or may be constructed as a stand-alone device with its own user interface, power supply and other electronic and mechanical components.

As shown in Figure 1, a photo-emitter (81) transmits a beam of light that passes through a filter (82) to select the spectral band of the light to be used. The spectral band is chosen to allow inexpensive components and materials to be used whilst maximising the sensitivity and discrimination with respect to the analyte. The beam is collimated by a lens (83) to shine through a body part, such as a finger (84). A beam splitter (85) divides the beam between a non-analyte cell (86) and analyte cell (87). Photo-detectors (88) measure the intensity of the beam after it has passed through each cell. A differential amplifier may be used to amplify the difference in signals from the two photo-detectors.

Figure 2 shows another arrangement in which the photo-emitter and photo-detector are on the same side of a body part, the photo-detector being sensitive to the light scattered back from the body part. A moving mirror (101) reflects light sequentially to each of two fixed mirrors (102) and hence to the non-analyte cell (86) or analyte cell. The photo-detector (108) measures the intensity of the beam that has passed the cells.

In each of these arrangements, the difference between the intensity when the beam of light has passed through the non-analyte cell and through the analyte cell is a measure of the amount of absorption by the analyte within the body part.

The invention disclosed in WO 2013/001265 goes some way towards the goal of a sensor that is non-invasive, inexpensive, accurate and reliable. However, it is not specific to the analyte contained in blood because the signal is also affected by analyte in the surrounding tissue. Further improvements are also desirable to reduce the cost of implementation and to improve accuracy.

The Present Invention

Embodiments of the present invention greatly improve on the performance of the PHHM. Embodiments of the present invention exploit more effectively a second degree of correlation to improve specificity.

Disclosed herein is a personal hand-held monitor (PHHM) comprising a signal acquisition device for acquiring signals which can be used to derive a measurement of a parameter related to the health of the user, the signal acquisition device being integrated with a personal hand-held computing device (PHHCD), wherein the signal acquisition device comprises a blood photosensor having one or more photo-emitters for transmitting light to a body part of a user, one or more photo-detectors for detecting light transmitted through or scattered by the body part and two or more optical cells, at least one of which contains an analyte to be detected or which mimics the absorption spectrum of the analyte to be detected, through which the light that has been or will be transmitted through or scattered by the body part passes before it reaches the or each photo-detector, wherein the processor of the PHHM is adapted to process the signals received from the or each photo-detector to calculate the difference in intensity of light which has passed through the or each analyte cell and light which has passed through the or each non-analyte cell and to process signals

obtained from the photosensor in the presence of the body part and in the absence of the body part to provide a measurement of the concentration of the analyte in the user's blood.

Preferably, the processor of the is adapted to determine the pulse of the user and to correlate the signals obtained from the photosensor with the user's pulse in providing a measurement of the analyte in the user's blood. The processor of the PHHM may be adapted to analyse the signals received from the blood photosensor to determine the pulse of the user. Alternatively, the PHHM may include an electrical sensor comprising at least a first and a second electrode which are electrically isolated from one another and which are arranged to be contacted by two separate parts of the user's body, such as a finger on one hand and a finger on the other hand, and the processor of the PHHM is adapted to analyse the signals from the electrical sensor to determine the pulse of the user. Such an electrical sensor is disclosed in WO 2013/001265.

Disclosed herein is a personal hand-held monitor (PHHM) comprising a signal acquisition device for acquiring signals which can be used to derive a measurement of a parameter related to the health of the user, wherein the signal acquisition device comprises a blood photosensor having one or more photo-emitters for transmitting light to a body part of a user, one or more photo-detectors for detecting light transmitted through or scattered by the body part and two or more optical cells, at least one of which contains an analyte to be detected or which mimics the absorption spectrum of the analyte to be detected, through which the light that has been or will be transmitted through or scattered by the body part passes before it reaches the or each photo-detector, wherein the processor of the PHHM is adapted to process the signals received from the or each photo-detector to calculate the difference in intensity of light which has passed through the or each analyte cell and light which has passed through the or each non-analyte cell, to determine the pulse of the user and to correlate the signals obtained from the photosensor in the presence of the body part and in the absence of the body part with the user's pulse to provide a measurement of the concentration of the analyte in the user's blood.

The processor of the PHHM may be adapted to analyse the signals from the blood photosensor to determine the pulse or the PHHM may include an electrical sensor as referred to above.

Preferably, the PHHM is self-contained and includes a processor, display and control, communications and storage means to provide a measurement of the concentration of the analyte in the user's blood. Alternatively, the signal acquisition device is integrated with a personal hand-held computing device (PHHCD).

