(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
4 December 2003 (04.12.2003)

PCT

(10) International Publication Number
WO 03/100377 A2

(51) International Patent Classification[7]: G01N

(21) International Application Number: PCT/NZ03/00106

(22) International Filing Date: 26 May 2003 (26.05.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
519198 27 May 2002 (27.05.2002) NZ

(71) Applicant (*for all designated States except US*): **SENSORTEC LIMITED** [NZ/NZ]; PO Box 20055, 533 Grey Street, 2001 Hamilton (NZ).

(72) Inventor; and
(75) Inventor/Applicant (*for US only*): **WHYTE, David, Simon** [NZ/NZ]; 258 Rotokauri Road, RD 9, 2001 Hamilton (NZ).

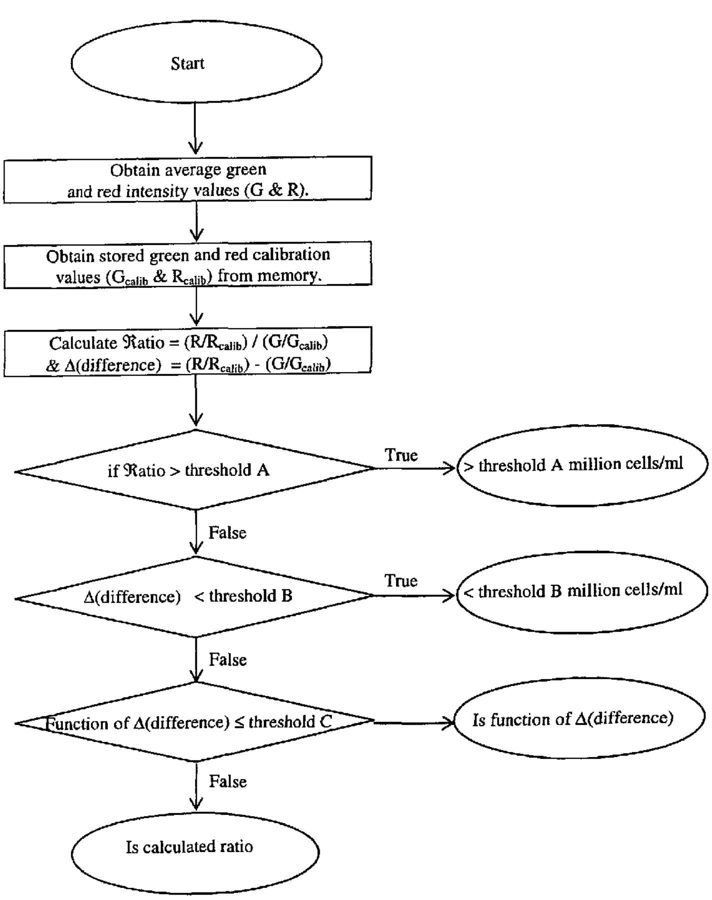
(74) Agents: **WILSON, Kathryn, Shelley** et al.; Private Bag 3140, Level 12, KPMG Centre, 85 Alexandra Street, 2001 Hamilton (NZ).

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: IMPROVED DETECTION SYSTEM AND METHOD OF DETECTION



(57) Abstract: The present invention relates to an improved detection system and method of detection preferably adapted for use with milk based products. The present invention can provide a detection system adapted to detect the presence of a specific component within a compound, where this system includes one or more transmitters which are adapted to emit energy into the compound involved. The system also includes one or more receivers adapted to receive energy reflected, scattered or transmitted through the compound. One or more of these transmitters and one or more of these receivers are adapted to emit or receive energy with a first frequency band which is affected by the presence of a specific component to be detected and one or more of these transmitters and one or more of these receivers are adapted to emit or receive energy with a second frequency band which is not affected by the presence of the specific component to be detected.

WO 03/100377 A2

Published:
— *without international search report and to be republished upon receipt of that report*

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.

IMPROVED DETECTION SYSTEM AND METHOD OF DETECTION

TECHNICAL FIELD

This invention relates to improvements to detection systems, and also methods of detecting specific components within a compound. Preferably the present invention may be adapted to provide an in-line sensor or detection system which can detect the presence of a specific component within a compound travelling through a delivery line. However, those skilled in the art should appreciate there are other applications also envisioned, and reference to the above throughout this specification should in no way be seen as limiting.

BACKGROUND ART

Numerous different types of machines have been developed to assist in the chemical analysis of compounds. These machines are normally used within a laboratory, and can both indicate the presence of a particular component, as well as its concentration in a compound. Such analytical devices can provide results with a high degree of accuracy through the use of relatively expensive and bulky equipment.

These types of laboratory machines can only be employed to analyse batches of discreet samples, with significant delays between the taking of a sample and its transportation to the laboratory for subsequent analysis. In some applications it is preferable to have an "in-line" sensor or detection system which can detect the presence (and potentially the concentration) of particular compound components travelling through a delivery line, or within a storage vessel. These in-line sensors or detectors can be used in quality control applications to check the quality of a compound before it is released from a delivery line or storage environment.

In-line detection systems preferably need to be implemented with relatively small physical components. Small components limit the potential for the detector to interfere with the flow or supply of the compounds which are to be analysed. A relatively small component design also allows these types of detectors to be retro-fitted to existing manufacturing plants or other forms of equipment.

