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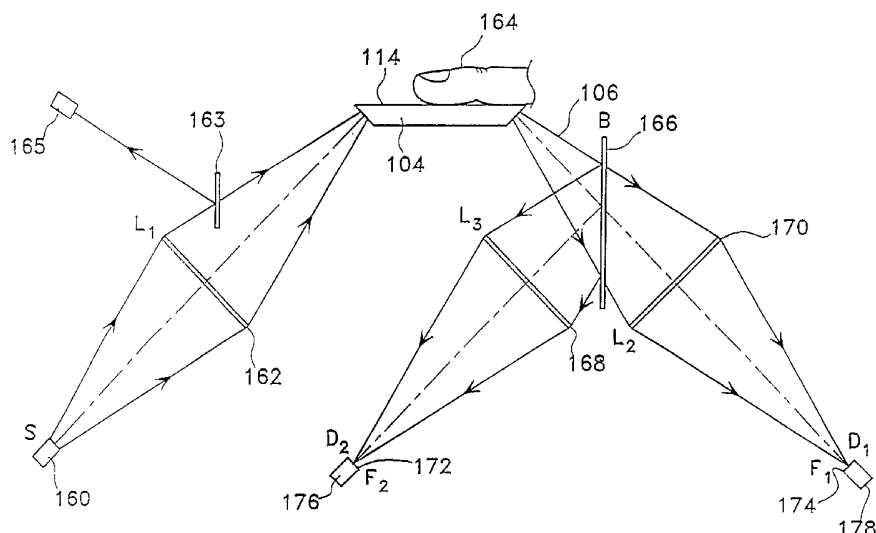
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(54) Title: CLEANING KIT FOR INFRARED GLUCOSE MEASUREMENT SYSTEM



(57) Abstract: This invention involves a non-invasive glucose measurement device for determining blood glucose levels in the human body using infrared spectroscopy. The device is typically used on a fingertip and compares two specific regions of a measured infrared spectrum to determine the blood glucose level of the user. The invention further provides a cleaning kit for cleaning the skin exterior prior to taking a glucose measurement. The kit typically includes a glucose solvent and a solvent for removing the glucose solvent. The solvents have IR spectra, which have no peaks between about 8.25 micrometers and about 8.75 micrometers and between about 9.50 micrometers and about 10.00 micrometers. The solvents may be provided on absorbent wipes (300, 304, 310, 312, 314, 316), and the wipes or their packaging (302, 306) may have features that prevent more than a single use. Similarly, the wipes or their packaging may have special features (326, 334) requiring their presence in order to activate the device.



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

## CLEANING KIT FOR INFRADED GLUCOSE MEASUREMENT SYSTEM

**Related Applications**

[0001] This is a continuation-in-part of U.S. Patent Application Serial No. 10/131,562, filed April 23, 2002, which is a continuation of U.S. Patent Application Serial No. 09/547,433, filed April 12, 2000, which is a continuation-in-part of PCT/US99/23823, filed October 12, 1999, designating the U.S., which in turn derives benefit from U.S. Patent Application Serial No. 60/103,883, to Berman and Roe, filed October 13, 1998, each of which is incorporated herein by reference in its entirety.

**Field of the Invention**

[0002] This invention involves a non-invasive glucose measurement device and a process for determining blood glucose level in the human body using the device. In typical operation, the glucose measurement device is self-normalizing in that it does not employ an independent reference sample in its operation. The inventive device uses attenuated total reflection (ATR) infrared spectroscopy. Preferably, the device is used on a fingertip or other part of the body. Although the inventive procedure preferably compares two specific regions of a measured mid-infrared spectrum to determine the blood glucose level of the user. Clearly, this device is especially suitable for monitoring glucose levels in the human body, and is especially beneficial to users having diabetes mellitus. The device and procedure may be used for other materials which exhibit unique mid-IR signatures of the type described below and that are found in appropriate regions of the outer skin. A cleaning kit and related procedure for preparation of the skin surface is also included.

**Background of the Invention**

[0003] The American Diabetes Association reports that approximately 6% of the population in the United States, a group of 16 million people, has diabetes, and that it is growing at a rate of 12-15% per annum. The Association further reports that diabetes is the seventh leading cause of death in the United States, contributing to nearly 200,000 deaths per year. Diabetes is a life-threatening disease with broad complications, which include blindness, kidney disease, nerve disease, and heart disease, amputation and stroke. Diabetes is believed

to be the leading cause of new cases of blindness in individuals in the range of ages between 20 and 74; from 12,000-24,000 people per year lose their sight because of diabetes. Diabetes is the leading cause of end-stage renal disease, accounting for nearly 40% of new cases. Nearly 60-70% of people with diabetes have mild to severe forms of diabetic nerve damage which, in severe forms, can lead to lower limb amputations. People with diabetes are 2-4 times more likely to have heart disease and to suffer strokes.

**[0004]** Diabetes is a disease in which the body does not produce or properly use insulin, a hormone needed to convert sugar, starches, and the like into energy. Although the cause of diabetes is not completely understood, genetics, environmental factors, and viral causes have been partially identified.

**[0005]** There are two major types of diabetes: Type I and Type II. Type I diabetes (also known as juvenile diabetes) is caused by an autoimmune process destroying the beta cells that secrete the insulin in the pancreas. Type I diabetes most often occurs in young adults and children. People with Type I diabetes must take daily insulin injections to stay alive.

**[0006]** Type II diabetes is a metabolic disorder resulting from the body's inability to make enough, or properly to use, insulin. Type II diabetes accounts for 90-95% of diabetes. In the United States, Type II diabetes is nearing epidemic proportions, principally due to an increased number of older Americans and a greater prevalence of obesity and a sedentary lifestyle.

**[0007]** Insulin, in simple terms, is the hormone that unlocks the cells of the body, allowing glucose to enter those cells and feed them. Since, in diabetics, glucose cannot enter the cells, the glucose builds up in the blood and the body's cells literally starve to death.

**[0008]** Diabetics having Type I diabetes typically are required to self-administer insulin using, e.g., a syringe or a pin with needle and cartridge. Continuous subcutaneous insulin infusion via implanted pumps is also available. Insulin itself is typically obtained from pork pancreas or is made chemically identical to human insulin by recombinant DNA technology or by chemical modification of pork insulin. Although there are a variety of different insulins for rapid-, short-, intermediate-, and long-acting forms that may be used variously, separately or mixed in the same syringe, use of insulin for treatment of diabetes is not to be ignored.

**[0009]** It is highly recommended by the medical profession that insulin-using patients practice self-monitoring of blood glucose (SMBG). Based upon the level of glucose in the

blood, individuals may make insulin dosage adjustments before injection. Adjustments are necessary since blood glucose levels vary day to day for a variety of reasons, e.g., exercise, stress, rates of food absorption, types of food, hormonal changes (pregnancy, puberty, etc.) and the like. Despite the importance of SMBG, several studies have found that the proportion of individuals who self-monitor at least once a day significantly declines with age. This decrease is likely due simply to the fact that the typical, most widely used, method of SMBG involves obtaining blood from a finger stick. Many patients consider obtaining blood to be significantly more painful than the self-administration of insulin.

[0010] There is a desire for a less invasive method of glucose measurement. Methods exist or are being developed for a minimally invasive glucose monitoring, which use body fluids other than blood (e.g., sweat or saliva), subcutaneous tissue, or blood measured less invasively.

[0011] Subcutaneous glucose measurements seem to lag only a few minutes behind directly measured blood glucose and may actually be a better measurement of the critical values of glucose concentrations in the brain, muscle, and in other tissue. Glucose may be measured by non-invasive or minimally-invasive techniques, such as those making the skin or mucous membranes permeable to glucose or those placing a reporter molecule in the subcutaneous tissue. Needle-type sensors have been improved in accuracy, size, and stability and may be placed in the subcutaneous tissue or peripheral veins to monitor blood glucose with small instruments. See, "*An Overview of Minimally Invasive Technologies*", Clin. Chem. 1992 Sep.; 38(9):1596-1600.

[0012] Truly simple, non-invasive methods of measuring glucose are not commercially available.

[0013] U.S. Patent No. 4,169,676 to Kaiser, shows a method for the use of ATR glucose measurement by placing the ATR plate directly against the skin and especially against the tongue. The procedure and device shown there uses a laser and determines the content of glucose in a specific living tissue sample by comparing the IR absorption of the measured material against the absorption of IR in a control solution by use of a reference prism. See, column 5, lines 31 et seq.

[0014] Swiss Patent No. 612,271, to Dr. Nils Kaiser, appears to be the Swiss patent corresponding to U.S. Patent No. 4,169,676.

**[0015]** U.S. Patent No. 4,655,255, to Dähne et al., describes an apparatus for non-invasively measuring the level of glucose in a blood stream or tissues of patients suspected to have diabetes. The method is photometric and uses light in the near-infrared region. Specifically, the procedure uses light in the 1,000 to 2,500 nm range. Dähne's device is jointly made up to two main sections, a light source and a detector section. They may be situated about a body part such as a finger. The desired near-infrared light is achieved by use of filters. The detector section is made up of a light-collecting integrating sphere or half-sphere leading to a means for detecting wavelengths in the near-infrared region. Dähne et al. goes to some lengths teaching away from the use of light in the infrared range having a wavelength greater than about 2.5 micrometers since those wavelengths are strongly absorbed by water and have very little penetration capability into living tissues containing glucose. That light is said not to be "readily useable to analyze body tissue volumes at depths exceeding a few microns or tens of microns." Further, Dähne et al. specifically indicates that an ATR method which tries to circumvent the adverse consequences of the heat effect by using a total internal reflection technique is able only to investigate to tissue depths not exceeding about 10 micrometers, a depth which is considered by Dähne et al. to be "insufficient to obtain reliable glucose determination information."

**[0016]** U.S. Patent No. 5,028,787, to Rosenthal et al., describes a non-invasive glucose monitoring device using near-infrared light. The light is passed into the body in such a way that it passes through some blood-containing region. The so-transmitted or reflected light is then detected using an optical detector. The near-infrared light sources are preferably infrared emitting diodes (IRED). U.S. Patent No. 5,086,229 is a continuation in part of U.S. Patent No. 5,028,787.

**[0017]** U.S. Patent No. 5,178,142, to Harjunmaa et al, teaches the use of a stabilized near-infrared radiation beam containing two alternating wavelengths in a device to determine a concentration of glucose or other constituents in a human or animal body. Interestingly, one of the transmitted IR signals is zeroed by variously tuning one of the wavelengths, changing the extracellular to intracellular fluid ratio of the tissue by varying the mechanical pressure on a tissue. Or, the ratio may be allowed to change as a result of natural pulsation, e.g., by heart rate. The alternating component of the transmitted beam is measured in the "change to fluid ratio" state. The amplitude of the varying alternating signal is detected and is said to represent

glucose concentration or is taken to represent the difference in glucose concentration from a preset reference concentration.

[0018] U.S. Patent No. 5,179,951 and its divisional, U.S. Patent No. 5,115,133, to Knudson, show the application of infrared light for measuring the level of blood glucose in blood vessels in the tympanic membrane. The detected signal is detected, amplified, decoded, and, using a microprocessor, provided to a display device. The infrared detector (No. 30 in the drawings) is said simply to be a "photo diode and distance signal detector" which preferably includes "means for detecting the temperature of the volume in the ear between the detector and the ear's tympanic membrane." Little else is said about the constituency of that detector.

[0019] U.S. Patent No. 5,433,197, to Stark, describes a non-invasive glucose sensor. The sensor operates in the following fashion. A near-infrared radiation is passed into the eye through the cornea and the aqueous humor, reflected from the iris or the lens surface, and then passed out through the aqueous humor and cornea. The reflected radiation is collected and detected by a near-infrared sensor which measures the reflected energy in one or more specific wavelength bands. Comparison of the reflected energy with the source energy is said to provide a measure of the spectral absorption by the eye components. In particular, it is said that the level of glucose in the aqueous humor is a function of the level of glucose in the blood. It is said in Stark that the measured glucose concentration in the aqueous humor tracks that of the blood by a fairly short time, e.g., about 10 minutes. The detector used is preferably a photodiode detector of silicon or InGaAs. The infrared source is said preferably to be an LED, with a refraction grating so that the light of a narrow wavelength band, typically 10 to 20 nanometers wide, passes through the exit slit. The light is in the near-infrared range. The use of infrared regions below 1400 nanometers and in the region between 1550 and 1750 nanometers is suggested.

[0020] U.S. Patent No. 5,267,152, to Yang et al., shows a non-invasive method and device for measuring glucose concentration. The method and apparatus uses near-infrared radiation, specifically with a wavelength of 1.3 micrometers to 1.8 micrometers from a semiconductor diode laser. The procedure is said to be that the light is then transmitted down through the skin to the blood vessel where light interacts with various components of the blood and is then diffusively reflected by the blood back through the skin for measurement.

