US 20100286951A1

(19) **United States**

(12) **Patent Application Publication**

Danenberg et al.

(10) **Pub. No.: US 2010/0286951 A1**

(43) **Pub. Date: Nov. 11, 2010**

(54) **FOOT MEASURING DEVICE**

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(21) Appl. No.: **12/811,463**

(22) PCT Filed: **Jan. 5, 2009**

(86) PCT No.: **PCT/IL2009/000018**

§ 371 (c)(1),
(2), (4) Date: **Jul. 1, 2010**

(30) **Foreign Application Priority Data**

Jan. 7, 2008 (IL) 188645

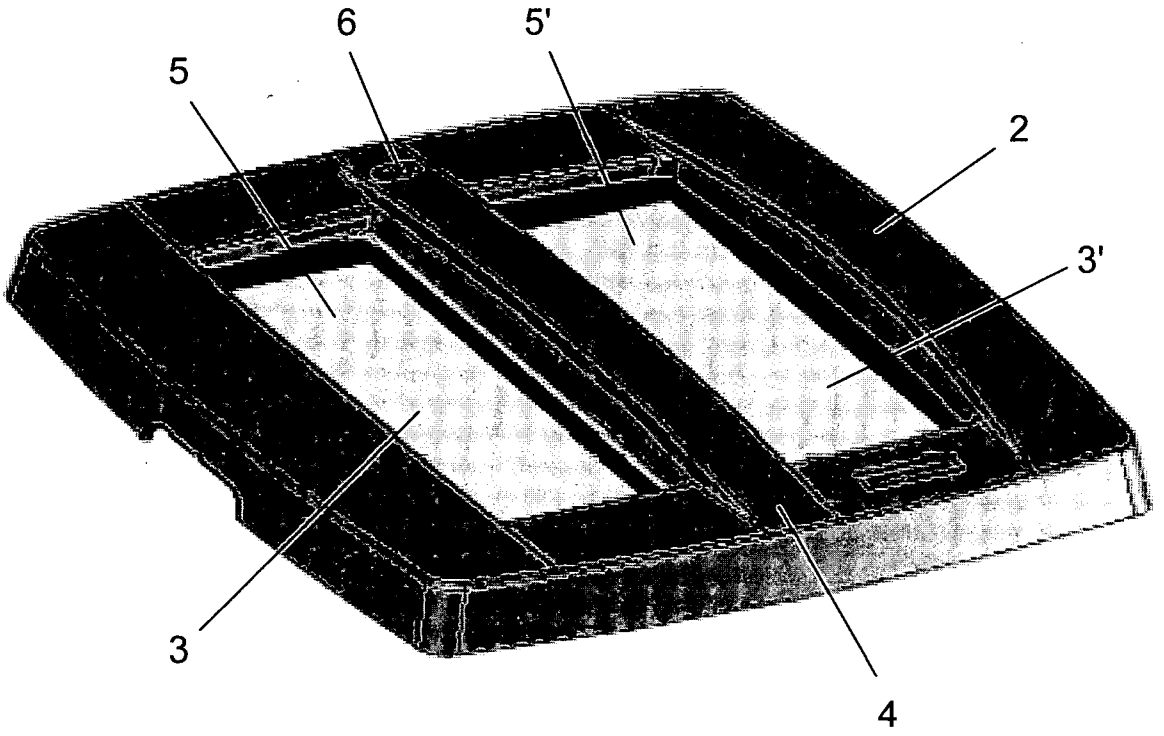
Publication Classification

(51) **Int. Cl.**
A43D 1/02 (2006.01)
G01B 11/02 (2006.01)

(52) **U.S. Cl.** ..... **702/172**; 33/3 R; 33/6

(57) **ABSTRACT**

The invention presents an apparatus for measuring the dimensions of human feet. The apparatus is comprised of a base (**20**) and a cover (**2**), which fits over it to define the borders of two essentially rectangular wells (**3**, **31**) in the upper surface of said base, into which the feet to be measured are placed. Pressure pads (**5**, **5'**) containing a sensor are placed at the bottom of each well and the perimeters of the well, are surrounded by arrays comprised of a multitude of emitter/detector pairs, which are used to make length and width measurements of said feet. In addition, computational means, which calculate the dimensions of the feet from data from the pressure pads and emitter/detector pairs and display means are provided. The apparatus is characterized in that the computational means comprises a software algorithm, which uses information supplied by the pressure pads to correct errors in the length and width measurements caused by misplacement/misalignment of the feet in the wells and the emitters and corresponding detectors are provided in two contiguous levels spaced in a way that increases the accuracy of the measurements. A method of using the apparatus is also presented.