Furthermore, it is also preferable to construct such in-line sensors from relatively robust components which can still perform effectively in harsh environments. For example, in some instances it is preferable to have an in-line sensor which can function at high or low temperatures or after exposure to or immersion in water, acidic or alkaline liquids, or other fluids with an organic nature such as milk.

Applications for this type of in-line detection technology can be found in the dairy industry. An in-line detector may, for example, be placed into a supply line of a dairy shed between the milking cups used to extract milk from an animal's udder and a collection vat for all the milk collected from a herd during milking. Such in-line detection systems can be employed to shunt or filter out milk from a particular animal if contaminant components are detected within the animal's milk before the milk reaches the collection vat. Contaminants such as blood, puss, urine, faecal material, colostrums or forms of medication can potentially be detected within an animal's milk, which can subsequently be prevented from reaching the collection vat.

However, in-line milk quality sensors or detectors are difficult to design with a reasonable degree of accuracy. Milk has a variable fat concentration depending on the particular animal being milked. Fat content within milk can provide a biasing effect on the results of standard spectrometry based sensors using a visible, infra-red or near infra-red light energy transmitted or scattered through milk. The variable fat content of milk to be analysed needs to be considered, making calibration of such contaminant detectors and their subsequent accurate operation difficult.

Furthermore, similar biasing or error producing effects may also be produced by compounds other than fat particles. In milk line sensing applications, other types of particles such as for example, proteins, entrained air or other gases within the milk in the line may all again cause such biasing or error producing effects. These scattering producing components (or scattering components) present within milk need to be considered during calibration of contaminant detectors and the subsequent operation and use.

It would be of advantage to have an improved detector system which has a compact design, enabling use as an in-line detection sensor or system. Furthermore, it would also be of advantage to have a detection system which could be used to accurately detect contaminant components of milk within a milk supply line - irrespective of the presence of scattering components present within such milk.

All references, including any patents or patent applications cited in this specification are hereby incorporated by reference. No admission is made that any reference constitutes prior art. The discussion of the references states what their authors assert, and the applicants reserve the right to challenge the accuracy and pertinency of the cited documents. It will be clearly understood that, although a number of prior art publications are referred to herein, this reference does not constitute an admission that any of these documents form part of the common general knowledge in the art, in New Zealand or in any other country.

It is acknowledged that the term 'comprise' may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this specification, and unless otherwise noted, the term 'comprise' shall have an inclusive meaning - i.e. that it will be taken to mean an inclusion of not only the listed components it directly references, but also other non-specified components or elements. This rationale will also be used when the term 'comprised' or 'comprising' is used in relation to one or more steps in a method or process.

It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

DISCLOSURE OF INVENTION

According to one aspect of the present invention there is provided a detection system adapted to detect the presence of a specific component within a compound, the system including,

one or more transmitters adapted to emit energy into said compound, and

one or more receivers adapted to receive energy reflected, scattered or transmitted through said compound, and

whereby said one or more transmitters and said one or more receivers are adapted to emit or receive energy with a first frequency band which is affected by the presence of the specific component to be detected, and

said one or more transmitters and said one or more receivers are adapted to emit or receive energy with a second frequency band which is not affected by the presence of the specific component to be detected.

According to another aspect of the present invention there is provided a detection system substantially as described above, wherein the first and second energy frequency bands are affected by the presence of at least one non-specific component within the compound.

According to a further aspect of the present invention there is provided a detection system substantially as described above which includes two or more transmitters and one or more receivers.

According to an additional aspect of the present invention there is provided a detection system substantially as described above which includes two or more transmitters and two or more receivers.

According to yet another aspect of the present invention there is provided a detection system substantially as described above wherein at least one transmitter is adapted to emit visible or near infra-red light.

According to yet another aspect of the present invention there is provided a detection system substantially as described above wherein at least one transmitter is formed from a light emitting diode.

According to yet another aspect of the present invention there is provided a detection system substantially as described above which includes at least one transmitter formed from a light emitting diode adapted to emit substantially green light, and at least one transmitter formed from a light emitting diode adapted to emit substantially red light.

According to yet another aspect of the present invention there is provided a detection system substantially as described above wherein the output of a receiver receiving energy emitted with a second frequency band is adapted to correct for the effect of a variable concentration of at least one scattering component on the output of a receiver receiving energy emitted with a first frequency band.

According to a further aspect of the present invention there is provided a detection system substantially as described above which is adapted to provide an in-line detector which includes an inlet and an outlet, said inlet and outlets being connected in series to at least one supply line of a milking machine system.

According to a further aspect of the present invention there is provided a detection system substantially as described above wherein the component to be detected is at least one blood related compound.

According to yet another aspect of the present invention there is provided a detection system substantially as described above wherein milk is the compound analysed.

According to a further aspect of the present invention there is provided a method of detecting a specific component within a compound characterised by the steps of;

(i) transmitting energy with a first frequency band at the compound, and

(ii) transmitting energy with a second frequency band at the compound, and

(iii) receiving reflected, scattered or transmitted energy with a first frequency band and generating a first band output signal, and

(iv) receiving reflected, scattered or transmitted energy with a second frequency band and generating a second band output signal, and

(v) correcting for the effect of non-specific components within the compound on the first band output signal using the second band output signal, and

(vi) using the corrected first band output signal to detect the presence and/or concentration of said specific component within the compound.