[0021] Similarly, U.S. Patent No. 5,313,941, to Braig et al., suggests a procedure and apparatus for monitoring glucose or ethanol and other blood constituents in a non-invasive

fashion. The measurements are made by monitoring absorption of certain constituents in the longer infrared wavelength region. The long wavelength infrared energy is passed through the finger or other vascularized appendage. The infrared light passing through the finger is measured. The infrared source is pulsed to prevent burning or other patient discomfort. The bursts are also synchronized with the heartbeat so that only two pulses of infrared light are sent through the finger per heartbeat. The detected signals are then analyzed for glucose and other blood constituent information.

[0022] U.S. Patent No. 5,398, 681, to Kuperschmidt, shows a device which is said to be a pocket-type apparatus for measurement of blood glucose using a polarized-modulated laser beam. The laser light is introduced into a finger or ear lobe and the phase difference between a reference signal and the measurement signal is measured and processed to formulate and calculate a blood glucose concentration which is then displayed.

[0023] U.S. Patent No. 6,001,067 shows an implantable device suitable for glucose monitoring. It utilizes a membrane which is in contact with a thin electrolyte phase, which in turn is covered by an enzyme-containing membrane, e.g., glucose oxidase in a polymer system. Sensors are positioned in such a way that they measure the electro-chemical reaction of the glucose within the membranes. That information is then passed to the desired source.

[0024] None of the cited prior art suggests the device and method of using this device described and claimed below.

## SUMMARY OF THE INVENTION

[0025] This invention is a glucose level measurement device utilizing IR-ATR spectroscopy and a method of using the device. The inventive device itself is preferably made up of four parts:

- a.) an IR source for emitting an IR beam into the ATR plate,
  - b.) the ATR plate against which the sampled human skin surface is pressed, and
  - c.) at least two IR sensors for simultaneously measuring absorbance of two specific regions of the IR spectrum, i.e., a "referencing wavelength" and a "measuring wavelength."
- The IR source must emit IR radiation at least in the region of the referencing wavelength and the measuring wavelength. For glucose, the referencing wavelength is between about 8.25 micrometers and about 8.75 micrometers and the measuring wavelength is between about 9.50



micrometers and about 10.00 micrometers. The IR sources may be broadband IR sources, non-laser sources, or two or more selected wavelength lasers.

[0026] Other analyte materials which have both referencing wavelengths and measuring wavelengths as are described in more detail below and that preferably are found in the outer regions of the skin may be measured using the inventive devices and procedures described herein.

[0027] The ATR plate is configured to permit multiple internal reflections, perhaps 3-15 internal reflections or more, against said measurement surface prior to measurement by the IR sensors. Typically the IR beam emitted from the ATR plate is split for the IR sensors using a beam splitter or equivalent optical device. Once the split beams are measured by the IR sensors, the resulting signals are then transformed using analog comparators or digital computers into readable or displayable values.

[0028] It is usually important that the device have some accommodation for holding the body part against the ATR plate, preferably at some value which is constant and above a selected minimum pressure.

[0029] The method for determining the blood glucose level, using the glucose measurement device, comprises the steps of.

- a.) contacting a selected skin surface with the ATR plate,
- b.) irradiating that human skin surface with an IR beam having components at least in the region of the referencing wavelength and the measuring wavelength, and
- c.) detecting and quantifying those referencing and said measuring wavelength components in that reflected IR beam.

[0030] The procedure ideally includes the further steps of maintaining the skin surface on said ATR plate at an adequate pressure which is both constant and above a selected minimum pressure and, desirably cleaning the skin surface before measurement. A step of actually measuring the pressure may also be included.

[0031] A normalizing step practiced by simultaneously detecting and quantifying the referencing and measuring wavelength components prior to contacting the skin surface is also desirable.

[0032] A final portion of this invention includes cleaning materials for cleaning the skin exterior prior to testing. The cleaning materials do not have significant IR wavelength peaks between about 8.25 micrometers and about 8.75 micrometers or between about 9.50

micrometers and about 10.00 micrometers. The cleaning materials may comprise a glucose solvent and a solvent for removing the glucose solvent. The solvents may optionally be absorbed in wipes and packaged in any number of ways.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

[0033] Figures 1A, 1B, 1C, and 1D show a side view of various ATR plates and their general operation.

[0034] Figure 2 shows an IR spectrum of d-glucose.

[0035] Figure 3 shows a schematicized layout of the optics of the inventive device.

[0036] Figure 4 shows a packaged variation of the inventive glucose measuring device.

[0037] Figure 5 shows a graph of pressure on the ATR crystal vs. IR value.

[0038] Figure 6 shows a graph correlating glucose levels measured using a specific variation of the device with glucose levels in the blood determined using a commercial device.

[0039] Figure 7 shows a graph using a transmittance trough as the referencing wavelength.

[0040] Figure 8 shows a pair of glucose IR curves (taken before and after eating) for an individual having diabetes made using the inventive glucose measuring device.

[0041] Figure 9 shows a graph comparing glucose levels in a non-diabetic individual (taken before and after eating) made using the inventive glucose measuring device and direct blood measurement. This graph shows that the inventive procedure tracks blood glucose levels with minimum time lag.

[0042] Figures 10A-10C show packaged wipes for cleaning the skin exterior prior to taking a glucose measurement.

[0043] Figures 11A-11B show variations of wipes having more than one solvent therein.

[0044] Figures 12A-12B show the wipes of the present invention packaged in suitable containers.

[0045] Figures 13A-13B show a multiplicity of wipes having perforations between each individual wipe.

[0046] Figures 14A-14B show how a barcode and a magnetic component respectively, may be used with the packaging of the wipe.

[0047] Figure 15 shows how a barcode scanner and additional mechanisms may be incorporated into the device.

[0048] Figure 16 shows how the wipes of the present invention may be packaged together with the device of the present invention.

### DESCRIPTION OF THE INVENTION

[0049] The device in this invention uses infrared ("IR") attenuated total reflectance ("ATR") spectroscopy to detect and ultimately to determine the level of a selected analyte, preferably blood glucose, in the human body. Preferably, the inventive device uses an ATR procedure in which the size and configuration of the crystal permits a number of internal reflections before the beam is allowed to exit the crystal with its measured information. In general, as shown in Figures 1A and 1B, when an infrared beam (102) is incident on the upper surface of the ATR crystal (104) -- or ATR plate -- at an angle which exceeds a critical angle  $\Theta_C$ , the beam (102) will be completely totally reflected within crystal (104). Each reflection of the beam within the ATR plate, and specifically against the upper surface (114), provides a bit more information about the composition of the sample (112) resting against that upper surface (114). The more numerous the reflections, and the greater the penetration depth of the reflection, the higher is the quality of the information. The incident beam (102) becomes reflected beam (106) as it exits crystal (104) as shown in Figure 1A. Higher refractive index materials are typically chosen for the ATR crystal to minimize the critical angle. The critical angle is a function of the refractive indices of both the sample and the ATR crystal and is defined as:

$$\Theta_C = \sin^{-1} \left( \frac{n_2}{n_1} \right)$$

[0050] Here,  $n_1$  is the refractive index of the ATR crystal and  $n_2$  is the refractive index of the sample.

[0051] Throughout this specification, we refer to wavelength measures as specific values. It should be understood that we intend those values to be bands or ranges of values,

typically with a tolerance of  $\pm 0.20$  micron, preferably  $\pm 0.10$  micron. For instance, a value of 8.25 microns would mean a band of 8.15 to 8.35 microns, and perhaps 8.05 to 8.45 microns depending upon the context.

[0052] As shown in Figure 1B, the internally reflected beam (108) includes an evanescent wave (110) which penetrates a short distance into sample (112) over a wide wavelength range. In those regions of the IR spectrum in which the sample absorbs IR, some portion of the light does not return to the sensor. It is these regions of IR absorbance which provide information, in this inventive device, for quantification of the glucose level.

[0053] We have found that the mid-IR spectrum does not penetrate into the skin to an appreciable level. Specifically, the skin is made up of a number of layers: the outermost -- the *stratum corneum* -- is a layer substantially free of cholesterol, water, gamma globulin, albumin, and blood. It is a shallow outer region covering the *stratum granulosum*, the *stratum spinosum*, and the basal layer. The area between the basal layer to the outside is not vascularized. It is unlikely that any layer other than the *stratum corneum* is traversed by the mid-IR light involved in this inventive device. Although we do not wish to be bound by theory, it is likely that the eccrine or sweat glands transport the glucose to the outer skin layers for measurement and analysis by our inventions.

[0054] We prefer the use of higher refractive index crystals such as zinc selenide, zinc sulfide, diamond, germanium, and silicon as the ATR plate. The index of refraction of the ATR plate (104) should be significantly higher than that of the sample (112).

[0055] Further, the ATR crystal (104) shown in Figure 1A is shown to be trapezoidal and having an upper surface (114) for contact with the sample, which sample, in this case, is skin from a living human body. However, this shape is only for the purposes of mechanical convenience and ease of application into a working commercial device. Other shapes, in particular, a parallelogram (111) such as shown in Figure 1C and the reflective crystal (113) shown in Figure 1D having mirrored end (115), are also quite suitable for this inventive device should the designer so require. The mirrored reflective crystal (113) has the advantage of, and perhaps the detriment of having both an IR source and the IR sensors at the same end of the crystal.

[0056] It is generally essential that the ATR crystal or plate (104) have a sample or upper surface (114) which is essentially parallel to the lower surface (116). In general, the ATR plate (104) is preferably configured and utilized so that the product of the practical

number of internal reflections of internal reflected beam (108) and the skin penetration per reflection of this product is maximized. When maximizing this product, called the effective pathlength (EPL), the information level in beam (106) as it leaves ATR plate (104) is significantly higher. Further, the higher the value of the index of refraction,  $n_2$ , of the ATR plate (104), the higher is the number of internal reflections. The sensitivity of the IR sensors also need not be as high when the EPL is maximized. We consider the number of total reflections within the crystal to be preferably from 3-15 or more for adequate results.

[0057] We have surprisingly found that a glucose measuring device made according to this invention is quite effective on the human skin of the hands and fingers. We have found that the glucose concentration as measured by the inventive devices correlates very closely with the glucose concentration determined by a direct determination from a blood sample. As will be discussed below, the glucose level as measured by the inventive device also is surprisingly found closely to track the glucose level of blood in time as well. This is surprising in that the IR beam likely passes into the skin, i.e., the *stratum corneum*, for only a few microns. It is unlikely in a fingertip that any blood is crossed by that light path. As discussed above, the *stratum corneum* is the outer layer of skin and is substantially unvascularized. The *stratum corneum* is the final outer product of epidermal differentiation or keratinization. It is made up of a number of closely packed layers of flattened polyhedral corneocytes (also known as squames). These cells overlap and interlock with neighboring cells by ridges and grooves. In the thin skin of the human body, this layer may be only a few cells deep, but in thicker skin, such as may be found on the toes and feet, it may be more than 50 cells deep. The plasma membrane of the corneocyte appears thickened compared with that of keratinocytes in the lower layers of the skin, but this apparent deposition of a dense marginal band formed by stabilization of a soluble precursor, involucrin, just below the *stratum corneum*.

[0058] It may sometimes be necessary to clean the skin exterior before taking a glucose measurement in order to remove extraneous glucose from the skin surface. This is because extra or residual glucose may affect the accuracy of the glucose measurement, for example, by increasing the reading to include the contribution from the glucose already at or within the skin surface. In cleaning the skin exterior, it therefore becomes important to select cleaning materials that will not interfere with the IR measurement of glucose, for example cleaning materials that do not have IR peaks between about 8.25 micrometers and about 8.75

micrometers or between about 9.50 micrometers and about 10.00 micrometers. Any such cleaning materials may be suitable.

[0059] For example, the cleaning materials may be one or more solvents applied to the skin exterior alone, or in combination with other solvents. It may, for example, be beneficial to first employ a solvent for removing the glucose and a second solvent for removing the glucose solvent. In this way, the skin surface is cleaned of both the glucose and the glucose solvent. To facilitate use of the solvents, it may be desirable to provide these solvents on an absorbent pad, a woven, a nonwoven, a porous cloth, a mixture of various polymers or fibers, or any other such similar support. For ease of description only, the term "wipe" will be used herein to include any type of fabric, woven, non-woven, cloth, pad, polymeric or fibrous mixture, and similar such supports capable of absorbing a solvent or having an solvent impregnated therein. The composition of suitable wipes will be described in greater detail below.

[0060] As noted above, the cleaning materials may include solvents. For example, a suitable glucose solvent would have the capacity to solubilize glucose without interfering with the IR measurement of glucose at or within the skin surface (we have found that soap and its residue are sometimes a problem). Polar solvents, and in particular, a mixture of distilled water and alcohol, have provided very good results in removing residual glucose from the skin exterior. The ratio of distilled water to alcohol may be chosen such that there is sufficient water to dissolve the glucose, but not so much water as to make the removal of the excess water take an inconveniently long period of time relative to the measurement of glucose (e.g., more than 5 minutes). As noted above, it is desirable that the alcohol/water mixture, or other polar solvent, be selected such that it removes the residual glucose, but does not interfere with the glucose IR measurement. We have found that a 50-50 mixture of isopropyl alcohol and distilled water is particularly useful in accomplishing these tasks.

