the coaxial cable 16 is soldered in a small hole 34 on top of the inner electrode 33. Besides the inner conductor 35 the coaxial cable 16 comprises an outer conductor 37, dielectric material 36 between them and a sleeve 38. A separate clamping part 39 is pressed against the outer electrode 31 so that outer conductor 37 of the coaxial cable 16 is compressed between them, thus being in electric contact with the outer electrode 31. While the outer conductor 37 is pressed against the outer electrode 31, two wedge-like pieces 40 cause tight pression of the coaxial cable 16 against the clamping part 39. All parts in figure 3, apart from the wedge-like pieces 40, are rotationally symmetric.

[0023] Figure 4 shows the cross section A-A of the probe similar to figure 3. The graph illustrates particularly the setting of the two wedge-like pieces 40.

[0024] The device is arranged to measure the phase coefficient of the probe's reflection coefficient at a single low radio frequency (which is approximately 0,2-5 MHz).

[0025] The radio frequency section of the apparatus, which comprises the parts 20-26 and the probe 17 in figure 2, is radio technically arranged. Practically this means that the lines between the components are microstrip lines with specific wave impedance, e.g. 50 ohm. Thus waves propagating in opposite directions can travel in the single signal path. In this context a signal means such a propagating wave. The operation of the high frequency components is not at all affected by the fact that the dimensions of the circuit are small compared with the wavelength.

[0026] The apparatus operates so that the outgoing sinusoidal signal from the oscillator 20 is led through the directional coupler 23 into the probe 17. The reflected signal from the probe 17 is connected to one input of the phase detector 26 through the directional coupler 23. A signal directly from the oscillator 20 through the power splitter 22 is led to the other input. The output of the phase detector 26 is proportional to the phase difference, which again is dependent only on the capacitance of the probe 17. Thus the apparatus operates with one single frequency, and the result is dependent only on the dielectric properties of the skin, not on conductivity.

[0027] The oscillator 20 of the apparatus is operating always when the apparatus is switched on. So there is a constant voltage in the output of the phase detector 26 and the subsequent low pass filter 27. The apparatus is used so that the press button 12 is pressed at the same time as the probe 17 is pressed on the skin. The measurement starts at this moment and the indicator light 13

is on during the measurement. The timer circuit in the digital electronic unit 28 activates the measurement for a preselected standard time, after which the indicator light 13 is switched off. The apparatus contains also a buzzer (not shown in the figures) inside the case 10 and it gives a sound indicating that the measurement is completed. After the measurement a reading appears at the display 11. The reading is proportional to the capacitance of the probe 17 and the moisture content of skin. The apparatus ends the measurement automatically when the measurement time is over and after that the reading shown at the display 11 is no longer affected by the skin contact of the probe 17. The LED indicators 14 operate completely in accordance with the display 11, thus the moisture content of skin can be read after the measurement merely by the amount of lights 14 switched on. The lights 14 have different colours: in case of dry skin only yellow lights are on, in case of normal skin besides yellow also green lights are on, and in case of moist skin besides the above mentioned lights also blue lights are on. Pressing the reset button 15 resets the display 11 and switches off the lights 14.

[0028] It is necessary to standardize the measurement time to obtain reliable measurement result, because the output voltage of the low pass filter 27 changes slowly but constantly when the probe 17 touches the skin. This is caused by the increase of moisture content of skin under the probe 17, when the skin contact of the probe 17 prevents the evaporation of the water vapour passing the skin. An appropriate measurement time is 5-20 seconds.

[0029] An optional feature of the radio frequency unit of the apparatus, containing the parts of the block diagram in figure 2 apart from the digital electronic unit 28, is that signal voltage in both inputs of the phase detector 26 is so high that the detector operates in a saturated state. Only then the phase detector 26 measures merely the phase shift of incoming signals. This phase shift is proportional to the capacitance of the probe 17, which again is proportional to the dielectric constant of the filling of the capacitor (in this case the surface of the skin). The dielectric constant depends on the moisture content of skin surface. Thus the measurement result is not affected e.g. by the electrolyte content, unlike in devices which are sensitive to the conductivity of the skin.