The present invention is adapted to provide a detection system and also preferably a method of detecting a specific component within the compound. Preferably such a detection system and method may also provide an indication as to the concentration or amount of the specific component within the compound analysed, in addition to just indicating the presence of same within the compound.

The specific component detected and also the compound analysed will vary depending on the particular application within which the present invention is used.

For example, in a preferred embodiment the compound analysed may be milk, either from cows, sheep, goats or any other lactating mammal. Milk is a useful food product which should have its quality monitored through all stages of collection and subsequent processing and packaging.

Reference throughout this specification will also be made to the compound analysed being milk, preferably sourced from a dairy cow. However, those skilled in the art should appreciate that other types of compounds may also be investigated using the present invention and reference to the above only throughout this specification should in no way be seen as limiting.

In a preferred embodiment the specific component to be detected within the milk analysed may be a contaminant, which will either need removal from the milk or require isolation of the milk which contains the contaminant component. Contaminants such as blood, urine, faecal material, pus, colostrum, medicinal chemicals or other similar contaminants may potentially be detected using the present invention.

In a further preferred embodiment the specific component to be detected may be at least one blood related compound present within milk. The presence of blood related compounds within milk needs to be avoided due to food quality reasons and it is also preferable to detect the presence of same during milk collection to identify health problems associated with a particular animal.

Those skilled in the art should appreciate that blood related compounds may include blood itself, red blood cells, haemoglobin or myoglobin compounds. All of the above constitute blood related compounds, preferably to be detected as a specific component in conjunction with the present invention.

Reference throughout this specification will also be made to the specific component to be detected within the milk analysed being blood. However, those skilled in the art should appreciate that other components may also be detected in other implementations of the present invention, and reference to the above only throughout this specification should in no way be seen as limiting. Furthermore, those skilled in the art should also appreciate that references to blood also encompasses references to red blood cells, haemoglobin or myoglobin compounds.

Preferably the detection system may be adapted to provide an in-line detector. Such in-line detectors can be adapted to be used within a manufacturing plant, storage facility, or in the case of a preferred embodiment, within the milk collection plant of a dairy shed. An in-line detector can provide an early warning system for contaminants within the milk supply or delivery line, or in a milk containment vat. Such in-line detectors may preferably be implemented using relatively small and robust components which can easily be retro-fitted or installed into existing milk processing, storage or transportation equipment.

In a further preferred embodiment, the detection system when configured as an in-line detection may include an inlet and an outlet where these inlets and outlets are connected in series to at least one supply line of a milking machine system. These components can allow the present invention to provide a detector placed in-line with the milking machine system and thereby allow the milk within such a system to be monitored in real-time for the detection of contaminants or other compounds.

Preferably the present invention includes at least one transmitter which is adapted to emit energy directed into milk to be analysed. The specific frequency or frequency bands of emitted energy will depend on the specific component of a compound which is to be detected.

In a further preferred embodiment a transmitter may be adapted to emit visible light, and/or near infra-red (NIR) light and to direct said light at milk to be analysed within a supply line. Visible or NIR light can be generated easily and in-expensively using a range of compact electrical components and has a large enough band of frequencies available to allow the components of milk to be colourmetrically analysed.

In a further preferred embodiment a transmitter may be formed from or implemented using a light emitting diode. Light emitting diodes are robust electrical components which can emit a wide range of visible and NIR light frequencies at high light intensities. Light Emitting Diodes or LED's are also relatively in-expensive, small components which can be used to provide a small and compact design for a detector system.

In a preferred embodiment the present invention may include two or more transmitters, with a single discreet transmitter being provided for each particular frequency or frequency band of energy to be emitted. Discreet or separate transmitters can easily be configured to emit energy over a selected frequency band to be used in conjunction with the present invention.

In a further preferred embodiment the present invention may include two transmitters only formed from two separate light emitting diodes. In such an embodiment the detection system may employ two frequency bands only of energy to be emitted and directed towards the compound to be analysed. However, those skilled in the art should appreciate that other configurations of the present invention are envisioned and reference to the above only throughout this specification should in no way be seen as limiting.

Preferably the present invention includes at least one receiver which is adapted to receive, sense or indicate the presence of energy scattered, reflected or transmitted from the compound to be analysed. The specific type of receiver employed and the numbers of receivers employed will be determined by the specific compound which the present invention is to be used to detect.

In a further preferred embodiment, a receiver may be used to provide a measurement with respect to the degree of transmission of energy through the compound analysed to detect the specific component or components of interest. Absorption of energy by such components can therefore result and reduce transmission of energy which can be measured by a receiver.

Reference throughout this specification will also be made to the transmission of a second frequency which is not affected by the presence of a specific component to be detected. Those skilled in the art should appreciate that in practical terms a specific component to be detected may have a negligible or minimal effect on the second energy frequency band employed which could be detected with sensitive equipment. However, the variable effects on the first frequency band when compared to the second may be of at least one order of magnitude in difference. Those skilled in the art should appreciate that references to the specific component having no effect on the second frequency band should encompass such minor fluctuations or variations.