[0061] Similarly, a second solvent may be employed for removing the glucose solvent. A suitable solvent for removing the glucose solvent may have the capacity to remove the glucose solvent without interfering with the glucose IR measurement. We have found that a mixture of distilled water and alcohol provides good results. The ratio of distilled water to alcohol may be chosen such that there is sufficient alcohol to remove the glucose solvent, but not so much alcohol that over drying of the skin results (e.g., resulting in the skin becoming hardened or whitened). Similarly, the ratio may be chosen such that glucose is not prevented

from being restored to the skin surface in the time period in which the glucose measurement is desired to be made (e.g., within five minutes after use of the second solvent). We have found that a mixture of 95% isopropyl alcohol to 5% distilled water is particularly useful in accomplishing these tasks.

**[0062]** The wipe itself may be made from a variety of different materials. Selection of an appropriate material will often depend on the desired physical properties of the wipe, for example, softness, resiliency, strength, flexibility, integrity, toughness, absorbency, liquid retention, thickness, tear resistance, surface texture, drapability, wettability, wicking ability and the like. In some instances it may be desirable that the wipe have a number of different physical properties. In these instances, for example, the wipe may be multi-layered, configured to provide one desired physical property within one layer and another physical property within another layer. For example, the wipe may include at least one layer configured to provide strength and resilience, and at least another layer configured to provide a soft, gentle wiping surface. It may be particularly desirable that the wipe provide at least one soft and non-fleecing surface, so that the wipe is soft, but does not deteriorate or leave fibers on the skin exterior. Similarly, because the wipe may also be used to clean portions of the IR measurement device (e.g., the crystal surface), it may also be desirable to have at least a surface or portion of the wipe be non-abrasive.

**[0063]** Suitable materials for the wipes include, for example, meltblown materials, coform materials, air-laid materials, bonded-carded web materials, hydroentangled materials, spunbond materials and the like. The wipes may comprise any number of natural or synthetic fibers. Suitable natural fibers for use in the present invention include cellulosic fibers (e.g., wood pulp fibers, cotton fibers, flax fibers, hemp fibers, jute fibers, silk fibers) as well as keratin fibers (e.g., wool fibers, camel hair fibers, etc.) and the like. Suitable thermoplastic polymeric fibers include polyolefins such as polypropylene and polyethylene, and polyamides such as nylons (e.g., nylon 6, nylon 66, nylon 610, and the like).

**[0064]** Other suitable synthetic fibers include those selected from the group consisting of acetate fibers, acrylic fibers (e.g., acrilan, creslan, and the acrylonitrile-based fibers) cellulose ester fibers (e.g., cellulose acetate, amel, and acele), modacrylic fibers, polyamide fibers, polyester fibers (e.g., fortrel, kodel), polyvinyl alcohol fibers, rayon fibers, polyethylene foam, polyurethane foam, and combinations thereof, such as polyethylene terephthalate and

polybutylene terephthalate. The wipe can be woven or nonwoven, or be some combination thereof.

**[0065]** For example, suitable nonwovens may include materials selected from the group consisting of sponges (both natural and synthetic), formed films, fibrous nonwovens, battings, and combinations thereof. These and other suitable fibers and the nonwovens prepared therefrom are generally described in Riedel, "Nonwoven Bonding Methods and Materials," *Nonwoven World* (1987); *The Encyclopedia Americana*, vol. 11, pp. 147-153, and vol. 26, pp. 566-581 (1984); U.S. Pat. No. 4,891,227, to Thaman *et al.*; and U.S. Pat. No. 4,891,228, each of which is hereby incorporated by reference in its entirety. Non-limiting examples of suitable nonwoven materials include those disclosed in U.S. Pat. No. 4,447,294 to Osborn; U.S. Pat. No. 4,603,176 to Bjorkquist; U.S. Pat. No. 4,981,557 to Bjorkquist; U.S. Pat. No. 5,085,736 to Bjorkquist; U.S. Pat. No. 5,138,002 to Bjorkquist; U.S. Pat. No. 5,262,007 to Phan *et al.*; U.S. Pat. No. 5,264,082, to Phan *et al.*; U.S. Pat. No. 4,637,859 to Trokhan; U.S. Pat. No. 4,529,480 to Trokhan; U.S. Pat. No. 4,687,153 to McNeil; U.S. Pat. No. 5,223,096 to Phan *et al.*; and U.S. Pat. No. 5,679,222, to Rasch *et al.*, each of which is incorporated by reference herein in its entirety.

**[0066]** Methods of making nonwovens are well known in the art. Generally, nonwovens can be made by air-laying, water-laying, meltblowing, coforming, spunbonding, or carding processes in which the fibers or filaments are first cut to desired lengths from long strands, passed into a water or air stream, and then deposited onto a screen through which the fiber-laden air or water is passed. The resulting layer is then typically subjected to at least one of several types of bonding techniques, to anchor the individual fibers together to form a self-sustaining web. The nonwoven may also be a polymeric mesh sponge as described in European Patent Application No. EP 702550A1 published Mar. 27, 1996, which is hereby incorporated by reference in its entirety.

**[0067]** The wipes may be packaged in any number of configurations. For example, the glucose solvent wipe and the solvent for removing the glucose solvent wipe may be packaged as individual wipes in individually sealed packets. The packets may be such that the solvent within the wipe remains at a relatively constant concentration prior to use and the wipe remains moist. In some instances, this may be accomplished by providing a wipe package having a foiled lining or other similar non-permeable liner, which may help to prevent the solvent from escaping.



**[0068]** The wipes and their corresponding packages may be of any geometry, providing wipes and packages having a variety of different shapes. Such shapes include a circle, an oval, a square, or any other shape. The wipe and the corresponding package may have the same shape, or may have different shapes. For example, the wipe may take the form of a circular pad (300) and have a corresponding circular package (302) as shown in FIG. 10A. Alternatively, the wipes may have a first shape and the packages may have a second shape, different from the shape of the wipe. For example the wipe may be circular (304) and the package may be rectangular (306), as shown in FIG. 10B.

**[0069]** The wipe packaging may be configured such that it is easy to open, for example, by being tearable. An optional pre-cut slit (308) may be placed at any convenient location on the package to facilitate its tearing. Similarly, the package may be opened by other convenient methods such as by peeling away a first layer to reveal the wipe thereunder. While circles and rectangles have been depicted in the figures, it should be understood that such shapes are merely illustrative, and not intended to be limiting. Any number of shapes and combinations of wipes and packages is possible. In addition, the wipes can be formed into balls, such as cotton balls, or applied to delivery systems such as applicators for swabs. The dimensions of each individual wipe, including its thickness, will vary depending upon the shape of the wipe and its desired configuration.

**[0070]** The glucose solvent wipe (310) and the wipe for removing the glucose solvent (312) may also be packaged together as a single unit as shown in FIG. 10C. Again while rectangular wipes and packages are shown, it is intended that any number of shape combinations be used. Alternatively, a single wipe may contain both the glucose solvent and the solvent for removing the solvent therein. For example, different surfaces (or layers) of the wipe may have different solvents therein (e.g., FIG. 11A) or different portions of the wipe may have different solvents therein (e.g., FIG. 11B). For example, FIG. 11A illustrates a wipe having a first layer containing the glucose solvent (314) and a second layer having the solvent for removing the glucose solvent (316). Similarly, FIG. 11B illustrates a wipe having a glucose solvent portion (314) and a second portion having a solvent for removing the glucose solvent (316).

**[0071]** The wipes may also be packaged as a stack of wipes housed within a suitable container (e.g., a plastic container) as shown in FIGS. 12A-12B. Within each container, the individual wipes may be arranged in any number of ways. For example, the wipes may be in a

folded configuration and stacked one on top of another. Such folded configurations are well known to those skilled in the art and include c-folded, z-folded, quarter-folded configurations and the like. The containers may have additional solvent therein to maintain the moistness and concentration of the solvent on the wipe. The containers may or may not have removable lids (318). For example, a container may not have a removable lid, but instead have a slit (320) or similar such opening so that the wipes may pass therethrough. Similarly, the container may have both a removable lid and a slit thereon, as shown in FIGS. 12A-B. In this way, if a wipe were to fall from the slit opening into the body of the container, the lid may simply be removed and the wipe pulled back through the slit opening (320). Similarly, having a removable lid facilitates replacement of the wipes without having to replace both the container and the wipes.

**[0072]** Any number of container configurations may be used. The container may be of any shape and be of any size. Separate containers may be used for separate wipes, as shown in FIG. 12A, or a single container may be used to house both the glucose solvent wipe (314) and the wipe for removing the glucose solvent wipe (316) as shown in FIG. 12B. As shown in FIG. 12B, a wall (322) or other similar type separator (e.g., a plastic divider) keeps the wipes and solvents separated.

**[0073]** The wipes may also be packaged as a continuous strip, having perforations between each wipe as shown in FIGS. 13A-13B. The continuous strip may be wound into a roll for dispensing as shown in FIG. 13A, or arranged in a stack as shown in FIG. 13B. The perforations (324) may be placed at any desirable distance from one another.

**[0074]** The wipe packages, or the wipes themselves may also be designed such that their presence is required in order to use a particular device. For example, the wipe package may have a barcode (326) located on a portion thereof, which may be scanned by a scanner on the device that will take the IR measurement, as shown in FIGS. 14 and 15. The scanner (328) may serve the purpose of activating or powering on the IR measurement system. In this way, an IR measurement may not be taken without the use of a particular wipe (i.e., the wipe having the barcoded package). In addition, the device may include a data storage or memory component capable of storing a given number of bar code readings. That is, the memory component can store a certain number of prior bar code readings (e.g., 100) and those numbers may then be used to compare with the present bar code reading. In this way, the device senses

when a bar code has been previously used, and prevents the same bar code from being used more than once.

[0075] Common bar code scanners are well known in the art. Examples of bar code scanners that may be used in the present invention are those described in U.S. Pat. Nos. 4,097,729 to Seligman *et al.*; 6,206,289 to Sharpe; 5,886,336 to Tang; 4,967,074 to Von Stein; 5,124,538 to Lapinski, and the references cited therein, each of which are hereby incorporated by reference in its entirety.

[0076] The barcode (326) may be placed at any convenient location along the package. For example, the barcode may be placed on an outer surface of the package. In this way, the barcode may be readable by the scanner prior to package being opened. Similarly, the bar code may be located on an inner surface of the package. In this way the barcode would be accessible, and therefore, readable, only after the package has been opened. The scanner (328) may be placed on any convenient location of the device.

[0077] In addition to the scanner, the device may include timing (330) and clearing (332) mechanisms, which may for example, help prevent delayed use of the device and erroneous scannings of the wipe, as shown in FIGS. 15 and 16. For example, a timer may help prevent a wipe from being scanned at a time well prior to the time that it is desired that the device actually be used. In this way if the user scans the wipe, but then fails to use the device within a certain time period thereafter, the IR measurement device will be powered off, or deactivated, because the timing mechanism will "time-out" the device. Similarly, the device may contain a clearing mechanism. Such a mechanism may be used to clear the scanning of the wipe within a certain period of time. In this way, if a wipe is first scanned, but it has been decided that no measurement is to be taken, the device can be reset so that a second wipe need not be used in order to re-activate the IR measurement system.

[0078] Similarly, magnetism may be used to indicate that the wipe is acceptable for use with a particular device, as shown in FIG. 14B. For instance the wipe package may have a magnetic strip or other magnetic component (334) capable of activating the power to the IR measurement system when brought into close enough proximity to a receiving sensor on the device. In addition, the device may demagnetize the magnetic component after a single use, thus preventing the wipe from being used more than once. Any other similar features (e.g., chemical detection) may also be used to ensure that a particular wipe is used with a particular device.

[0079] The wipes may also be designed to prevent more than a single use. For example, the wipe may contain a chemical capable of being detected by the device prior to use. In this way, the chemical may indicate whether or not the wipe has already been used. If the wipe has already been once used, for example, the IR measurement system could power off. Similarly, the wipe itself may be designed such that all the solvent evaporates after a certain period of time after the wipe is removed from the package. Other methods of preventing more than a single use (*e.g.*, by using magnetism and barcodes) were mentioned above.

[0080] The wipes (*e.g.*, packaged in any of the forms mentioned above) may be additionally packaged together with the device for measuring glucose as shown in FIG. 16. In this way, the user will have the glucose solvent wipe (310) and the wipe for removing the glucose solvent (312) together with the device. While circular wipes having circular packages are depicted in FIG. 16, it should be understood that the shapes of the wipes and their corresponding packages may be of any shape, as described above. The use of circular wipes and packages in FIG. 16 is merely illustrative.

[0081] The device itself can be highly simplified compared to other known devices in that the device can be “self-normalizing” due to the specifics of the IR signature of glucose. Figure 2 shows the IR absorbance spectra of d-glucose. The family of curves there shows that in certain regions of the IR spectrum, there is a correlation between absorbance and the concentration of glucose. Further, there is a region in which the absorbance is not at all dependent upon the concentration of glucose. Our device, in its preferable method of use, uses these two regions of the IR spectra. These regions are in the so-called mid-IR range, *i.e.*, wavelengths between 2.5 and 14 micrometers. In particular, the “referencing wavelength” point is just above 8 micrometers (150), *e.g.*, 8.25 to 8.75 micrometers, and the pronounced peaks (152) at the region between about 9.50 and 10.00 micrometers is used as a “measuring wavelength”. The family of peaks (152) may be used to determine the desired glucose concentration.