[0030] Another optional feature of the radio frequency unit is the attenuator 21 between the oscillator 20 and the power splitter 22. Its purpose is to prevent the reflected signal from the probe 17 from entering a wrong signal path, to the input of the amplifier 24. Due to the attenuator the reflected signal from the probe has to travel twice through the attenuator 21 when travelling to the input of the amplifier 24 after being reflected. If the attenuator 21 is e.g. 6 dB, the total attenuation with this signal is 12 dB, which is sufficient.

[0031] The present invention is not restricted to the described advantageous application, but it can be embodied in other forms within the limits of the inventional

idea defined by the claims.

Claims

1. Method for measuring the moisture content of skin in which method a probe (17) of an apparatus is placed on the skin for measuring the capacitance of the skin, a wave signal is transmitted into the probe, the capacitance of the probe (17) is measured by comparing the phases of the direct and reflected wave, wherein the apparatus operates only at one strictly predetermined frequency which is low, 0,2-5 MHz, so that the moisture content of the uppermost layer of the skin is measured
2. Method according to claim 1, **characterized in that** a wave signal is transmitted to the probe (17) from an oscillator (20) and that reflections of the waves forming the signal between the oscillator and the probe are prohibited by placing an attenuator (21) on the signal path between the oscillator and the probe.
3. Method according to claim 1 or 2, **characterized in that** the phases of the wave transmitted to and reflected from the probe are deviated with a power splitter (22) from each other by 90 degrees in addition to the minor phase difference caused by the probe.
4. Method according to any of claims 1-3, **characterized in that** the phases of the wave transmitted to and reflected from the probe are compared with a phase detector (26).
5. Method according to claim 4, **characterized in that** the propagating waves are amplified in the phase detector (26) inputs so that the phase detector operates in a saturated state.
6. Apparatus for measuring the moisture content of skin, which apparatus comprises a probe (17) to be placed on the skin and devices (20-28) connected to the probe for transmitting and transferring a wave signal to the probe and for transferring and analysing the signal reflected from the probe and for measuring the capacitance of the skin, and a phase detector (26), into the input of which the wave formed by the signal reflected from the probe is arranged to be led, and into the other input of which a wave forming a signal and transmitted to the probe is arranged to be led, at which the capacitance can be measured by comparing the phases of the wave, wherein the apparatus is arranged to operate only at one constant frequency which is 0,2-5 MHz.
7. Apparatus according to claim 6, **characterized in that** there is an attenuator (21) between an oscillator

(20) and a power splitter (22).

Patentansprüche

1. Verfahren zum Messen des Feuchtigkeitsgehalts der Haut, wobei eine Sonde (17) einer Vorrichtung auf der Haut angeordnet wird, um die Kapazität der Haut zu messen, ein Wellensignal in die Sonde gesendet wird und die Kapazität der Sonde (17) gemessen wird, indem die Phasen der direkten und der reflektierten Welle verglichen werden, wobei die Vorrichtung nur bei einer streng vorgegebenen niedrigen Frequenz von 0,2 bis 5 MHz arbeitet, so dass der Feuchtigkeitsgehalt der obersten Schicht der Haut gemessen wird.
2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** ein Wellensignal von einem Oszillator (20) zu der Sonde (17) gesendet wird und dass Reflexionen der Wellen, die das Signal zwischen dem Oszillator und der Sonde bilden, verhindert werden, indem auf dem Signalweg zwischen dem Oszillator und der Sonde ein Dämpfungsglied (21) angeordnet wird.
3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Phasen der Welle, die an die Sonde gesendet und von dort reflektiert wird, mit einem Leistungsverteiler (22) zusätzlich zu der geringen Phasendifferenz, die von der Sonde verursacht wird, zueinander um 90 Grad verschoben werden.
4. Verfahren nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** die Phasen der Welle, die an die Sonde gesendet und von dort reflektiert wird, mit einem Phasendetektor (26) verglichen werden.
5. Verfahren nach Anspruch 4, **dadurch gekennzeichnet, dass** die sich ausbreitenden Wellen in den Eingängen des Phasendetektors (26) verstärkt werden, derart, dass der Phasendetektor in einem Sättigungszustand arbeitet.
6. Vorrichtung zum Messen der Feuchtigkeit der Haut, wobei die Vorrichtung eine Sonde (17), welche auf der Haut anzuordnen ist, und Vorrichtungen (20 bis 28), die mit der Sonde verbunden sind, um ein Wellensignal zu senden und zu der Sonde zu übertragen und um das von der Sonde reflektierte Signal zu übertragen und zu analysieren und um die Kapazität der Haut zu messen, und einen Phasendetektor (26) umfasst, in dessen Eingang die Welle geleitet wird, die von dem Signal gebildet wird, das von der Sonde reflektiert wird, und in dessen anderen Eingang eine Welle geleitet wird, die ein Signal bildet und zu der