In a preferred embodiment, the detection system may include two transmitters and two or more receivers. The two transmitters may provide the two distinct bands of energy required whereas these emissions may be detected by two or more receivers if required.

In a preferred embodiment a receiver may be formed from any type of photosensitive electrical device which can provide an output voltage or current signal dependent on the intensity of light received. These photo-electric devices have a relatively compact nature and can also be manufactured inexpensively, allowing a small inexpensive in-line detection system to be provided in accordance with the present invention.

Preferably, any transmitter or transmitters and receiver or receivers used in conjunction with the present invention are adapted to emit or receive energy with a first and second frequency band. Two distinct frequency bands of energy may be employed in conjunction with the present invention to detect the presence of a specific component within a compound and also to eliminate or alleviate the biasing effect of other non-specific components present within the same compound.

Those skilled in the art should appreciate that many different physical configurations of a transmitter or receiver may be employed to implement that aspect of the present invention. For example, in one instance a single transmitter may be employed which transmits energy over a wide range of frequencies encompassing both the first and second frequency bands required. Appropriate filtering devices or systems may then be placed or associated with receivers to block energy other than the particular frequency bands of interest. Alternatively, the present invention may be implemented through a discreet single transmitter, single receiver pair for each frequency band to be employed. However, preferably a separate transmitter may be provided for each first and second frequency bands of energy, while a single receiver can be used in conjunction with the pulsed, out of phase, activation of each transmitter to obtain both a first band output signal and a second band output signal from the same receiver.

Reference throughout this specification will also be made to the present invention being implemented using two transmitters formed from two separate light emitting diodes and one receiver formed from one photo diode. However, those skilled in the art should appreciate that other hardware of configurations of the present invention are envisioned, and reference to the above only throughout this specification should in no way be seen as limiting.

Preferably the first LED employed may emit visible and/or NIR light energy over a frequency band defined as the first frequency band. This first frequency band is selected from frequencies which the specific component to be detected is known to affect. Conversely, a second light emitting diode can be selected to emit light energy over a second frequency band, which the specific component to be detected does not affect. The specific component to be detected may affect the passage or transmission of such light energy through the compound analysed through for example, absorbing the energy from the selected frequencies used, or alternatively scattering or reflecting this energy.

The effect or interference of the specific component involved can then be used to detect its presence within the compound analysed. A measure can be made of, for example, the amount of light from each of the first and second frequency bands transmitted through the compound analysed, with absorption of energy from particular frequency bands indicating at least in part, the presence of the specific component within the compound. Alternatively, the same approach may be taken to measure the scattering or reflection of energy from particular frequency bands, again to detect the presence of the specific component involved within the compound analysed. Furthermore, a quantitative approach may also be taken to give an indication of the concentration of a specific component through the amount of energy transmitted through the compound or alternatively the amount of energy reflected or scattered from the compound.

Reference throughout this specification will also be made to the present invention measuring the degree of transmission of energy through the compound analysed to detect the specific component in question. However, those skilled in the art should appreciate that the measure of scattering or reflection of light (i.e. back scattering of light) can also be employed in other embodiments to achieve the same aim.

Preferably the second frequency band of energy may be selected to give a reference signal which is not affected by any presence of the specific component to be detected. This reference signal may then be used to track and counteract the effect of non-specific components not necessarily of interest within the compound analysed, where these components also will have an effect on the first band of energy frequencies transmitted at the compound.

A second frequency band output signal can be used to correct for biasing effects on the first frequency band output signal, so that the presence and also concentration of the specific component of interest can be measured without the interfering factors of other components within the compound.

In a preferred embodiment where the present invention is adapted to detect blood or blood related compounds within milk, the second frequency band of energy can be used to counteract biasing effects of scattering components within the milk analysed. The concentration of such scattering components which can include for example fat, protein and other solid particulars in addition to entrained air gas within milk flows can all vary from animal to animal and also will effect the transmission of visible or NIR light energy through a sample of milk.

In a further preferred embodiment where the present invention is adapted to detect blood within milk, the second frequency band of energy can be used to counteract the biasing effect of varying fat content within the milk analysed. As the concentration of fat within milk can vary from animal to animal, the effect of milk fat concentration will need to be considered as fat can also affect the transmission of visible or NIR light energy through a sample of milk.

Reference throughout this specification will also be made to the use of the second frequency band output signal to counteract the biasing effects of fat content within the milk analysed. However, those skilled in the art should appreciate that other configurations of the present invention are envisioned and reference to the above only throughout this specification should in no way be seen as limiting.

Preferably, one of the detection systems light emitting diodes may be adapted to emit a first frequency band of light energy which is substantially green in colour. This light energy, due to its green frequencies or wave length, will be absorbed by the red heme groups of the haemoglobin or myoglobin present in blood and therefore (through its absence at a receiver) will indicate the presence of blood within the milk analysed.

In a further preferred embodiment a second light emitting diode employed may emit light energy within a frequency band providing substantially red coloured light. This second frequency band will not be affected by blood in milk, as the red heme groups present in the blood will not absorb the red frequencies or wavelengths of the light transmitted.