[0082] Use of the two noted IR regions is also particularly suitable since other components typically found in the skin, *e.g.*, water, cholesterol, etc., do not cause significant measurement error when using the method described herein.

[0083] Figure 3 shows an optical schematic of a desired variation of the inventive device. ATR crystal (104) with sample side (114) is shown and IR source (160) is provided. IR source (160) may be any of a variety of different kinds of sources. It may be a broadband

IR source, one having radiant temperatures of 300°C to 800°C, or a pair of IR lasers selected for the two regions of measurement discussed above, or other suitably emitted or filtered IR light sources. A single laser may not be a preferred light source in that a laser is a single wavelength source and the preferred operation of this device requires light sources simultaneously emitting two IR wavelengths. Lens (162), for focusing light from IR source (160) into ATR plate (104), is also shown. It may be desirable to include an additional mirror (163) to intercept a portion of the beam before it enters the ATR plate (104) and then to measure the strength of that beam in IR sensor (165). Measurement of that incident light strength (during normalization and during the sample measurement) assures that any changes in that value can be compensated for.

**[0084]** The light then passes into ATR plate (104) for contact with body part (164), shown in this instance to be the desired finger. The reflected beam (106) exits ATR plate (104) and is then desirably split using beam splitter (166). Beam splitter (166) simply transmits some portion of the light through the splitter and reflects the remainder. The two beams may then be passed through, respectively, lenses (168) and (170). The so-focussed beams are then passed to a pair of sensors which are specifically selected for detecting and measuring the magnitude of the two beams in the selected IR regions. Generally, the sensors will be made up of filters (172) and (174) with light sensors (176) and (178) behind. Generally, one of the filters (172), (174) will be in the region of the referencing wavelength and the other will be in that of the measuring wavelength.

**[0085]** Figure 4 shows perhaps a variation of this device (200) showing the finger of the user (202) over the ATR plate (204) with a display (206). Further shown in this desirable variation (200) is a pressure maintaining component (208). We have found that is very highly desirable to maintain a minimum threshold pressure on the body part which is to be used as the area to be measured. Generally, a variance in the pressure does not shift the position of the detected IR spectra, but it may affect the sensitivity of the overall device. Although it is possible to teach the user to press hard enough on the device to reach the minimum threshold pressure, we have determined for each design of the device it is much more appropriate that the design of a particular variation of the inventive device be designed with a specific sample pressure in mind. The appropriate pressure will vary with, e.g., the size of the ATR plate and the like. A pressure above that minimum threshold value may be most desired.

[0086] The variation shown in Figure 4 uses a simple component arm (208) to maintain pressure of the finger (202) on ATR plate (204). Other variations within the scope of this invention may include clamps and the like.

[0087] It should be apparent that once an appropriate pressure is determined for a specific design, the inventive device may include a pressure sensor, e.g., (210) as is shown in Figure 4, to measure adherence to that minimum pressure. Pressure sensor (210) may alternatively be placed beneath ATR plate (204).

[0088] Further, as shown in Figure 5, the appropriate pressure may be achieved when using our device, simply by increasing the pressure of the body part on the ATR crystal surface until a selected pressure window (*i.e.*, greater than a minimum pressure and lower than a maximum pressure) is entered, at which time the IR source is activated and the device makes the desired measurement.

#### Method of Use

[0089] In general, the inventive device described above is used in the following manner: a skin surface on a human being, for instance, the skin of the finger, is placed on the ATR plate. The skin surface is radiated with an IR beam having components at least in the two IR regions we describe above as the "referencing wavelength" and the "measuring wavelength." The beam which ultimately is reflected out of the ATR plate then contains information indicative of the blood glucose level in the user. It may be desirable that the skin surface on the ATR plate be at a pressure above a selected minimum pressure and below a selected maximum pressure. The selected pressures may be determined by the device design.

[0090] Typically, the beam leaving the ATR plate is split using an optical beam splitter into at least two beams. Each of the two beams may be then focussed onto its own IR sensor. Each such IR sensor has a specific filter. This is to say that, for instance, one IR sensor may have a filter which removes all light which is not in the region of the referencing wavelength and the other IR sensor would have a filter which remove all wavelengths other than those in the region of the measuring wavelength. As noted above, for glucose, the referencing wavelength is typically in the range of about 8.25 to 8.75 micrometers. For glucose, the measuring wavelength is typically between about 9.5 and 10.0 micrometers.

[0091] Other analyte materials which have both referencing wavelengths and measuring wavelengths in the mid-IR range and that are found in the outer regions of the skin may also be measured using the inventive devices and procedures described herein.

[0092] Respective signals may be compared using analog or digital computer devices. The signals are then used to calculate analyte values such as blood glucose concentration using various stored calibration values, typically those which are discussed below. The resulting calculated values may then be displayed.

[0093] As noted above, it is also desirable both to clean the plate before use and to clean the exterior surface of the skin to be sampled. Again, we have found, for instance in the early morning that the exterior skin is highly loaded with glucose which is easily removed preferably by using the skin preparation kit, or, less preferably, by washing the hands. Reproducible and accurate glucose measurements may then be had in a period as short as ten minutes after cleaning the area of the skin to be measured.

[0094] We also note that, depending upon the design of a specific variation of a device made according to the invention, periodic, or at least an initial calibration of the device, using typical blood sample glucose determinations, may be necessary or desirable.

[0095] Determination of blood glucose level from the information provided in the IR spectra is straightforward. A baseline is first determined by measuring the level of infrared absorbance at the measuring and referencing wavelengths, without a sample being present on the sample plate. The skin is then placed in contact with the ATR plate and the two specified absorbance values are again measured. Using these four values, the following calculation is then made.

$$A_1 = \ln\left(\frac{T_{01}}{T_1}\right) = A_{g1} + A_{b1} \quad (\text{Absorbance at referencing spectral band.})$$

$$A_2 = \ln\left(\frac{T_{02}}{T_2}\right) = A_{g2} + A_{b2} \quad (\text{Absorbance at measuring spectral band.})$$

where:  $T_{01}$  = measured value at reference spectral band w/o sample

$T_{02}$  = measured value at measuring spectral band w/o sample

$T_1$  = measured value at reference spectral band w/ sample

$T_2$  = measured value at measuring spectral band w/ sample

$A_{g1}$  = absorbance of glucose at reference spectral band

$A_{g2}$  = absorbance of glucose at measuring spectral band

$A_{b1}$  = absorbance of background at reference spectral band

$A_{b2}$  = absorbance of background at measuring spectral band

$d$  = effective path length through the sample.

$a_2$  = specific absorptivity at measuring spectral band

$k$  = calibration constant for the device

$C_g$  = measured concentration of glucose

[0096] Since the background base values are approximately equal (i.e.,  $A_{b1} = A_{b2}$ ) and  $A_{g1} = 0$ , then:

$$A_2 - A_1 = A_{g2} = a_2 d C_g$$

and

$$C_g = k(A_2 - A_1)$$

The value of  $C_g$  is the desired result of this procedure.

[0097] Similarly, Figure 7 shows a graph in which the value of the analyte is assessed using similar calculations but in which the “referencing wavelength” is an absorbance trough (“b”) unaffected by the concentration of the analyte. The “measuring wavelength” peak (“a”) is measured against a baseline.



## EXAMPLES

### Example 1

[0098] Using a commercially available IR spectrometer (Nicolet 510) having a ZnSe crystal ATR plate (55mm long, 10mm wide, and 4mm thick) we tested the inventive procedure. We calibrated the output of the spectrometer by comparing the IR signal to the values actually measured using one of the inventor's blood samples. The inventor used a blood stick known as "Whisper Soft" by Amira Medical Co. and "Glucometer Elite" blood glucose test strips sold by Bayer Corp. of Elkhart, Ind. On each of the various test days, the inventor took several test sticks and measured the glucose value of the resulting blood; the IR test was made at the same approximate time.

[0099] As shown in the calibration curve of Figure 6, the data are quite consistent. So, where the blood glucose concentration "B" is in (mg/dl) and "S" is the difference between the absorbance at the referencing region and the measuring region as measured by the spectrometer:

$$B=[(1950) \bullet S]-(17).$$

### Example 2

[0100] In accordance with a clinical protocol, a diabetic was then tested. Curve 1 in Figure 8 shows the IR absorbance spectrum of the test subject's finger before eating (and after fasting overnight) and curve 2 shows IR absorbance spectrum of the same individual after having eaten. Incidentally, insulin was administered shortly after the measurement of curve 2.

[0101] In any event, the significant difference in the two peak heights at the 9.75 micrometer wavelength and the equality of the two IR absorbance values at the 8.50 micrometer value shows the effectiveness of the procedure in measuring glucose level.

### Example 3

[0102] That the inventive glucose monitoring device non-invasively determines blood glucose level and quickly follows changes in that blood glucose level is shown in Figure 9. Using both the inventive procedure and a commercial glucose device, one of the inventors

followed his glucose level for a single day. The blood sticks are considered to be accurate within 15% of the actual reading.

**[0103]** The results are shown in Figure 9. Of particular interest is the measurement just before 4:40pm wherein the two values are essentially the same. A high sugar candy bar was eaten at about 4:45pm and measurements of glucose level were taken using the inventive procedure at about 5:03, 5:18, 5:35 and 5:50. A blood sample was taken at 5:35 and reflected almost the same value as that measured using the inventive procedure. Consequently, the procedure tracks that measured by the blood very quickly.

**[0104]** This invention has been described and specific examples of the invention have been portrayed. The use of those specifics is not intended to limit the invention in any way. Additionally, to the extent there are variations of the invention which are within the spirit of the disclosure and yet are equivalent to the inventions found in the claims, it is our intent that this patent will cover those variations as well.

**WHAT WE CLAIM IS:**

1. A disposable wipe comprising:
  - a first solvent capable of removing glucose from the stratum corneum, said solvent having an IR spectra without absorbance peaks between about 8.25 micrometers and about 8.75 micrometers and between about 9.50 micrometers and about 10.00 micrometers; and
  - a support, wherein the solvent is absorbed or impregnated in the support.
2. The disposable wipe of claim 1 further comprising a sealed package, the package housing the wipe therein and being openable.
3. The disposable wipe of claim 2 wherein the package comprises a foiled liner on its inner surface.
4. The disposable wipe of claim 2 wherein the package further comprises a barcode.
5. The disposable wipe of claim 2 wherein the package further comprises a magnetic material.
6. The disposable wipe of claim 1 wherein the wipe further comprises a detectable chemical component.
7. The disposable wipe of claim 1, wherein the support is selected from the group consisting of a fabric, a woven, a nonwoven, a cloth, a pad, a polymeric or fibrous mixture, and any combination thereof.
8. The disposable wipe of claim 1 wherein the wipe is configured for a single use.
9. The disposable wipe of claim 8 wherein the wipe is configured for a single use by further comprising an additional chemical to prevent more than a single use.

10. The disposable wipe of claim 8 wherein the wipe is configured for a single use by being adapted to dry out quickly after a single use.
11. A single-use disposable wipe comprising:
  - a second solvent capable of removing a first solvent capable of removing glucose from the stratum corneum, said second solvent having an IR spectra without absorbance peaks between about 8.25 micrometers and about 8.75 micrometers and between about 9.50 micrometers and about 10.00 micrometers; and
  - a support, wherein the solvent is absorbed or impregnated in the support.
12. The disposable wipe of claim 11 further comprising a sealed package, the package housing the wipe therein and being openable.
13. The disposable wipe of claim 12 wherein the package comprises a foiled liner on its inner surface.
14. The disposable wipe of claim 12 wherein the package further comprises a barcode.
15. The disposable wipe of claim 12 wherein the package further comprises a magnetic material.
16. The disposable wipe of claim 11 wherein the wipe further comprises a detectable chemical component.
17. The disposable wipe of claim 11, wherein the support is selected from the group consisting of a fabric, a woven, a nonwoven, a cloth, a pad, a polymeric or fibrous mixture, and any combination thereof.
18. The disposable wipe of claim 11 wherein the wipe is configured for a single use.

19. The disposable wipe of claim 18 wherein the wipe is configured for a single use by further comprising an additional chemical to prevent more than a single use.

20. The disposable wipe of claim 18 wherein the wipe is configured for a single use by being adapted to evaporate quickly after a single use.

21. A cleaning kit for an infrared glucose measurement system comprising:

at least a first solvent capable of removing glucose from the stratum corneum;

at least a second solvent capable of removing the first solvent, each of said

solvents having an IR spectra without absorbance peaks between about 8.25 micrometers and about 8.75 micrometers and between about 9.50 micrometers and about 10.00 micrometers; and

a support selected from the group consisting of a fabric, a woven, a nonwoven, a cloth, a pad, a polymeric or fibrous mixture, and any combination thereof.

22. The cleaning kit of claim 21 wherein at least one of the first or second solvents is absorbed or impregnated in the support.

23. The cleaning kit of claim 21 wherein the first solvent is absorbed or impregnated into at least a first portion of the support and the second solvent is absorbed or impregnated into at least a second portion of the support, wherein the first and second portions of the support are different.