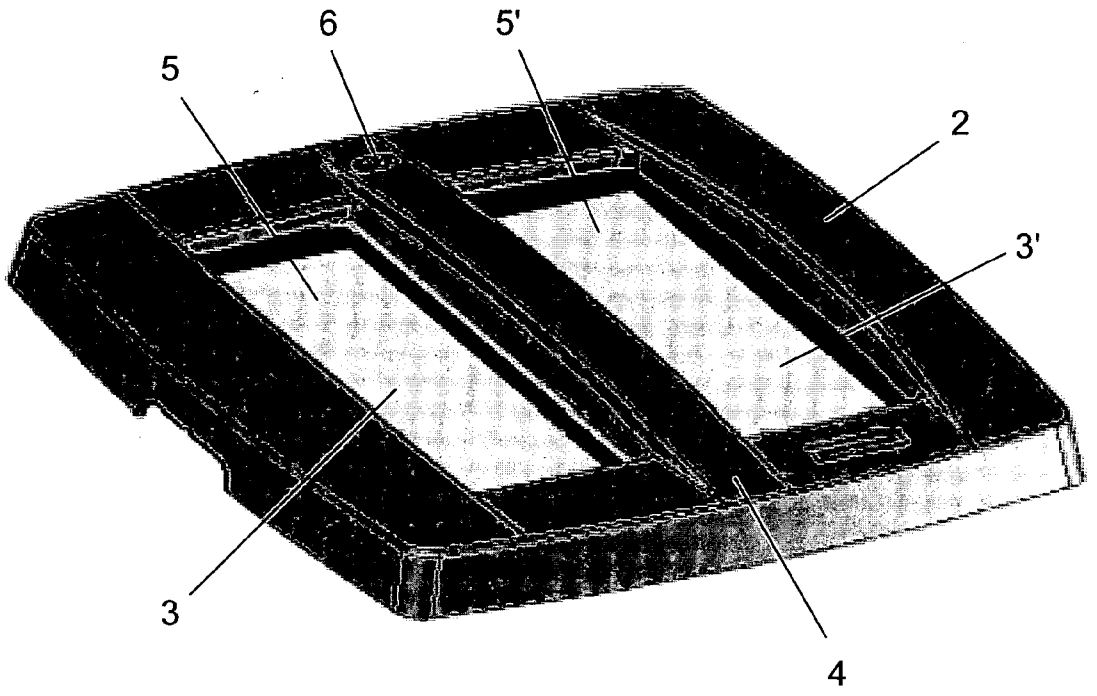


Fig. 1

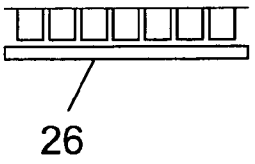


Fig. 2C

Fig. 2B

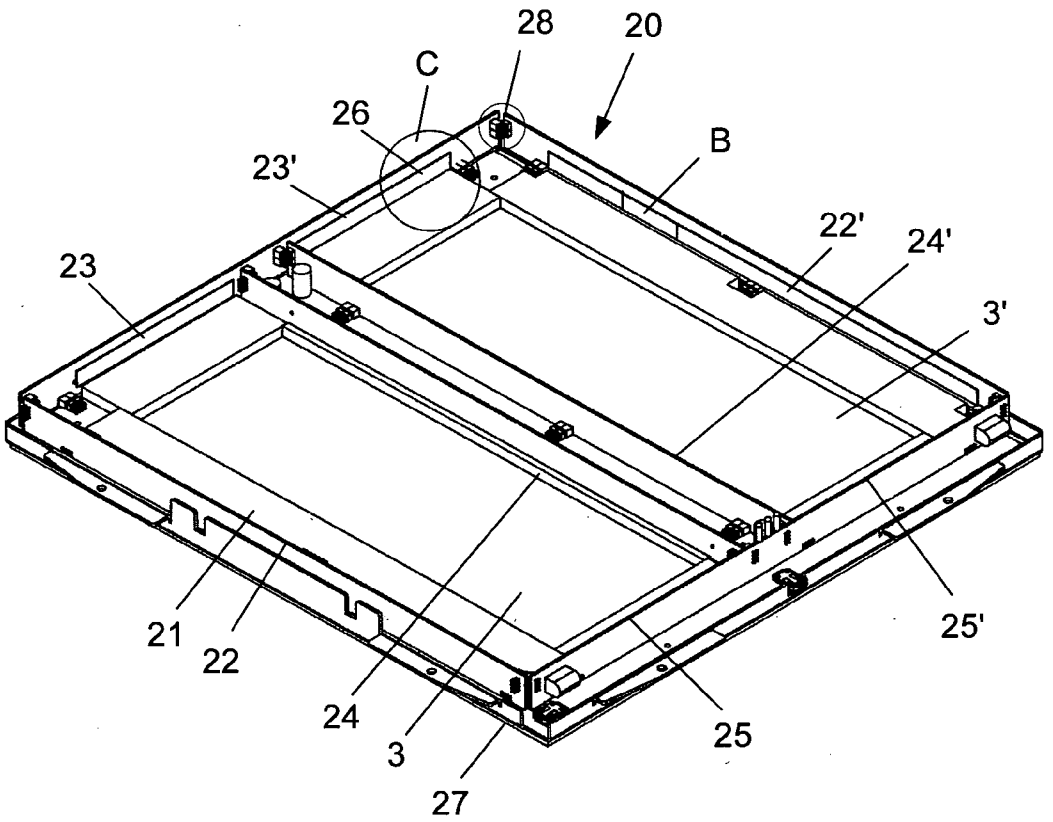


Fig. 2A

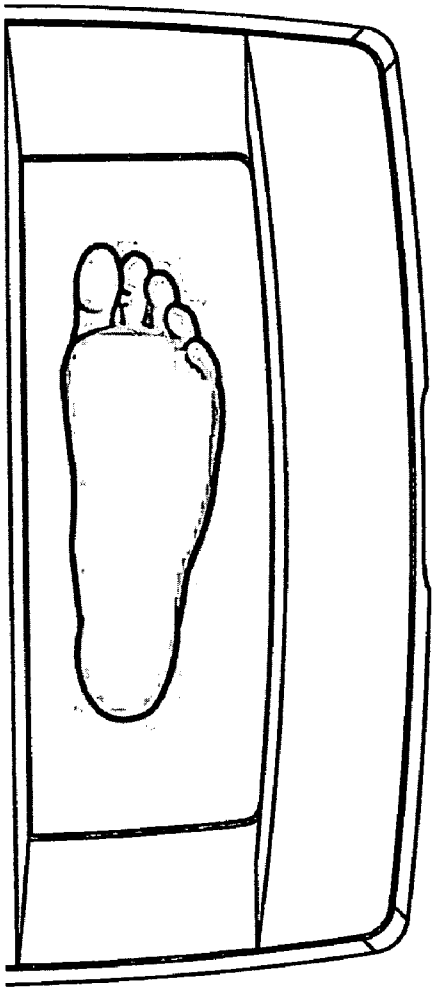


Fig. 3A

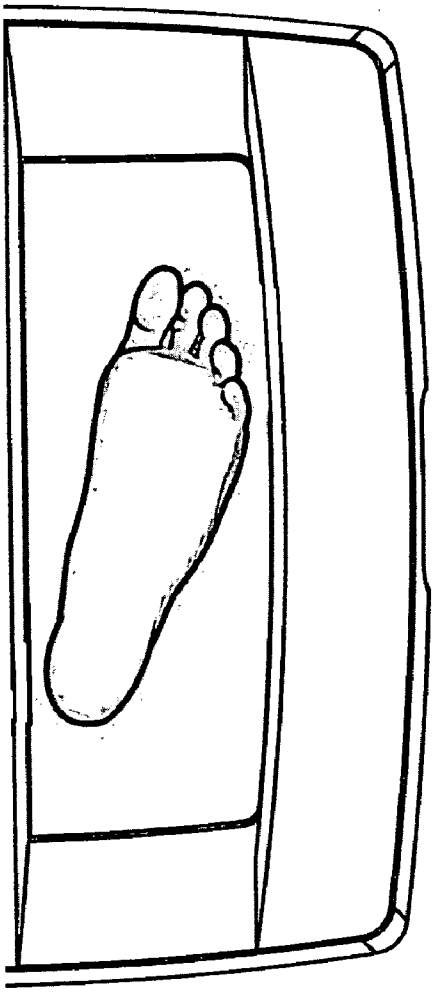


Fig. 3B

FOOT MEASURING DEVICE

FIELD OF THE INVENTION

[0001] The present invention is related to the field of measuring human feet for the purpose of determining shoe size and insole type. Specifically, the invention relates to an apparatus for optical measurement of feet which does not contain motors or moving parts.