In a further preferred embodiment the green LED may transmit light with wavelengths centred on 525 ± 35nm. Light from this band centred on 525 nanometers is absorbed by red heme groups within a sample of milk. In a further preferred embodiment, a light emitting diode obtained from relatively low cost common electrical components may be employed which emits light at a wavelength of approximately 525nm. This specific range of light wavelengths can be obtained easily using relatively inexpensive components.

In a further preferred embodiment the light emitting diode selected to emit substantially red light may emit light in a wavelength band centred on 660 ± 35nm. This range of frequencies exhibits little absorption by heme groups and as such can provide the second frequency band used in conjunction with the present invention. In a further preferred embodiment a low cost commercially available light emitting diode may be used to transmit light to a wavelength of approximately 660nm. This type of component can be used to provide an inexpensive yet compact detection system.

The above ranges of frequencies or wavelengths for the red and green LED's used exhibit substantially the same response to varying levels of scattering components within milk. Light from both bands will be absorbed approximately to the same degree with varying scattering component concentrations, thereby allowing the results obtained from the second band to be used to eliminate the effect of fat and other components on the first band, which will subsequently vary in relation to the blood content within the milk analysed.

According to a further aspect of the present invention there is provided a method of detecting the presence and/or concentration of a specific component within a compound using a detection system substantially as described above, said method being characterised by execution the steps of,

i) supplying the first output band signal, and/or the second output band signal to an assessment function, and

ii) comparing the output of the assessment function with at least one threshold parameter to determine which of two or more determination functions are to be used to detect the presence and/or concentration of the specific component, and

iii) supplying the first and second output band signals to the selected determination function to obtain an output parameter indicative of the presence and/or concentration of the specific component to be detected.

Preferably, an assessment function may be employed by the present invention to select from a plurality of determination functions used to calculate or detect the presence of the specific component of interest. Depending on the characteristics or state of the compound under investigation, a number of different determination functions may be used to improve the accuracy or reliability of the results provided by the present invention.

In a preferred embodiment an assessment function may be employed to determine whether there are relatively high or relatively low concentrations of the component of interest within the compound assessed. Various different determination functions may be used for high or low concentration values to again improve the results provided by the present invention.

In a further preferred embodiment, two or more assessment functions may also be employed to generate two or more values which are assessed to determine which determination function to employ.

Preferably, one of the assessment functions used may be a subtraction of the first output band signal from the second output band signal. This subtraction may give a difference value or parameter.

In a further preferred embodiment, a second assessment function employed may be a ratio function which divides the first output band signal into the second output band signal, or vice versa.

Preferably once the assessment function or functions employed have been used, the output or outputs produced may be compared with at least one threshold parameter. For example, in the case where two assessment functions are employed, two threshold parameters may be compared with the output of these assessment functions.

In one preferred embodiment, a threshold parameter employed may be a ratio value of 100. If the output of the determination function which provides a ratio of the first band output signal compared to the second band output signal produces a result which is greater than 100, the detection system may indicate that the compound involved is highly saturated with the component under investigation. In such instances, accurate measure of the concentration of the component of interest cannot be made.

A similar comparison may be made with respect to a difference threshold parameter compared with the output of a difference determination function. If the different value calculated is less than the valued 2.9, the detection system may indicate in general terms that the concentration of the component under investigation is too low to be accurately determined or detected using the present invention.

However, in a further preferred embodiment, a determination function may be selected through a comparison of the output of the difference assessment function. For example, in one instance if the difference value calculated is less than 25, then the compound under investigation will be known to have a relatively low concentration of the component of interest. Conversely if the output of the difference assessment function is above 25, then the compound is known to have a relatively high concentration of the component of interest.

In a preferred embodiment, a determination function whose output is equal to the first output band signal less the second output band signal may be selected and used when the compound investigated is known to have a relatively low concentration of the component of interest. Conversely, a determination function which provides an output value calculated from the ratio of the first output band signal divided by the second can be selected and used when relatively high concentrations of the component of interest is known to be present.

The output of either or any determination functions employed can be compared against previous calibration runs using known standard concentrations of the component of interest to provide in turn a concentration value for the component.

The present invention provides many potential advantages over the prior art.

The present invention may be used to implement a relatively low cost compact in-line detection system. This detection system may be used to detect any number of different types of contaminants within a supply line in preferred embodiments.

When employed to detect blood within milk supply lines the detector system and associated method of operation can effectively detect the presence of blood in addition to the concentration of blood within the milk analysed. The concentration values can be tracked accurately, independent of varying fat concentration levels within the milk analysed.

BRIEF DESCRIPTION OF DRAWINGS

Further aspects of the present invention will become apparent from the following description which is given by way of example only and with reference to the accompanying drawings in which:

Figure 1 shows a side cross-section schematic view of a detection system and associated supply line configured in accordance with the preferred embodiment, and

Figure 2 shows a schematic block flowchart of steps executed in the method of detection in accordance with the preferred embodiment.

Figure 3 shows a schematic block flow chart diagram of steps executed in the method of processing signals generated and employed by the detection system discussed with respect to figures 1 and 2.

BEST MODES FOR CARRYING OUT THE INVENTION

Figure 1 shows a side cross-section schematic view of a detection system and associated supply line configured in accordance with a preferred embodiment of the present invention.

In the embodiment shown the detection system (1) is configured as an "in-line" system which is associated with a milk supply line (2). The contents of the milk supply line can be analysed to determine or detect the presence of specific components such as blood within the milk in the line.