Sonde geleitet wird, in welchem durch Vergleichen der Phasen der Welle die Kapazität gemessen werden kann, wobei die Vorrichtung so eingerichtet ist, dass sie nur bei einer konstanten Frequenz arbeitet, die 0,2 bis 5 MHz beträgt.

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7. Vorrichtung nach Anspruch 6, **dadurch gekennzeichnet, dass** zwischen einem Oszillator (20) und einem Leistungsverteiler (22) ein Dämpfungsglied (21) angeordnet ist.

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Revendications

1. Procédé de mesure de la teneur en humidité de la peau, procédé dans lequel une sonde (17) d'un appareil est placée sur la peau afin de mesurer la capacitance de la peau, un signal d'onde est transmis à l'intérieur de la sonde, la capacitance de la sonde (17) est mesurée en comparant les phases de l'onde directe et réfléchie, dans lequel l'appareil fonctionne seulement à une fréquence strictement prédéterminée, laquelle est basse, 0,2-5 MHz, de telle sorte que la teneur en humidité de la couche la plus supérieure de la peau soit mesurée.
2. Procédé selon la revendication 1, **caractérisé en ce que** un signal d'onde est transmis à la sonde (17) à partir d'un oscillateur (20) et que des réflexions de l'onde formant le signal entre l'oscillateur et la sonde sont inhibées en plaçant un atténuateur (21) sur le trajet du signal entre l'oscillateur et la sonde.
3. Procédé selon la revendication 1 ou 2, **caractérisé en ce que** les phases de l'onde transmise à et réfléchie à partir de la sonde sont déviées avec un diviseur de puissance (22) l'une de l'autre de 90 degrés en plus de la différence de phase mineure provoquée par la sonde.
4. Procédé selon une quelconque des revendications 1 à 3, **caractérisé en ce que** les phases de l'onde transmise à et réfléchie à partir de l'échantillon sont comparées avec un détecteur de phase (26).
5. Procédé selon la revendication 4, **caractérisé en ce que** les ondes se propageant sont amplifiées dans les entrées du détecteur de phase (26) de telle sorte que le détecteur de phase fonctionne en un mode saturé.
6. Appareil de mesure de la teneur en humidité de la peau, lequel appareil comprend une sonde (17) à placer sur la peau et des dispositifs (20-28) connectés à la sonde pour transmettre et transférer un signal d'onde à la sonde et pour transférer et analyser le signal réfléchi à partir de la sonde et pour mesurer la capacitance de la peau, et un détecteur de phase

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(26), dans l'entrée duquel l'onde formée par le signal réfléchi à partir de la sonde est agencée afin d'être guidée, et dans l'autre entrée duquel une onde formant un signal et transmise à la sonde est agencée afin d'être guidée, au niveau duquel la capacitance peut être mesurée en comparant les phases de l'onde, dans lequel l'appareil est conçu afin de fonctionner seulement à une fréquence constante, laquelle est 0,2-5 MHz.

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7. Appareil selon la revendication 6, **caractérisé en ce que** un atténuateur (21) se trouve entre un oscillateur (20) et un diviseur de puissance (22).