BACKGROUND OF THE INVENTION

[0002] The problem of obtaining accurate foot measurements has existed since man first started to wear shoes. Many devices of varying degrees of complexity have been proposed over the years for providing two-dimensional measurements of length and width of the human foot in order to provide appropriately fitted shoes and insoles. Representative of such devices is that of Charles Brannock, disclosed in U.S. Pat. No. 1,725,334. Brannock's device, familiar to anyone who has ever visited a shoe store, basically consists of two slides mounted on an indexed base plate to determine the length and width of the foot.

[0003] Since Brannock's day the technology has improved, providing pressure sensors and light sensitive sensors of various types to measure the length and the width of the foot. In U.S. Pat. No. 5,659,395 is presented a system that improves somewhat on the existing foot measurement systems. The system disclosed in this patent utilizes a combination of a pressure pad assembly for each foot surrounded by a linear array of infrared light emitting diodes (LEDs) located around the perimeter on two sides of each pressure pad and two corresponding arrays of phototransistors acting as detectors on the opposing sides. The length and width measurements are determined by combining information provided by the pressure pad with the data from the infrared arrays indicating which of the optical paths are blocked by the foot placed between the emitters and the receivers. This system additionally has matrices of emitters and corresponding detectors to give height information at selected locations along the perimeter of the foot. However, U.S. Pat. No. 5,659,395 displays several significant disadvantages. First, the relatively large size and complexity of the apparatus makes it an expensive device, which may be prone to malfunction. Second, the accuracy of the measurements is limited by the size of the LEDs, because if a foot ends between two emitters, the reading will determine the size according to the last optical path blocked, with no consideration of in-between cases. Finally, for obtaining an accurate reading, the system requires that the axis of the measured foot is placed exactly parallel to the LEDs array, a relatively difficult task for many, especially children.

[0004] In allowed Patent Application 2007/0253004 by the same applicant, the description of which, including references cited therein, is incorporated herein by reference in its entirety, also describes a foot measuring device for the determination of feet dimensions. The device includes an optic means comprising two emitter/detector pairs, both surrounding two pressure pads assemblies, designed for each foot. The feet are measured by the use of mechanical moving components which enable the movement of the optical means in mutually orthogonal directions. Finally, the data obtained is stored, analyzed and displayed.

[0005] The field of retail shoe stores is an intensely competitive one in which each store owner must be able to provide a high level of service in order to achieve and maintain his share of the market. Part of providing such service would be to make available to his customers a system, for measuring their feet and using these measurements to supply good fitting shoes. In order to be able to provide this service, the measuring apparatus must be durable, reliable, and easy to operate; must provide accurate, easy to interpret results; and must be relatively inexpensive to purchase and operate.

[0006] It is a purpose of the present invention to provide an apparatus for measuring the length and width of the human foot.

[0007] It is another purpose of the present invention to provide an apparatus for measuring the length and width of a human foot that does not contain motors and moving parts, and that is easy to operate.

[0008] It is still another purpose of the present invention to provide an apparatus for measuring the length and width of a human foot with a high degree of accuracy.

[0009] It is yet another purpose of the present invention to provide an apparatus for measuring the length and width of a human foot that is relatively inexpensive to purchase and to operate.

[0010] It is still another purpose of the present invention to provide a method for calculating the exact length and width of a human foot in case that the foot was placed improperly in the measuring apparatus.

[0011] Further purposes and advantages of this invention will appear as the description proceeds.

SUMMARY OF THE INVENTION

[0012] The apparatus of the invention is meant to provide an accurate but inexpensive solution to the problem of measuring foot size for the purpose of selecting appropriately sized shoes. In order to accomplish this purpose, the apparatus measures the feet to determine their exact length and width.