In the embodiment shown elements of the detection system are shown outside of the supply line (2), but in alternative embodiments these components may be placed inside the line, or may be placed in contact with the milk travelling through the line if required.

The detection system (1) includes a pair of transmitters, formed in this embodiment by a green light emitting diode (3a) and a red light emitting diode (3b). On the opposite side of the milk line (2) there is provided a receiver (4) which is adapted to sense the intensity of light (6) transmitted through the milk in the line (2) at the opposite side of the line. These receivers are formed in this embodiment by a pair of photo-electric diodes.

The LED's (3a) and (3b) are pulsed in operation so that one LED will be on while the other is off. This operational scheme allows an output from the receiver (4) to be attained for light sourced from one LED only at one time.

The detection system (1) also includes control circuitry (5) linked to the receiver (4). The receiver is adapted to transmit an output signal to the control circuitry (5) where this output signal indicates or is proportional to the intensity of light received. In the embodiment shown a control circuitry (5) is formed from a microprocessor and other supporting memory based components, where this microprocessor is programmed with software adapted to manipulate the receiver's output signals to indicate whether blood has been detected within the milk in the line (2). The control circuitry (5) is also programmed to provide an indication of the concentration of blood within the line through investigating the degree of absorbance of the light emitted by the diodes (3a) and (3b), by milk in the line (2).

The green light emitting diode (3a) is adapted to emit visible light energy across a first frequency band which is affected by the presence of blood within the milk transported. The green light wavelengths or frequencies employed will be absorbed by the red heme groups present in blood and therefore the transmitted green light across the line will be attenuated, and the attenuation detected by the receiver (4).

The red light emitting diode (3b) is adapted to emit visible light energy across a second frequency band which is not affected by the presence of blood within the milk transported. The red light wavelengths or frequencies employed will not be absorbed by the red heme groups present in blood and therefore the transmitted red light across the line will not be attenuated and detected by the receiver (4).

The light frequencies or wavelengths emitted by the red diode have been selected to correct for the effect of a variable fat protein, entrained air and other forms of scattering components on the light frequencies of the green diode. The output signal from the receiver when the green LED is on (defined as the first band output signal) will vary proportionally with both the concentration of blood and also the concentration of scattering components in the milk transported in the line (2). Conversely, due to the red wavelengths frequencies emitted by the red diode (3b), the output signal from the receiver when the red LED is on (defined as the second band output signal) will vary approximately with the scattering components concentration only. The second band output signal can then be used to correct for the effect of the variable scattering components on the first band output signal.

Furthermore, the particular frequency range of red light emitted has been selected in this embodiment to have a response similar or close to the response of the green light frequencies due to the presence of fat in the milk line. Through having a response of both frequency bands closer together with respect to fat this substantially simplifies the processing work or algorithms implemented in the control circuitry (5) to give a concentration value of blood within the milk line.

Figure 2 shows a schematic block flowchart of steps executed in a method of detection provided in accordance with a preferred embodiment of the present invention. This method of detection can be implemented through software loaded into the control circuitry (5) discussed with respect to figure 1.

The initial stage of said method (10) is a reception of a first band output signal from the receiver. This output signal preferably has a voltage which varies proportionally to the intensity of the green light received.

The next stage (11) of this process is the reception of a second band output signal sourced from the receiver. This signal will again have a voltage which varies proportionally to the intensity of red light received.

The next step of this process (12) is a correction phase where the second band output signal is used to correct the first band output signal for the presence of scattering components in the milk analysed. The second band output signal varies approximately proportionally with the scattering component concentrations in the milk analysed, whereas the first band output signal varies with both fat and blood content within the milk analysed. Through subtraction or other mathematical operational functions, the first band output signal can be corrected to vary proportionally with blood content only within the milk analysed.

The next stage of the method (13) relates to the calculation of a blood concentration value through scaling or otherwise supplying a corrected first band output signal to a calibration function, where the output of the calibration function provides a measure of the concentration of blood within the milk analysed.

At the last stage of the method (14) the blood concentration value calculated is then displayed on a screen to a user of the detection system or otherwise provided to some form of output or memory device.

Figure 3 shows a schematic block flow chart diagram of steps executed in the method of processing signals generated and employed by the detection system discussed with respect to figures 1 and 2.

This selection or processing is preferably completed using a microprocessor or any other similar type of programmable logic device. The flowchart discussed below indicates the basic steps and the flow of control for actions completed within such a processing method.

Once the process starts, an initial block of readings from the first output band signal and second output band signals (red and green LED intensity values) are read into the system, followed by a read from a memory element of stored calibration values of the same signals.

At the next stage, a pair of assessment functions, being a ratio determination function and a difference determination function are calculated.

The ratio function is represented by the following expression

$$Ratio = (R/R_{calib}) / (G/G_{calib})$$

The difference function is represented by the following expression:

$$\Delta(\text{difference}) = (R/R_{calib}) - (G/G_{calib})$$

After these two assessment functions are run, an initial ratio threshold value comparison is made. If the output from the ratio assessment function is greater than 100, this indicates that the milk under investigation is saturated with blood cells and therefore an accurate or meaningful concentration value for such cells cannot be calculated.