24. The cleaning kit of claim 21 wherein the first solvent is absorbed or impregnated in a first support, and wherein the second solvent is absorbed or impregnated in a second support, wherein the first and second supports are independently selected from the group consisting of a fabric, a woven, a nonwoven, a cloth, a pad, a polymeric or fibrous mixture, and any combination thereof.

25. The cleaning kit of claim 21 wherein the first solvent comprises a mixture of alcohol and water.

26. The cleaning kit of claim 25 wherein the mixture is a 50-50 mixture of isopropyl alcohol and water.

27. The cleaning kit of claim 25 wherein the mixture is a 20-80 mixture of isopropyl alcohol and water.

28. The cleaning kit of claim 25 wherein the mixture is a 30-70 mixture of isopropyl alcohol and water.

29. The cleaning kit of claim 21 wherein the second solvent comprises a mixture of alcohol and water.

30. The cleaning kit of claim 29 wherein the mixture is a 95-5 mixture of isopropyl alcohol and water.

31. The cleaning kit of claim 29 wherein the mixture is a 90-10 mixture of isopropyl alcohol and water.

32. An infrared glucose measurement system comprising:

a device for measuring the glucose concentration of the stratum corneum said device comprising an infrared source for emitting an IR beam into an ATR plate, the IR beam having components at least in the region of a referencing wavelength and a measuring wavelength, the ATR plate having a measurement surface for contact with a human skin surface and for directing the IR beam against the skin surface, and at least two IR sensors for simultaneously measuring absorbance of at least said referencing wavelength and said measuring wavelength; and

the cleaning kit of claim 21.

33. An infrared glucose measurement system comprising:

a device for measuring the glucose concentration of the stratum corneum said device comprising an infrared source for emitting an IR beam into an ATR plate, the IR beam having components at least in the region of a referencing wavelength and a measuring

wavelength, the ATR plate having a measurement surface for contact with a human skin surface and for directing the IR beam against the skin surface, and at least two IR sensors for simultaneously measuring absorbance of at least said referencing wavelength and said measuring wavelength; and

the disposable wipe of claim 1.

34. An infrared glucose measurement system comprising:

a device for measuring the glucose concentration of the stratum corneum said device comprising an infrared source for emitting an IR beam into an ATR plate, the IR beam having components at least in the region of a referencing wavelength and a measuring wavelength, the ATR plate having a measurement surface for contact with a human skin surface and for directing the IR beam against the skin surface, and at least two IR sensors for simultaneously measuring absorbance of at least said referencing wavelength and said measuring wavelength; and the disposable wipe of claim 11.

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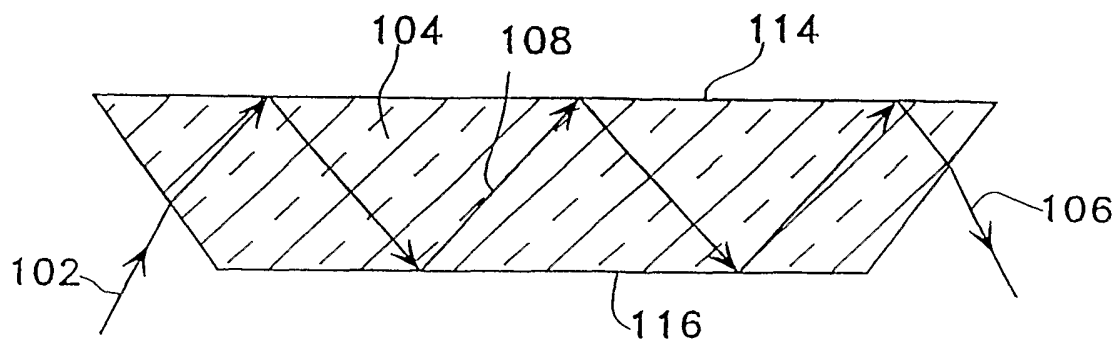