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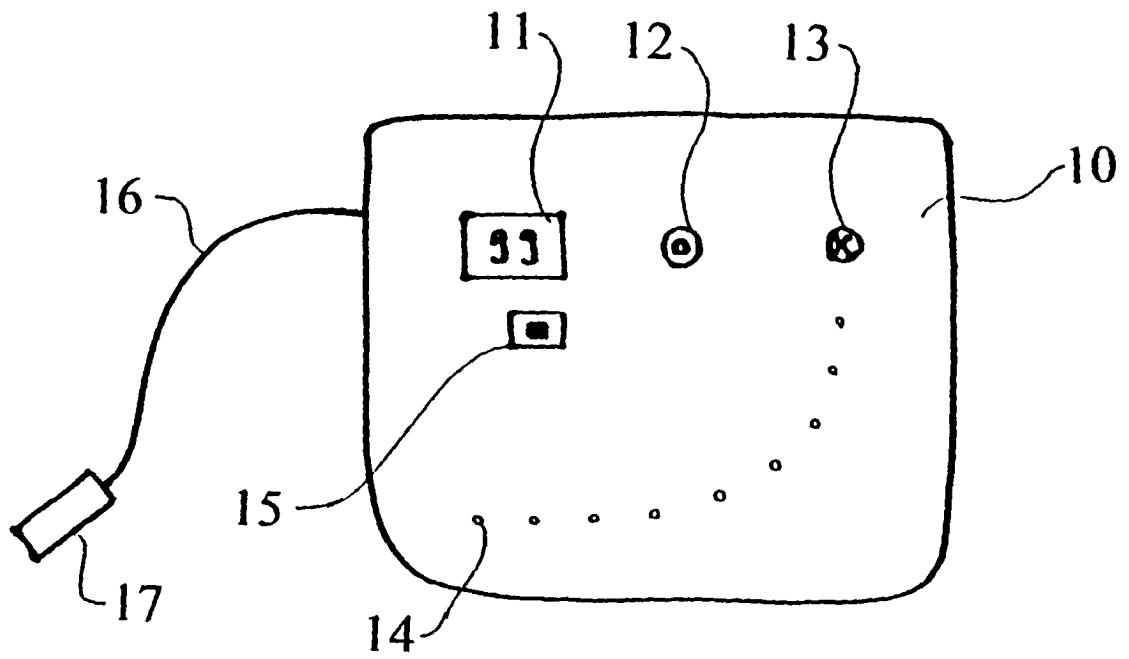