Preferably, in order further to improve the selectivity for the concentration of the analyte in blood, the processor of the PHHM is adapted to measure the intensity of a beam of light for use in photoplethysmography (PPG) to identify the time at which an artery in the body part dilates due to systole. The change in absorption at this point is a consequence solely of the additional amount of

paths through or to and from the body part. Multiple photo-detectors may be employed or the light through more than one non-analyte cell may be collected by one photo-detector and the light through more than one analyte cell be similarly collected.

WO 2013/001265 discloses a PHHM which is adapted to differentiate between signals when the body part is present from signals when it is not. It also discloses a way in which the properties of an artery during the pulse cycle may be exploited. It is well-known that the luminal area of an artery varies as a function of the pressure difference between the arterial blood pressure and the pressure imposed on the artery wall by the surrounding tissue. This is the principle of the Riva-Rocci sphygmomanometer. This is the basis of the disclosure in WO 2013/001265. In addition, the magnitude of the change of luminal area is greatest when the imposed pressure is close to or slightly greater than the diastolic blood pressure in the artery.

Preferably, the PHHM as per embodiments of the present invention includes a means for applying pressure to the body part in the region of an artery, a means for measuring the change in luminal area with each pulse and a means for adjusting the imposed pressure so as to approximate to diastolic blood pressure and thus maximise the change in luminal area. The processor of the PHHM is adapted to detect the difference between the signals from the photosensor when the artery is patent (*i.e.* at systole when the artery is expanded because the arterial pressure exceeds the imposed pressure) and those when it is occluded (*i.e.* at diastole when the artery is collapsed because the arterial pressure is less than the imposed pressure).

The signal analysis of the PHHM is thus coherent with the user's pulse.

According to an aspect of the present invention, there is provided a personal hand-held monitor (PHHM) comprising a signal acquisition device for acquiring signals which can be used to derive a measurement of a parameter related to the health of the user, wherein the signal acquisition device comprises a blood photosensor having one or more photo-emitters for transmitting light to a body part of a user, one or more photo-detectors for detecting light transmitted through or scattered by the body part and two or more optical cells, at least one of which contains an analyte to be detected or which mimics the absorption spectrum of the analyte to be detected, through which the light that has been or will be transmitted through or scattered by the body part passes before it reaches the or each photo-detector, wherein the processor of the PHHM is adapted to process the signals received from the or each photo-detector to calculate the difference in intensity of light which has passed through the or each analyte cell and light which has passed through the or each non-analyte cell, to determine the pulse of the user and to correlate the signals obtained from the photosensor with the pulse of the user, wherein the PHHM is adapted to apply pressure to the body part or to have pressure applied to it by the body part so that, in use, an artery in the body part changes from occluded to patent during each pulse and the processor of the PHHM is adapted to derive a measurement of the change in the luminal area

of the artery during each pulse and to correlate the signals received from the blood photosensor with the pulse and the change in the luminal area of the artery to provide a measurement of the concentration of the analyte in the arterial blood.

The means for applying an external pressure to the body part and means for detecting the change in luminal area on each pulse may comprise optical sensors as described in WO 2013/001265.

Preferably the processing means of the PHHM is further adapted to provide audible or visual feedback to the user so that the external pressure may be applied and maintained by the actions of the user, either by pressing the PHHM against the body part or the body part against the PHHM.

This preferred feature as per an embodiments of the invention has the benefit of simplifying the way of making measurements but also ensures that the difference between the signals that is measured depends effectively only on the quantity of analyte in the arterial blood and not on that in the surrounding tissue.

Preferably, the or each photo-detector is an InGaAs photo-detector. These offer improved signal to noise ratio over the photo-detectors proposed previously.

The signal obtained from the difference between the signals obtained from the non-analyte and analyte cells, or from the different windows of the rotating disc, must be normalised to estimate the concentration of analyte in the arterial blood. This normalisation may be non-linear. Preferably, the normalisation takes account of the amplitude of the signal from each cell, both with the artery patent and with it occluded, and the amplitude of the signal when the body part is absent. Preferably, it further takes account of the amplitude of the signal indicative of the luminal area to find the concentration of the analyte rather than the total quantity within the field of view of the sensor. Preferably, the processor of the PHHM is adapted to process signals received from the photosensor when the or each photo-emitter is turned off or the light emitted therefrom is completely blocked to compensate signals received when the light from the photo-emitter illuminates the body part for ambient light.

The present invention is described below with reference to the accompanying drawings by way of example only. The invention is not limited to the embodiments shown in the accompanying drawings. The scope of the invention is defined in the accompanying claims.

In the accompanying drawings:

Figures 1 and 2 show arrangements for an optical sensor to be used in a PHHM as disclosed in WO 2103/001265;

Figure 3 shows an arrangement of an optical sensor using a rotating disc;

Figure 4 shows an arrangement of an optical sensor using a thermal emitter; and

Figure 5 shows a graph derived from a mathematical model of the performance of an embodiment of the invention.