A similar approach is also taken with respect to the next threshold value comparison which looks at the output of the difference assessment function. If the difference detected is less than the threshold value of B, then the sample of material investigated is effectively clean of blood cells and hence again the detection system cannot provide a meaningful concentration value for such cells.

A third and final threshold value comparison is made against the result of the difference assessment functions.

If the difference calculated is less than 25, then a difference determination function equal to subtraction of the first output band signal from the second is used to determine the concentration of blood within the milk sample.

Conversely if the difference value is greater than threshold value C, then a ratio determination function equivalent to the first output band signal divided by the second output band signal is employed to provide the concentration calculation required.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof as defined in the appended claims.

WHAT WE CLAIM IS:

1. A method of detecting a specific component within a compound characterised by the steps of;

   i) transmitting energy with a first frequency band at the compound, and

   ii) transmitting energy with a second frequency band at the compound, and

   iii) receiving reflected, scattered or transmitted light with a first frequency band and generating a first band output signal, and

   iv) receiving reflected, scattered or transmitted energy with a second frequency band and generating a second band output signal, and

   v) correcting for the effect of non-specific components within the compound on the first band output signal using the second band output signal, and

   vi) using the corrected first band output signal to detect the presence and/or concentration of said specific component within the compound.

2. A method of detecting a specific component as claimed in claim 1, wherein milk is the compound analysed.

3. A method of detecting a specific component as claimed in claim 1 or claim 2, wherein the component to be detected is a blood related compound.

4. A method of detecting a specific component as claimed in any previous claim, wherein the first frequency band output signal is used to detect blood related compounds within milk.

5. A method of detecting a specific component as claimed in any previous claim, wherein the second frequency band is used to correct for the effect of a variable fat component within milk.

6. A detection system adapted to detect the presence of a specific component within a compound, the system including;

one or more transmitters adapted to emit energy into said compound, and

one or more receivers adapted to receive energy reflected, scattered or transmitted through said compound, and

whereby said one or more transmitters and said one or more receivers are adapted to emit or receive energy with a first frequency band which is affected by the presence of the specific component to be detected, and

said one or more transmitters and said one or more receivers and adapted to emit or receive energy with a second frequency which is not affected by the presence of the specific component to be detected.

7. A detection system as claimed in claim 6 wherein the first and second energy frequency bands are affected by the presence of at least one non-specific component within the compound.

8. A detection system as claimed in claim 6 or claim 7, wherein said detection system is adapted to provide an in-line detector which includes an inlet and an outlet, said inlet and outlets being connected in series to at least one supply line of a milking machine system.

9. A detection system as claimed in any previous claim, wherein milk is the compound analysed.

10. A detection system as claimed in any previous claim, wherein the component to be detected is a contaminant.

11. A detection system as claimed in claim 10, wherein the component to be detected is a blood related compound.

12. A detection system as claimed in any previous claim, wherein the system provides an indication of the concentration of the component.

13. A detection system as claimed in any previous claim, wherein a measurement is made of the degree of transmission of energy through the compound analysed to detect said specific component.

14. A detection system as claimed in any previous claim, wherein a transmitter is adapted to emit visible light.

15. A detection system as claimed in claim 14, wherein at least one transmitter is formed from a light emitting diode.

16. A detection system as claimed in claims 14 or 15, wherein a system includes two transmitters only formed from two separate light emitting diodes.

17. A detection system as claimed in claim 16, which includes at least one transmitter formed from a light emitting diode adapted to emit substantially green light, and at least one transmitter formed from a light emitting diode adapted to emit substantially red light.

18. A detection system as claimed in claim 17, which includes a green light emitting diode adapted to transmit light with wavelengths centred on 525± 35nm.

19. A detection system as claimed in claim 17 or 18, which includes a red light

emitting diode adapted to emit energy centred on 660± 35nm.

20. A detection system as claimed in any previous claim, wherein a receiver is formed from a photosensitive electrical device.

21. A detection system as claimed in any previous claim, wherein a second frequency band output signal is used to correct for the effects of non-specific components on the first frequency band output signal.

22. A detection system as claimed in any previous claim, wherein the first frequency band is used to detect blood related compounds within milk.

23. A detection system as claimed in any previous claim, wherein the second frequency band is used to correct for the effect of a variable fat component within milk.

24. A method of detecting the presence and/or concentration of a specific component within a compound using a detection system substantially as described above, said method being characterised by execution of,

i) supplying the first output band signal, and/or the second output band signal to an assessment function, and

ii) comparing the output of the assessment function with at least one threshold parameter to determine which of two or more determination functions are to be used to detect the presence and/or concentration of the specific component, and

iii) supplying the first and second output band signals to the selected determination function to obtain an output parameter indicative of the presence and/or concentration of the specific component to be detected.

25. A detection system substantially as herein described with reference to and as illustrated by the accompanying drawings and/or examples.

26. A method of detecting a specific component within a compound substantially as herein described with reference to and as illustrated by the accompanying drawings and/or examples.