FIG. 1A

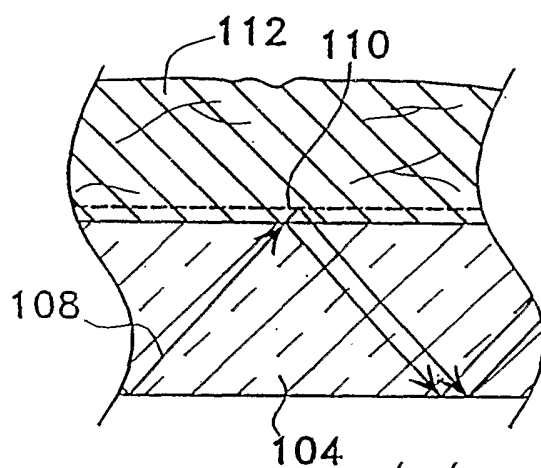


FIG. 1B

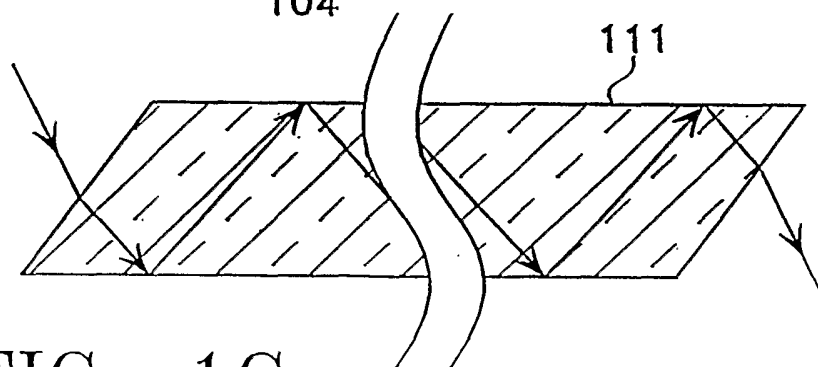


FIG. 1C

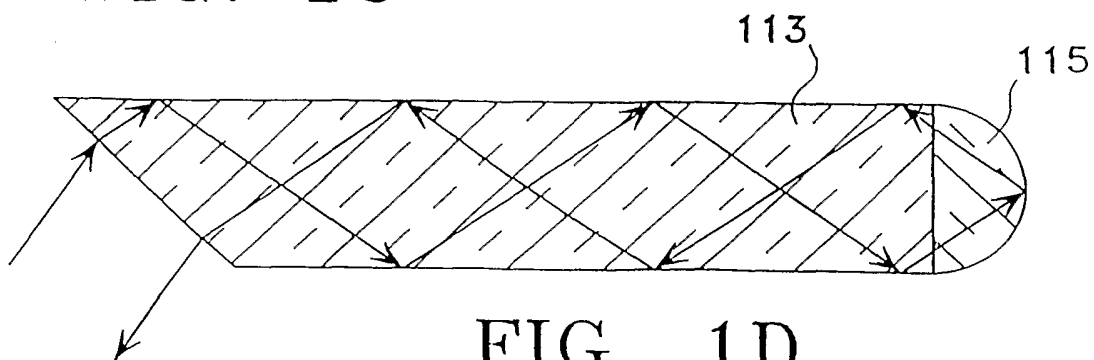


FIG. 1D



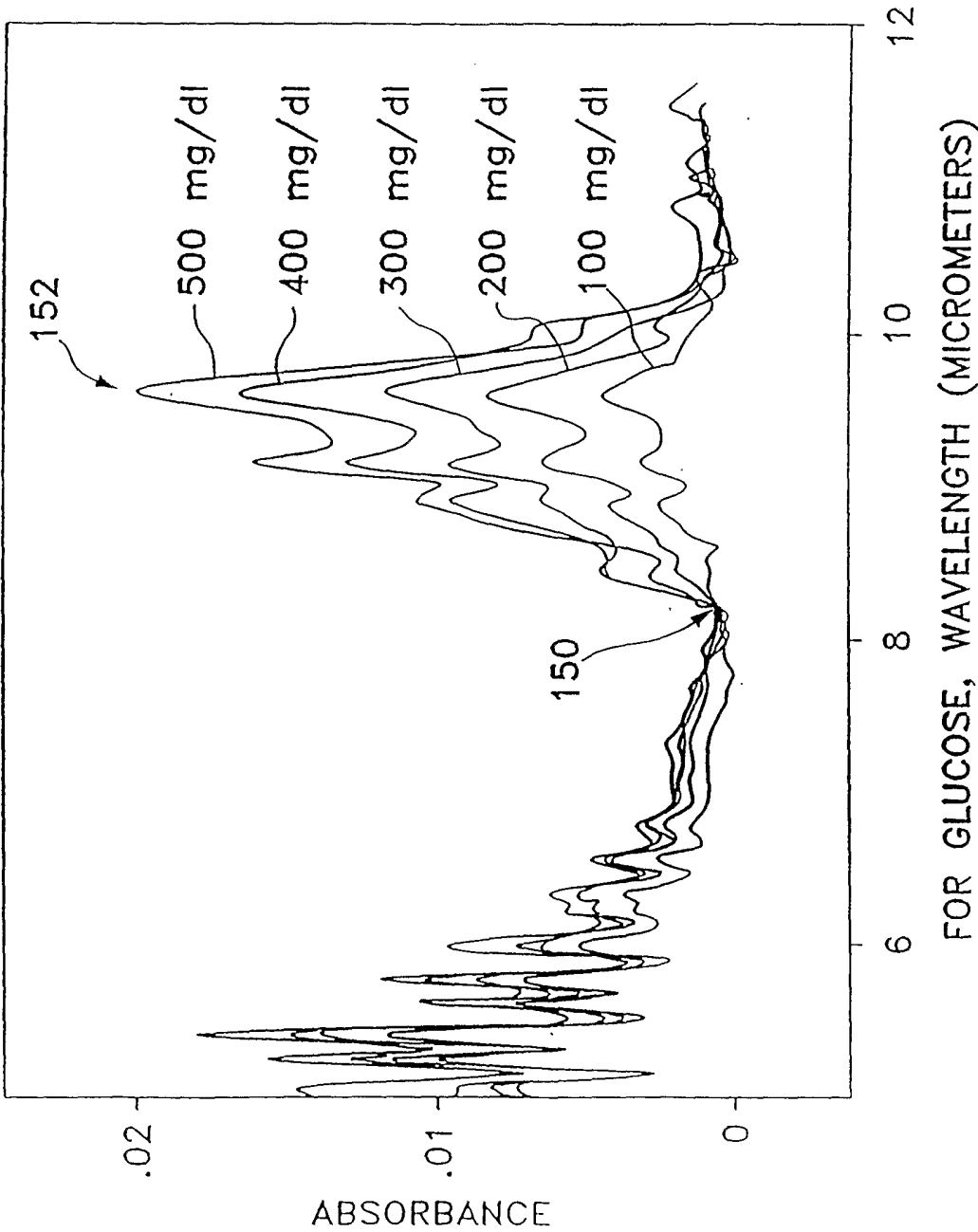


FIG. 2

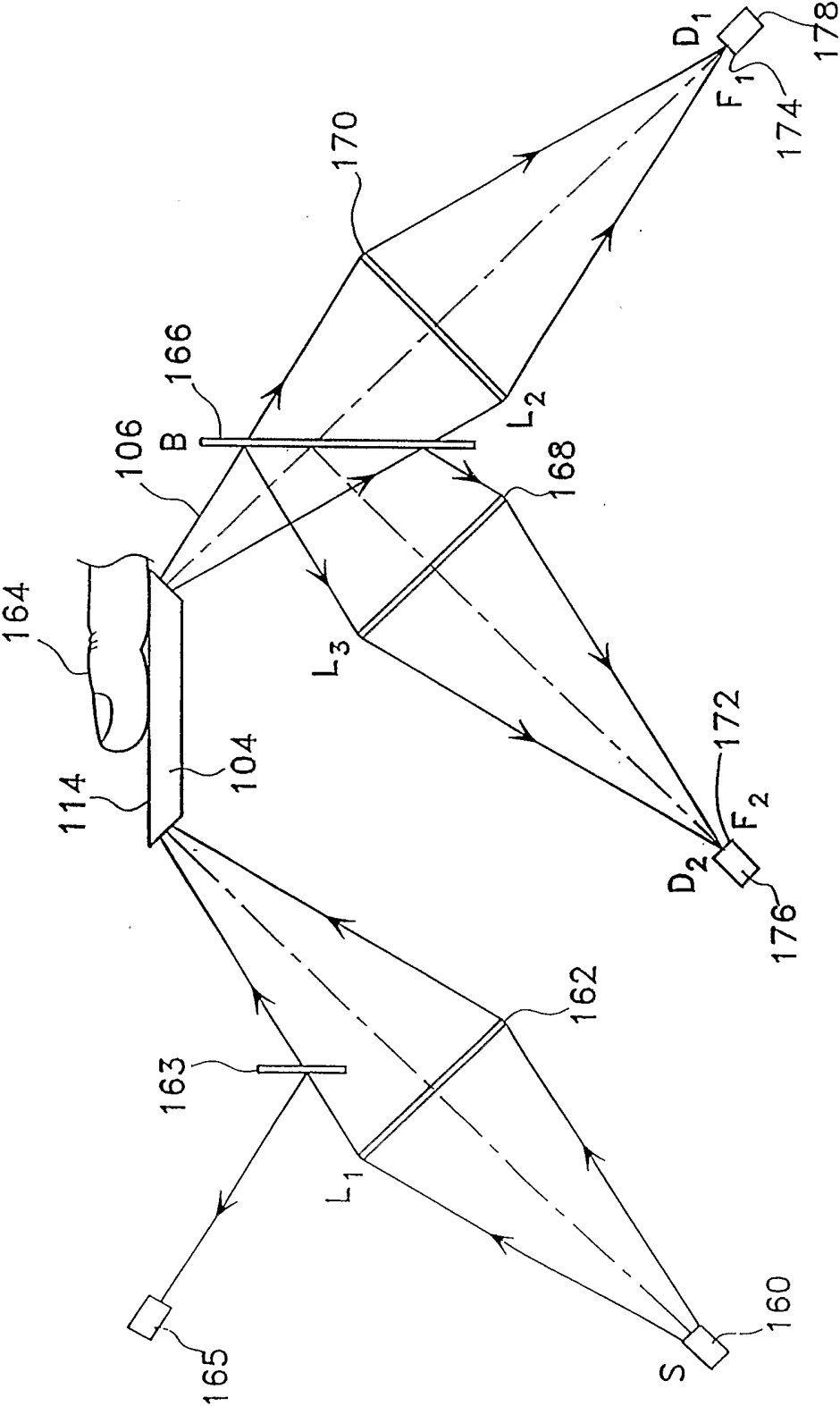


FIG. 3

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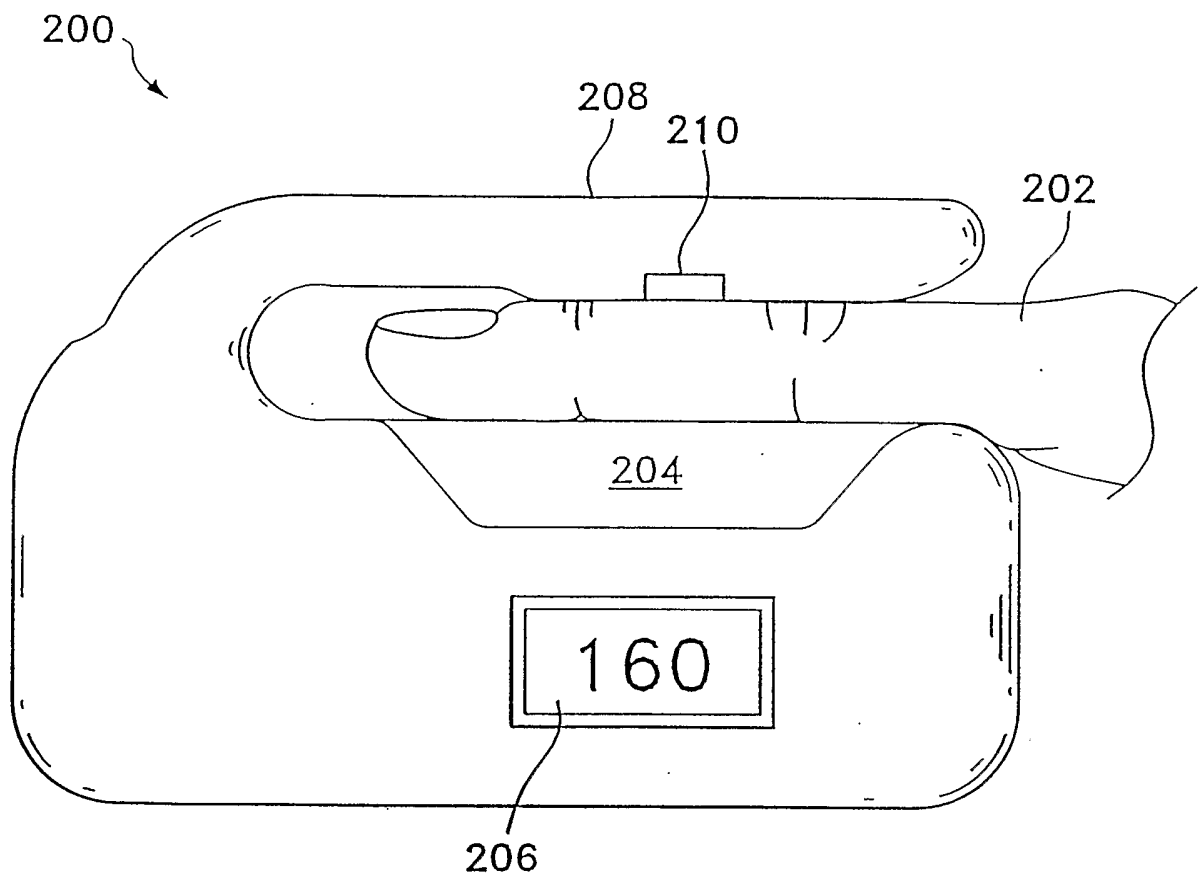


FIG. 4

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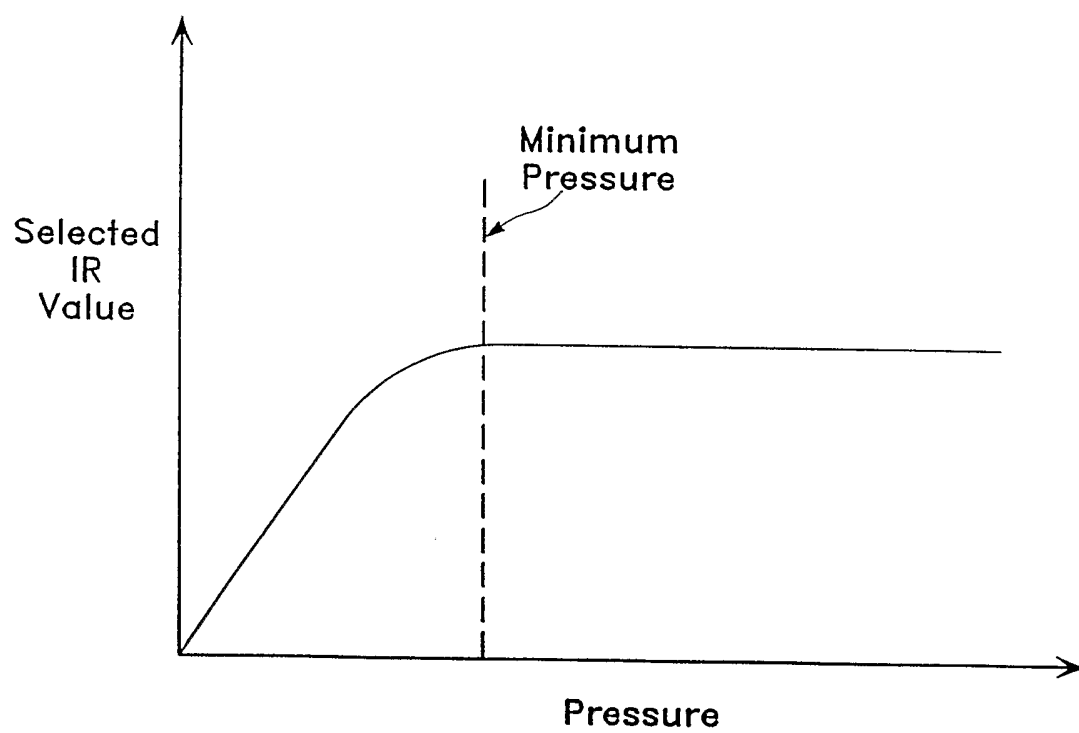
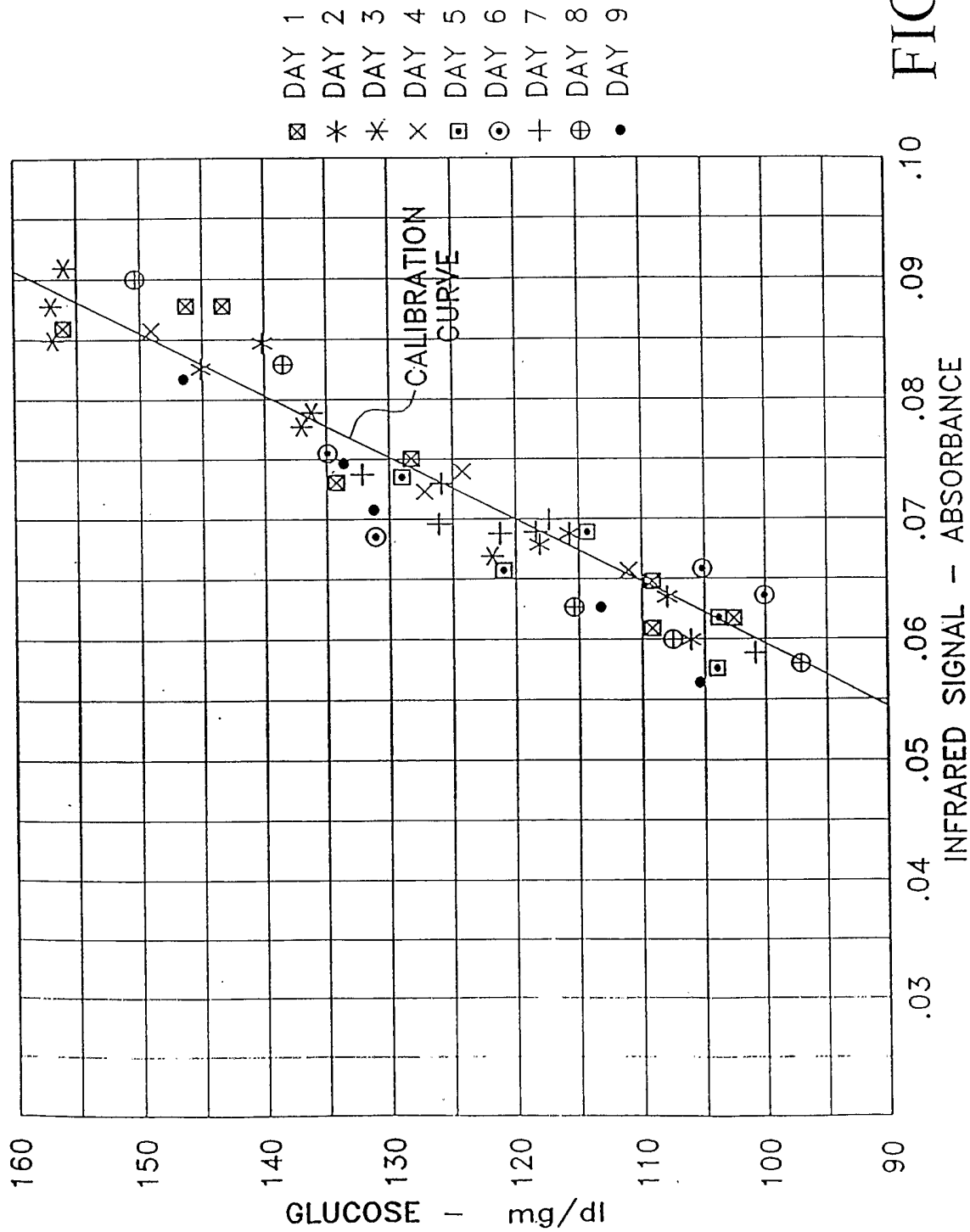