[0013] In a first aspect the present invention is an apparatus for measuring the dimensions of human feet, comprising:

[0014] a. a base, which comprises and supports electrical and optical components;

[0015] b. a cover, which fits over the base to protect the components, and defines the borders of two essentially rectangular wells in the upper surface of the base, into which the feet to be measured are placed;

[0016] c. pressure pads containing a sensor matrix, which are used to provide structural and additional information of the feet;

[0017] d. a multitude of emitter/detector pairs, which are used to make length and width measurements of the feet;

[0018] e. computational means, which calculate the dimensions from the measurements; and

[0019] f. display means, which display the dimensions, the structural information and other pre-determined information/

[0020] The apparatus is characterized in that the computational means comprises a software algorithm, which uses information supplied by the pressure pads to correct errors in the length and width measurements caused by misplacement of the feet in the wells, and the emitters and corresponding detector are provided in two contiguous levels, wherein the upper level is offset by one half of the width of an individual emitter/detector.

[0021] In the preferred embodiment of the apparatus of the invention the light sources are infrared emitting light emitting diodes and the detectors are infrared sensitive phototransistors.

[0022] The computation means and the display means can be an integral part of, the apparatus or at least a part of them can be provided by a separate computation unit, for example a personal computer, that is not an integral part of the apparatus.

[0023] In another aspect the present invention is a method for using the apparatus of the first aspect to automatically measure the length and width of the feet of a human. The method comprises the following steps:

[0024] i. providing an apparatus of the invention;

[0025] ii. placing the feet in the wells;

[0026] iii. initiating the measurement process;

[0027] iv. activating the light source/detector pairs for making the length and width measurements;

[0028] v. sending the data received from the detectors to the computational means;

[0029] vi. activating the pressure sensors incorporated in the pressure pads;

[0030] vii. sending data received from the pressure pads to the computational means;

[0031] viii. calculating the position of the feet from the data received from the pressure pads;

[0032] ix. calculating the apparent length and width of the feet from the data received from the detectors;

[0033] x. in case of misplacement of the feet in the wells of the apparatus, activating a software algorithm for correcting the calculated apparent length and width of the feet, thereby obtaining the actual length and width of the feet; and

[0034] xi. displaying the results of the measurements.

[0035] In an embodiment of the method of the invention the activation of the light source/detector pairs, for making the length and width measurements, are carried out simultaneously and sent to the computational means with the activation of the pressure sensors incorporated in the pressure pads.

[0036] All the above and other characteristics and advantages of the invention will be further understood through the following illustrative and non-limitative description of preferred embodiments thereof, with reference to the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] FIG. **1** is a perspective view showing the external view of an embodiment of the measuring apparatus of the invention;

[0038] FIG. **2**A is a perspective view showing the interior of an embodiment of the apparatus of the invention;

[0039] FIG. **2**B is an enlarged view of the area "B" of FIG. **2**A, showing the arrangement of the emitter/detector LEDs in an embodiment of apparatus of the invention;

[0040] FIG. **2**C is an enlarged top view of the area "C" of FIG. **2**A, showing the Polaroid film located in front of the detector LEDs in an embodiment of apparatus of the invention;

[0041] FIG. **3**A is an overall view showing the outline of a foot correctly positioned in an embodiment of the measuring apparatus of the invention; and

[0042] FIG. **3**B is an overall view showing the outline of a foot misplaced in an embodiment of the measuring apparatus of the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0043] FIG. **1** is a perspective view showing the external view of a preferred embodiment of the measuring apparatus of the invention. A cover **2** made of a suitable material such as an impact resistant plastic is fitted over the base **20**. The cover **2** contains two endpoint connections **6** for Universal Serial Bus (USB) cables to enable delivery of commands from a computer controlling the apparatus, as well as the transfer of the measurement readings back to the computer. The cover also has an open area in its interior divided into two sections by a bridge element **4**, which defines two essentially rectangular wells **3**, **3'** into which the left and right feet to be measured are placed respectively. At the bottom of wells **3**, **3'** are located pressure pads **5**, **5'**, both comprising a matrix of pressure sensors positioned above a printed circuit board. A conductive rubber layer, characterized by an even resistance to pressure, is placed on each sensor matrix to ensure that each sensor records the exact pressure exerted on it by the measured foot. The software of the apparatus is adapted as required to include the results of the pressure measurements to give additional diagnostic information such as the structure of the arch. Additional uses of the pressure pads will be described herein below.