FIG. 1

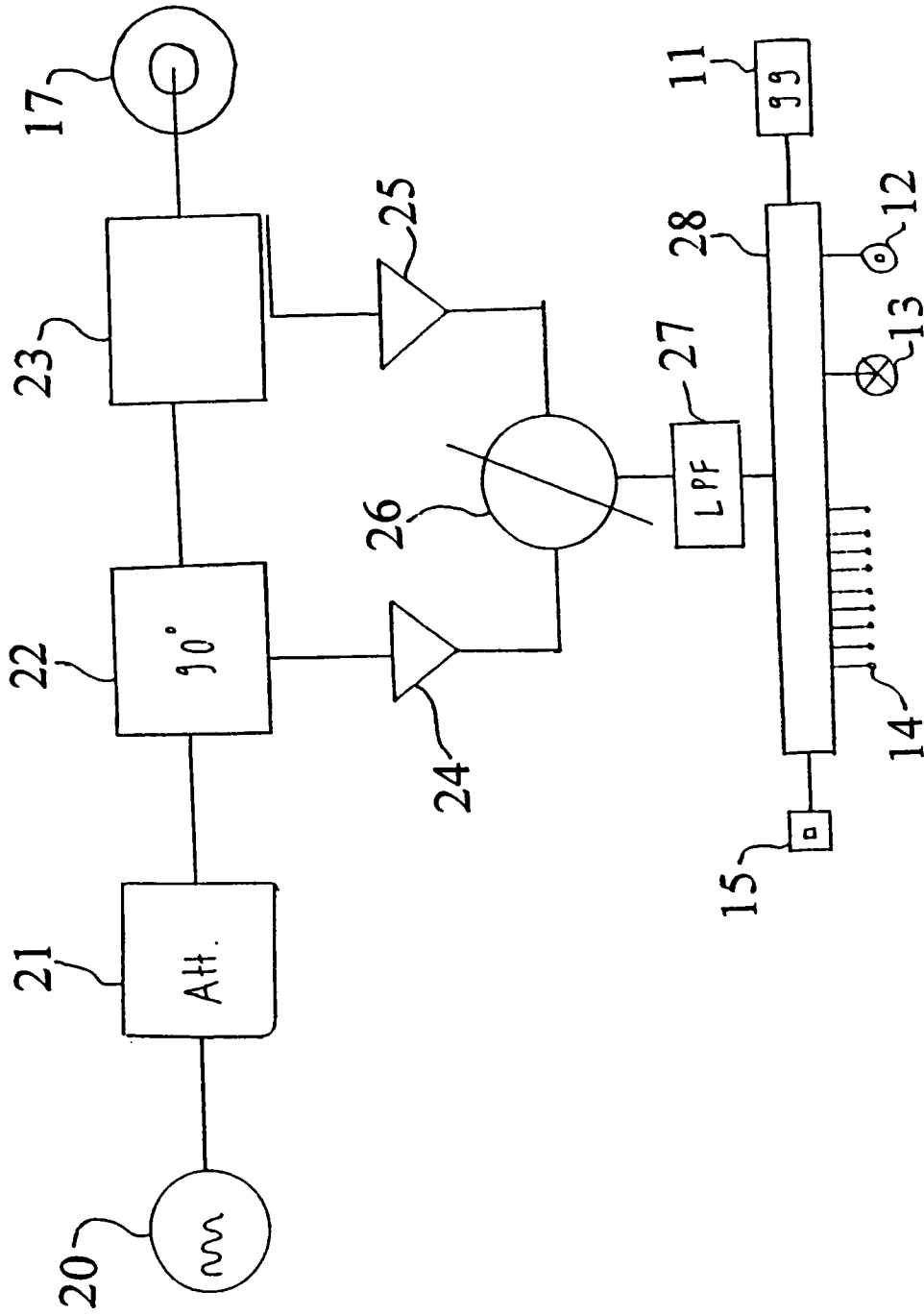
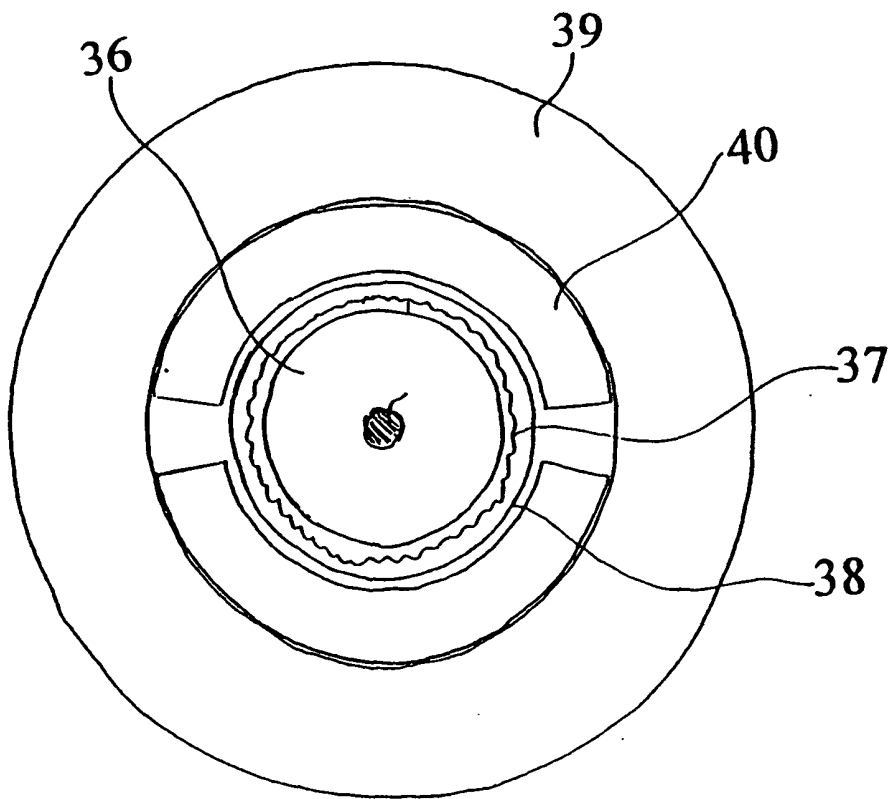
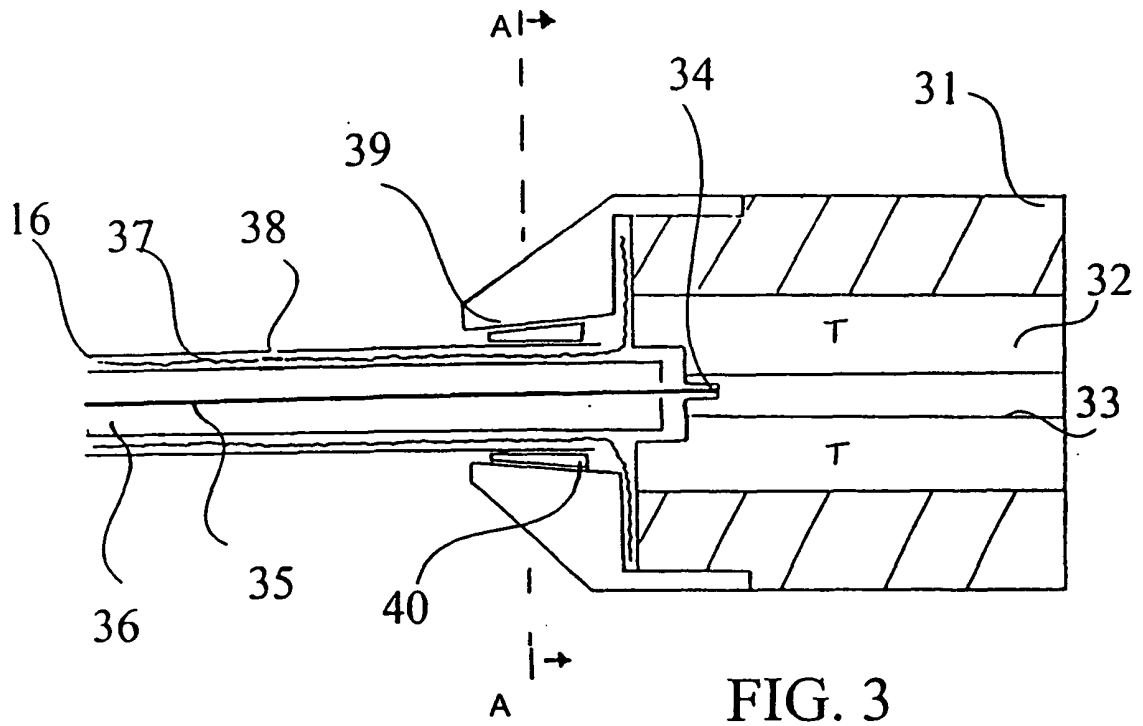