FIG. 5



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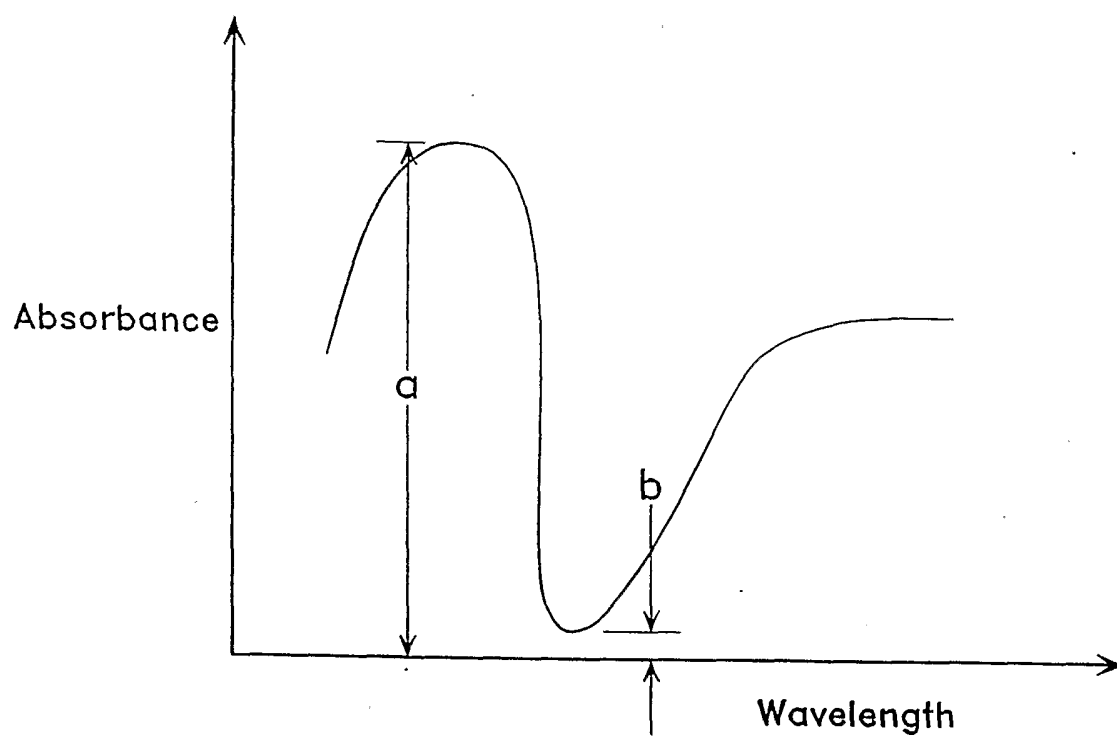
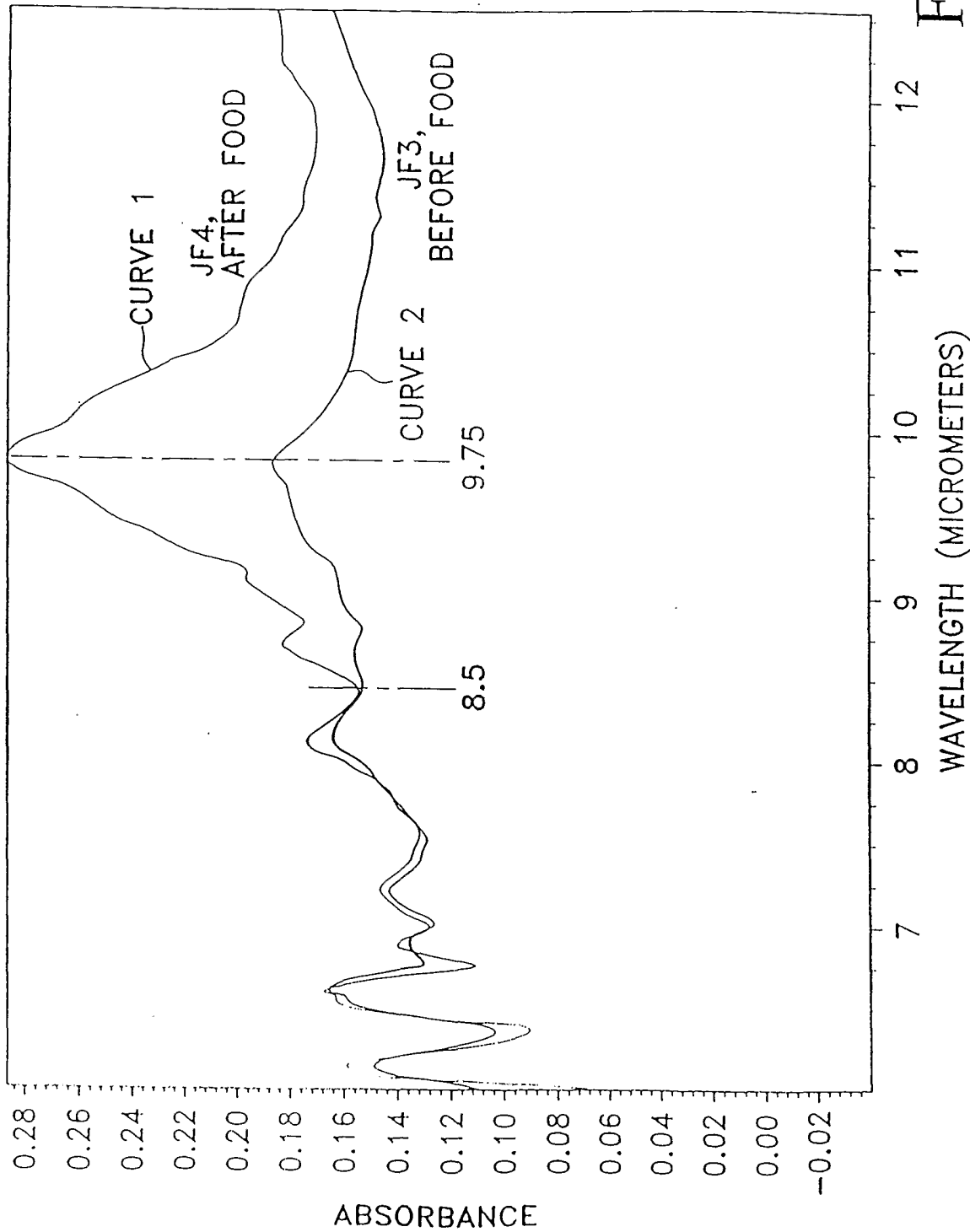


FIG. 7



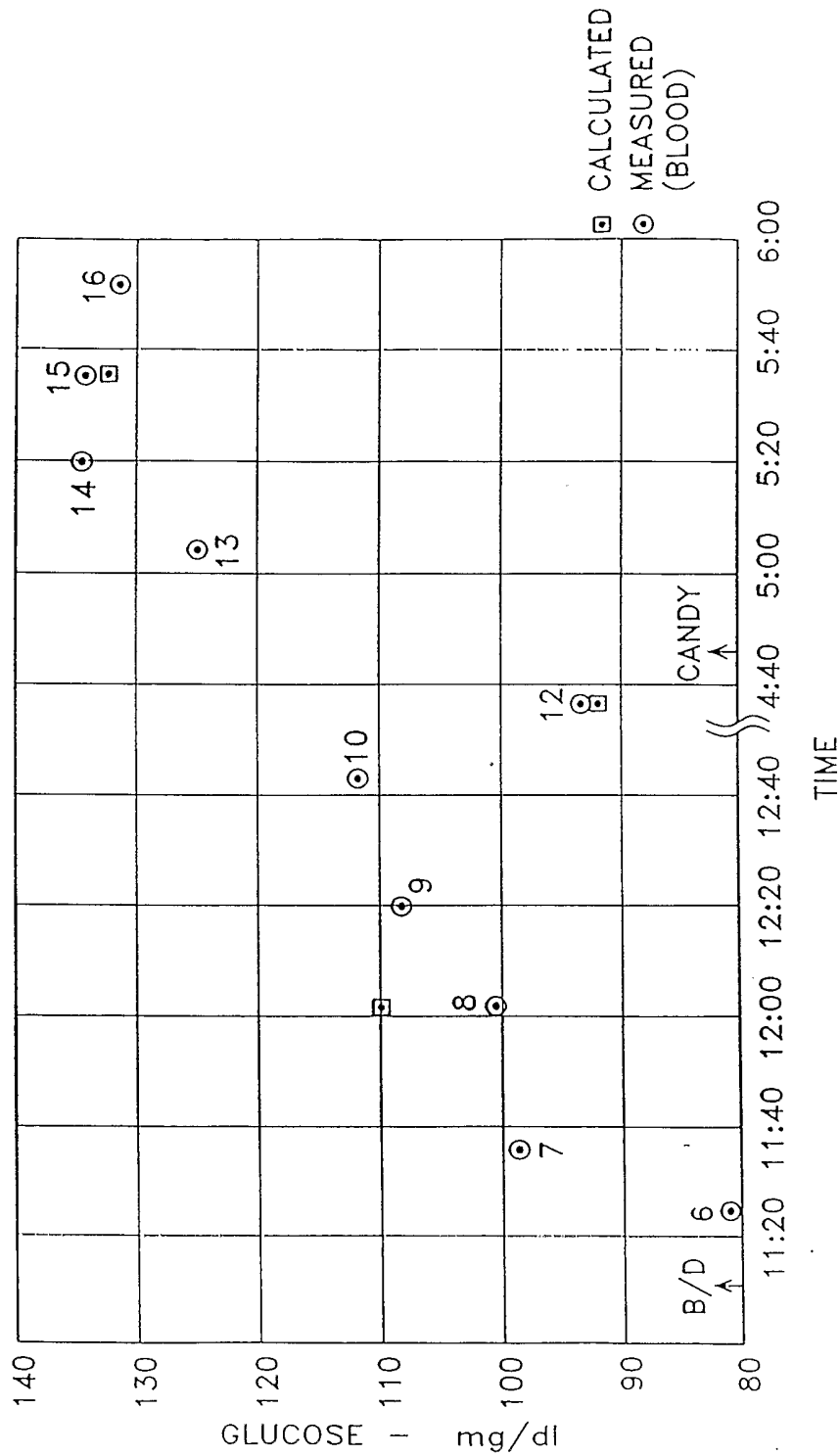


FIG. 9



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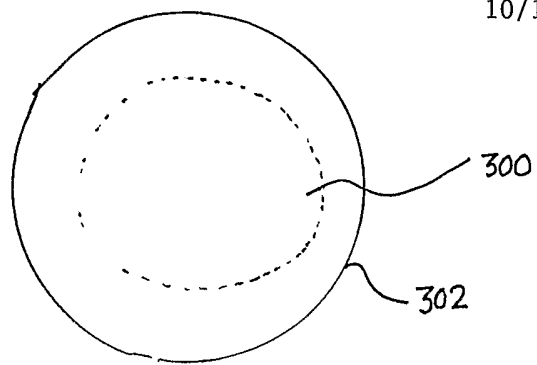


FIG. 10A

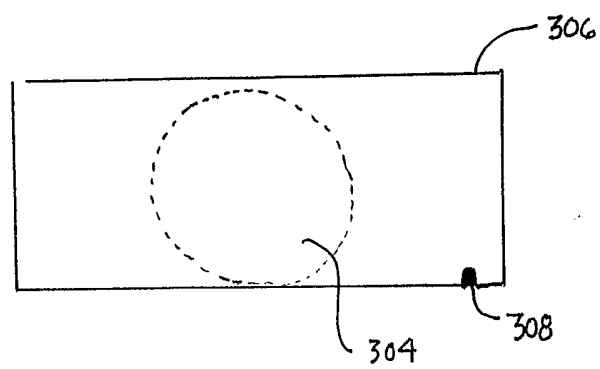


FIG. 10B

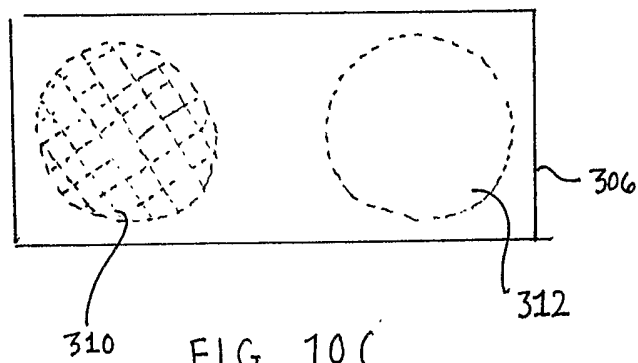
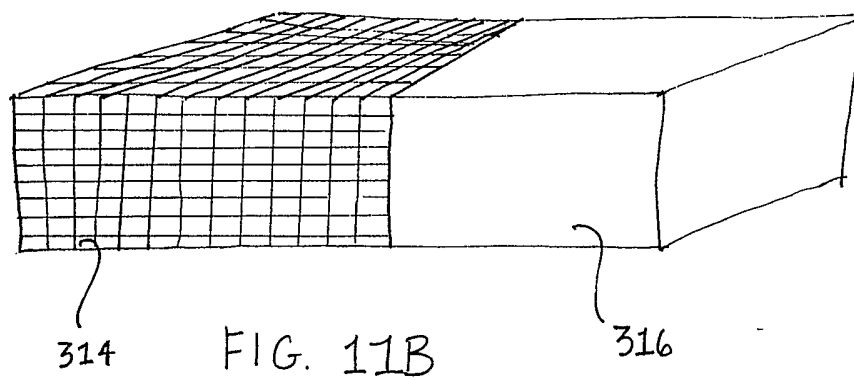
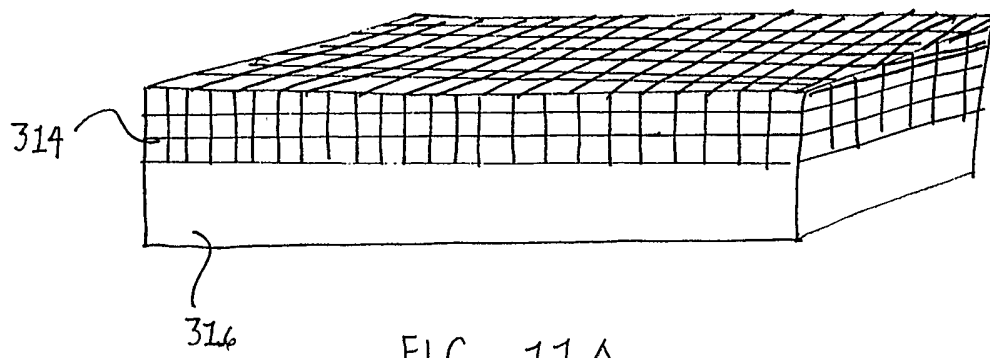