[0044] FIG. **2**A is a perspective view showing the interior of a preferred embodiment of the measuring apparatus of the invention. The base **20** of the measuring apparatus is comprised of a plate to which are attached strips **21** by attachment means **28**, which together define the walls of the wells **3**, **3'**. The walls are built of a suitable material such as a metal or an impact resistant plastic. In the preferred embodiment of the invention the strips **21** are fabricated from aluminum. The housing contains and supports on its surfaces and within its interior the electrical and optical components of the apparatus. On the top surface of the housing are created wells **3**, **3'** into which the left and right feet to be measured are placed. The floor of wells **3**, **3'** is covered with pressure pads **5**, **5'**.

[0045] The measurement is carried out optically by sources/detectors arranged in parallel line on opposite walls of each well **3**, **3'**. In the preferred embodiment of the apparatus of the invention the light sources are infrared light emitting diodes (LEDs) and the detectors are infrared sensitive phototransistors. The measurement is preformed by the emission of a light beam by each individual emitter LED and its detection (or not) by its corresponding detector. First are activated, one after the other, the emitter LEDs **24'**, which measure the length of the left foot; then emitter LEDs **24** which measure the length of the right foot; followed by emitter LEDs **25'**, which measure the width of the left foot; and finally, the width of the right foot is measured by emitter LEDs **25**. A small gap exists between the bottoms of wells **3**, **3'** and the lower part of the strips **27** and the bottom of the bridge **4**, to allow unobstructed passage of the light beams from source to detector in the absence of any object in one or both of the wells.

[0046] FIG. **2**B presents an enlarged view of the area designated as area "B" in FIG. **2**A, showing the arrangement of the emitter/detector in the apparatus of the present invention. An increased accuracy of the measurement is achieved in the apparatus of the present invention by providing of two levels

of emitters and corresponding detectors, wherein the levels are contiguous to each other and the upper level is offset by one half of the width of an individual emitter/detector.

[0047] In an embodiment the light beams transmitted by the emitter LEDs are infrared rays in the length of 940 nm, and the detectors detect light in the range of 940 nm. The detection of light in the range below 900 nm is prevented by 2 layers of Polaroid film **26** located in front of the detectors, thereby improving the accuracy of the measurement by filtering out stray signals caused by ambient light. FIG. **2**C presents an enlarged top view of the area designated as area "C" in FIG. **2**A, showing Polaroid film **26** in front of the array of detectors.

[0048] In the preferred embodiment of the apparatus of the invention the LEDs are activated one at a time in sequence, to ensure that each single detector receives only the signal of its corresponding emitter LED. A complete scan of a foot including the transmission of the measurements to the processing unit is a very quick process that ends in about 3000 milliseconds.

[0049] If a foot is placed in one or both wells **3**, **3'** then when a light beam transmitted from an emitter hits the first edge of the measured foot, the corresponding detector will not detect the light, and will not send a signal to the processing unit. Once the foot no longer blocks the beams, the signal will resume again, and subsequently the processing unit calculates the dimensions of the measured foot. The feet can be scanned one after the other or in another embodiment simultaneously.

[0050] Not shown in the figures are the electronic connections, wires, cables, etc. Preferably, the apparatus is connected by a USB cable to an external device, such as a personal computer (PC), which contains the software for operating the apparatus, receiving the signals from the detectors and pressure pads, and from these data, calculating the dimensions of the foot being measured, and finally displaying the results. Optionally, some or all of the operations described as being performed by an external PC can be performed by computing and display means built into the apparatus.

[0051] In order to reduce measurement errors to minimum, the apparatus of the present invention is programmed to self-test each emitter/detector pair before the measured foot is placed in the device, and later compare the results to the data collected from the foot measurement. This enables the software to neutralize any inaccuracy in the readings resulting from degradation of the LEDs.

[0052] Another software algorithm runs automatically during the foot measurement for the detection of continuous values, so that if there is any in-consistency in the reading of a single LED, the software is programmed to ignore it.