FIG. 2



REFERENCES CITED IN THE DESCRIPTION

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专利名称(译)	测量皮肤水分含量的方法和应用该方法的装置		
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其他公开文献	EP1238268A1		
外部链接	Espacenet		

摘要(译)

本发明涉及一种测量皮肤水分含量的方法，其中探针（17）放置在皮肤上以测量皮肤的电容。本发明还涉及一种应用该方法的装置，该装置包括探头（17）和连接到探头的装置（20-28），用于传输，传输和分析信号。在根据本发明的方法中，波信号被发送到探测器中，探测器（17）的电容通过比较发射波和反射波的波相来测量，并且施加的射频低，大约为0，2-5 MHz。根据本发明的装置包括一个装置（26），在其输入端，由探头反射的信号形成的波被设置为被引导，并且在另一个输入端，一个波形成信号并传输到探针被布置成被引导，其中可以通过比较波相来测量电容。

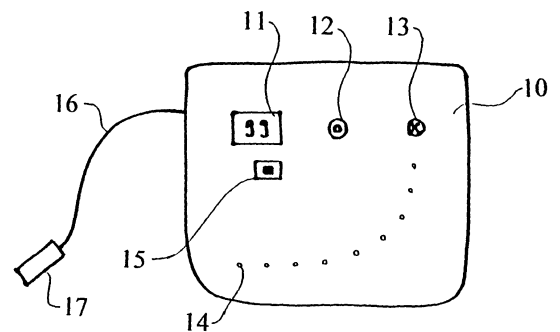


FIG. 1