FIG. 10C



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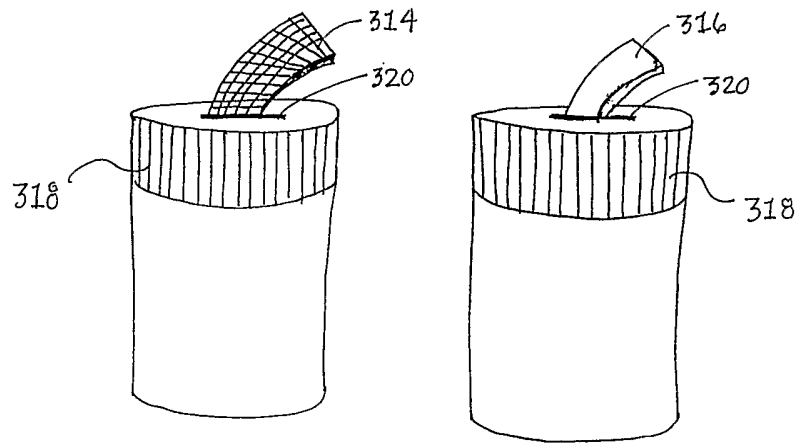


FIG. 12A

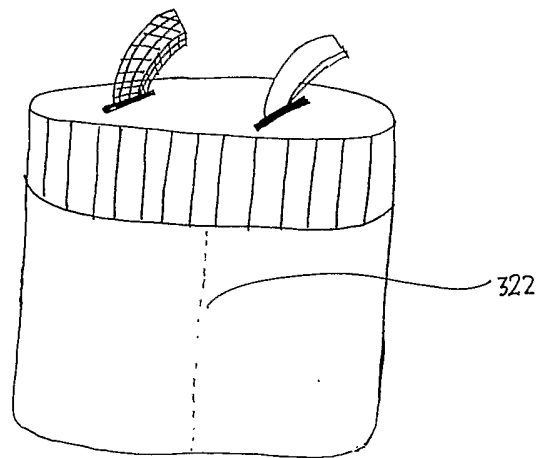


FIG. 12B

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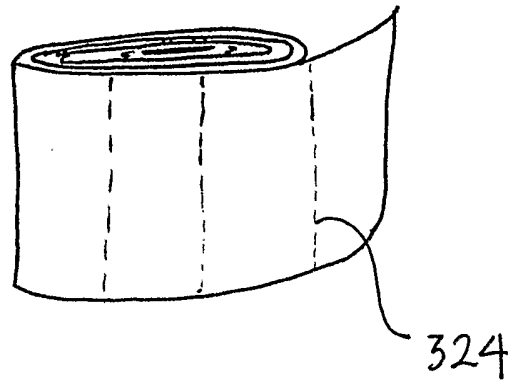


FIG. 13A

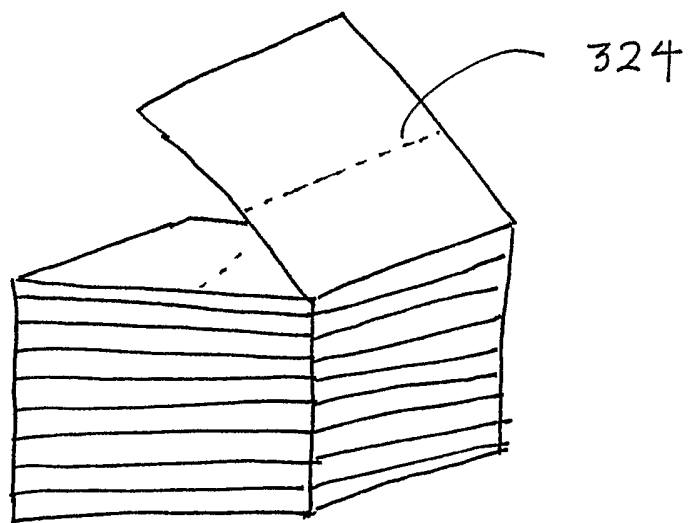


FIG. 13B

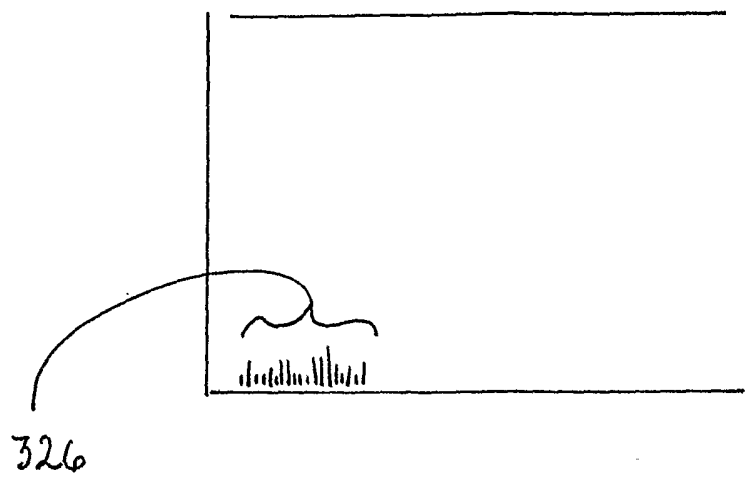


FIG. 14A

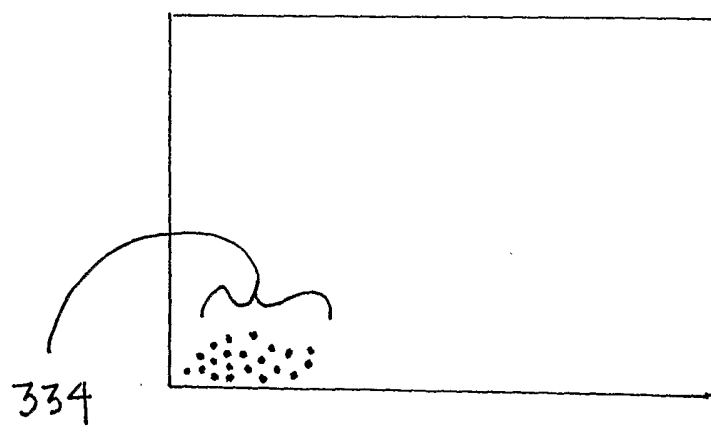


FIG. 14B

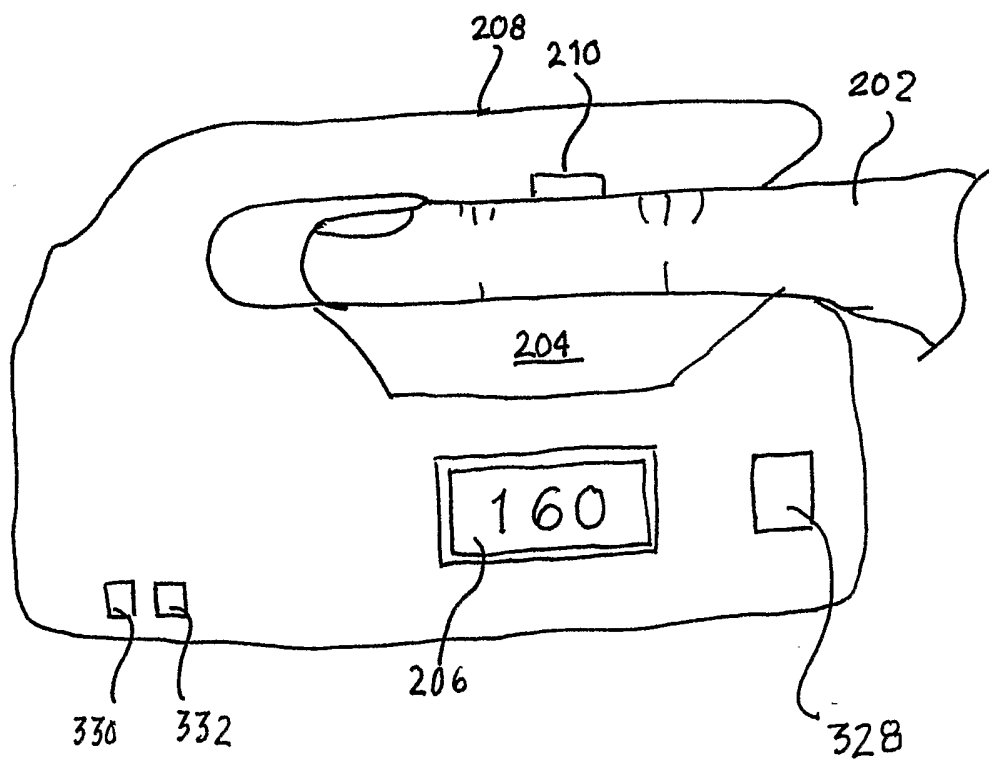


FIG. 15

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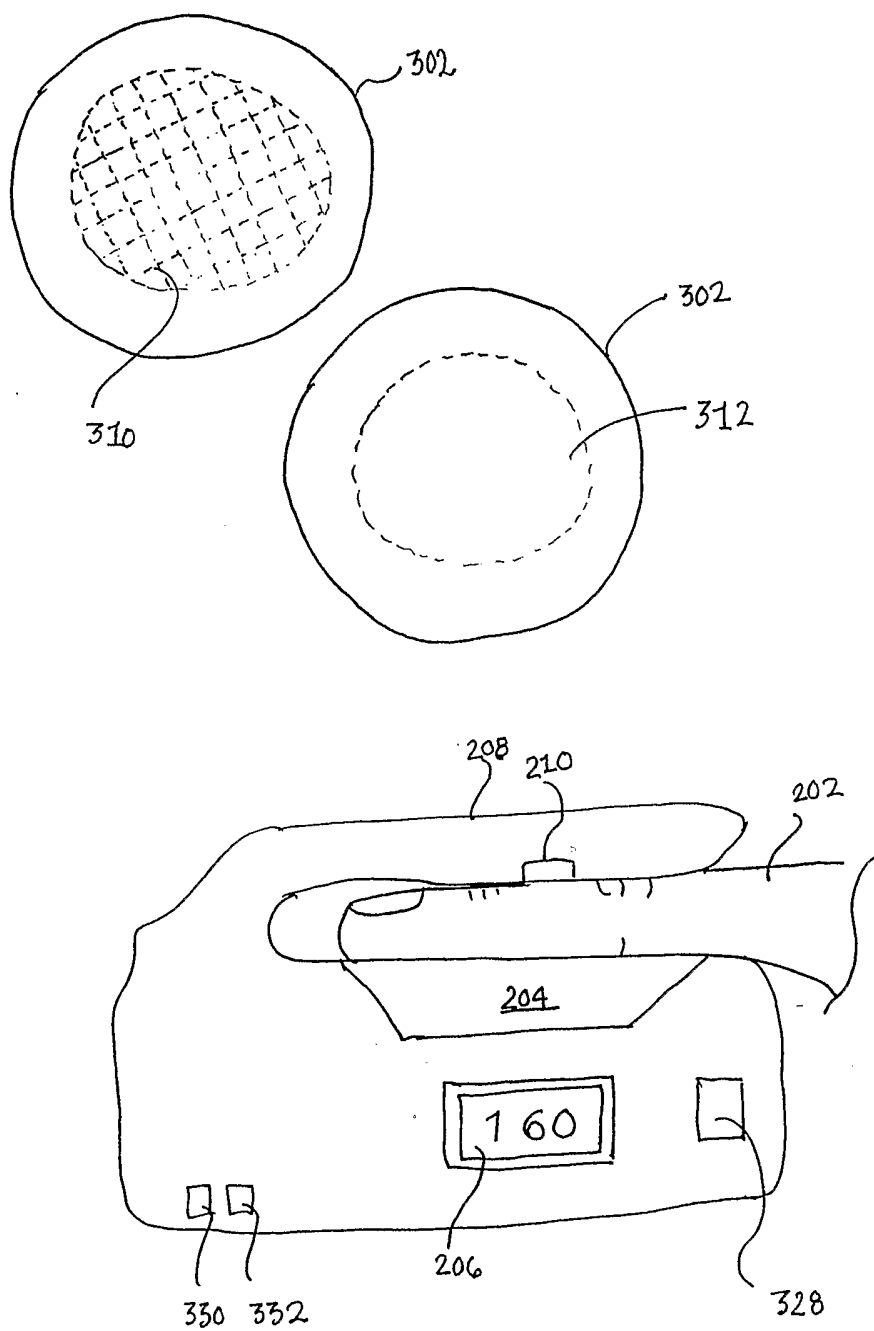


FIG. 16

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US2004/002611

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 A61B5/00 G01N21/55 A61K8/02

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 A61B G01N A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01/79818 A (ROE JEFFREY N ; MEDOPTIX INC (US); BERMAN HERBERT L (US)) 25 October 2001 (2001-10-25)  page 6, line 26 - page 8, line 14 claims 49-59 figure 3	1-4, 6-8, 10-14, 16-18, 20-23, 25-34
Y		5, 9, 15, 19, 24
Y	EP 0 520 443 A (PPG INDUSTRIES INC) 30 December 1992 (1992-12-30) column 52, line 34 - line 39  ----- -/--	5, 15

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

29 June 2004

Date of mailing of the international search report

06/07/2004

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# INTERNATIONAL SEARCH REPORT

International Application No  
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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

International Application No

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