[0053] A preferred embodiment of the present invention comprises a software algorithm that uses data received from the pressure pads to correct measurement errors caused by misplacing/misaligning the foot in the apparatus. FIG. **3**A is an overall view showing the outline of a foot correctly positioned in the apparatus of the invention. In order to receive exact dimensions of the measured foot, it is important the foot is placed in parallel to emitter/detector array. However, if a foot is misplaced, as shown in FIG. **3**B, which is an overall view showing the outline of such foot, than the measurement results are used by the above-described algorithm for calculation of new length and width. For this end, the algorithm finds the middle point of the top part of the foot and the middle point of the bottom part of the foot. Next, the angle between these points is determined, and finally the new length and width are calculated based on this angle. This key property of the invention enables to measure the feet of anyone, including children, since it does not require a certain foot position for obtaining exact and reliable results.

[0054] For purposes of fitting a pair of shoes, the person whose feet are to be measured simply removes his/her shoes and (optionally) stockings and steps into wells **3**, **3'**. Optimally, this foot is placed exactly in parallel to the array of LEDs, but this is not essential, as described above. The start switch is now pressed initiating the measurement process. In an embodiment of the invention, the measurement starts with left foot length then right foot length followed by left foot width and finally right foot width. Nevertheless, the measurement can be taken in any order with no effect on the results. Initially, there is no obstacle between the emitter LEDs and the detector LEDs, and only when the edge of the heel is reached, the beam blocked. The same approach is used for the measurement of the width of the feet. The length between the disappearance and the reappearance of the signals from the detectors is stored and used to determine the required shoe size of each foot.

[0055] In the preferred embodiment of the invention, after the person whose feet are to be measured steps into the wells of the device and the start button on the computer is pushed, all of the measuring process until the final results are displayed is carried out automatically under control of the computer which sends commands to the device and receives the return signals from the sensors which are either used immediately to guide the process or stored for later use when required.

[0056] The results of the measurements appear on the display and can appear in many forms including, but not limited to: the measurements expressed in centimeters or inches, the recommended shoe size, and additional information such as pictures of appropriately sized shoes of different types that are either available in the inventory of the store or can be ordered for home delivery.

[0057] Although embodiments of the invention have been described by way of illustration, it will be understood that the invention may be carried out with many variations, modifications, and adaptations, without departing from its spirit or exceeding the scope of the claims.

1. An apparatus for measuring the dimensions of human feet, comprising:

a. a base, which comprises and supports electrical and optical components;

b. a cover, which fits over said base to protect said components, and defines the borders of two essentially rectangular wells in the upper surface of said base, into which said feet to be measured are placed;

c. pressure pads containing a sensor matrix, which are used to provide structural and additional information of said feet;

d. a multitude of emitter/detector pairs, which are used to make length and width measurements of said feet;

e. computational means, which calculate said dimensions from said measurements; and

f. display means, which display said dimensions, said structural information and other pre-determined information;

characterized in that said computational means comprises a software algorithm, which uses information supplied by said pressure pads to correct errors in said length and width mea-

surements caused by misplacement/misalignment of said feet in said wells, and said emitters and corresponding detector are provided in two contiguous levels, wherein the upper level is offset from the lower level by one half of the width of an individual emitter/detector.

2. An apparatus according to claim **1**, wherein the light sources are infrared emitting light emitting diodes.

3. An apparatus according to claim **1**, wherein the detectors are infrared sensitive phototransistors.

4. An apparatus according to claim **1**, wherein the computation means and the display means are an integral part of said apparatus.

5. An apparatus according to claim **1**, wherein at least a part of the computation means and the display means are provided by a separate computation unit that is not an integral part of said apparatus.

6. An apparatus according to claim **5**, wherein the separate computation unit is a personal computer.

7. A method for using the apparatus of claim **1** to automatically measure the length and width of the feet of a human comprising the following steps:

i. providing an apparatus as defined in claim **1**;

ii. placing the feet in the wells;

iii. initiating the measurement process;

iv. activating the light source/detector pairs for making the length and width measurements;

v. sending the data received from said detectors to the computational means;

vi. activating the pressure sensors incorporated in the pressure pads;

vii. sending data received from said pressure pads to the computational means;

viii. calculating the position of the feet from said data received from said pressure pads;

ix. calculating the apparent length and width of the feet from said data received from said detectors;

x. in case of misplacement/misalignment of said feet in the wells of said apparatus, activating a software algorithm for correcting said calculated apparent length and width of the feet, thereby obtaining the actual length and width of said feet; and

xi. displaying the results of the measurements.

8. A method according to claim **7**, wherein steps (iv) to (v) are carried out simultaneously with steps (vi) and (vii).

* * * * *