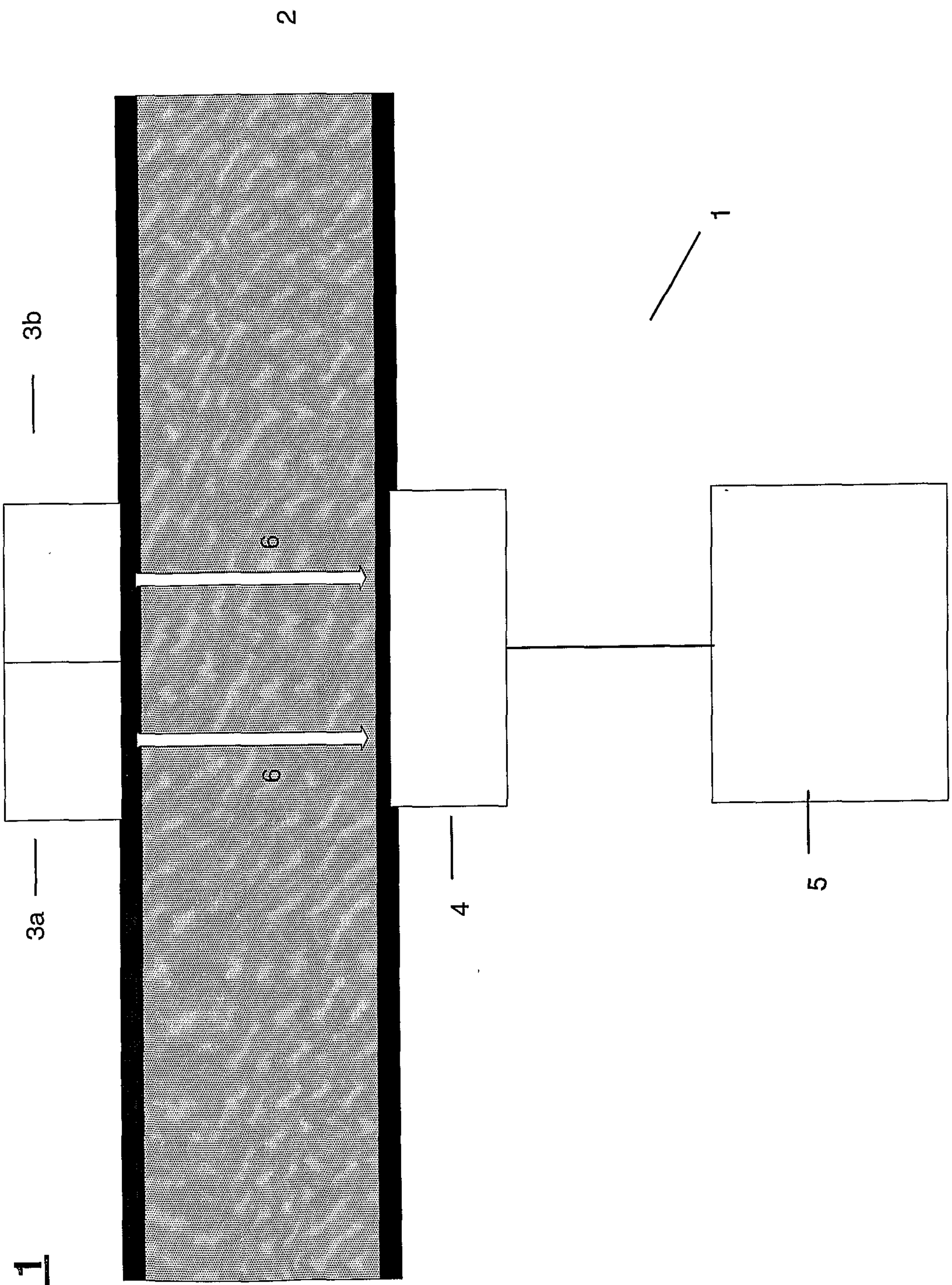


FIGURE 1

FIGURE 2

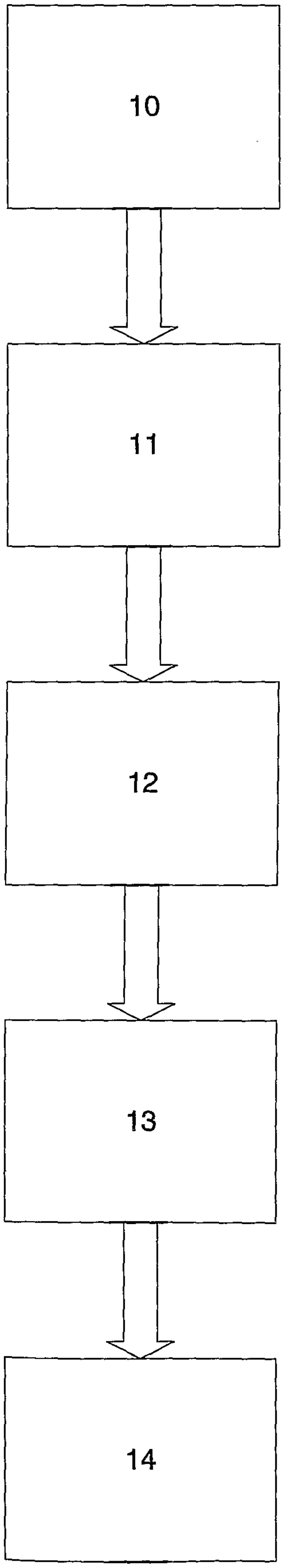
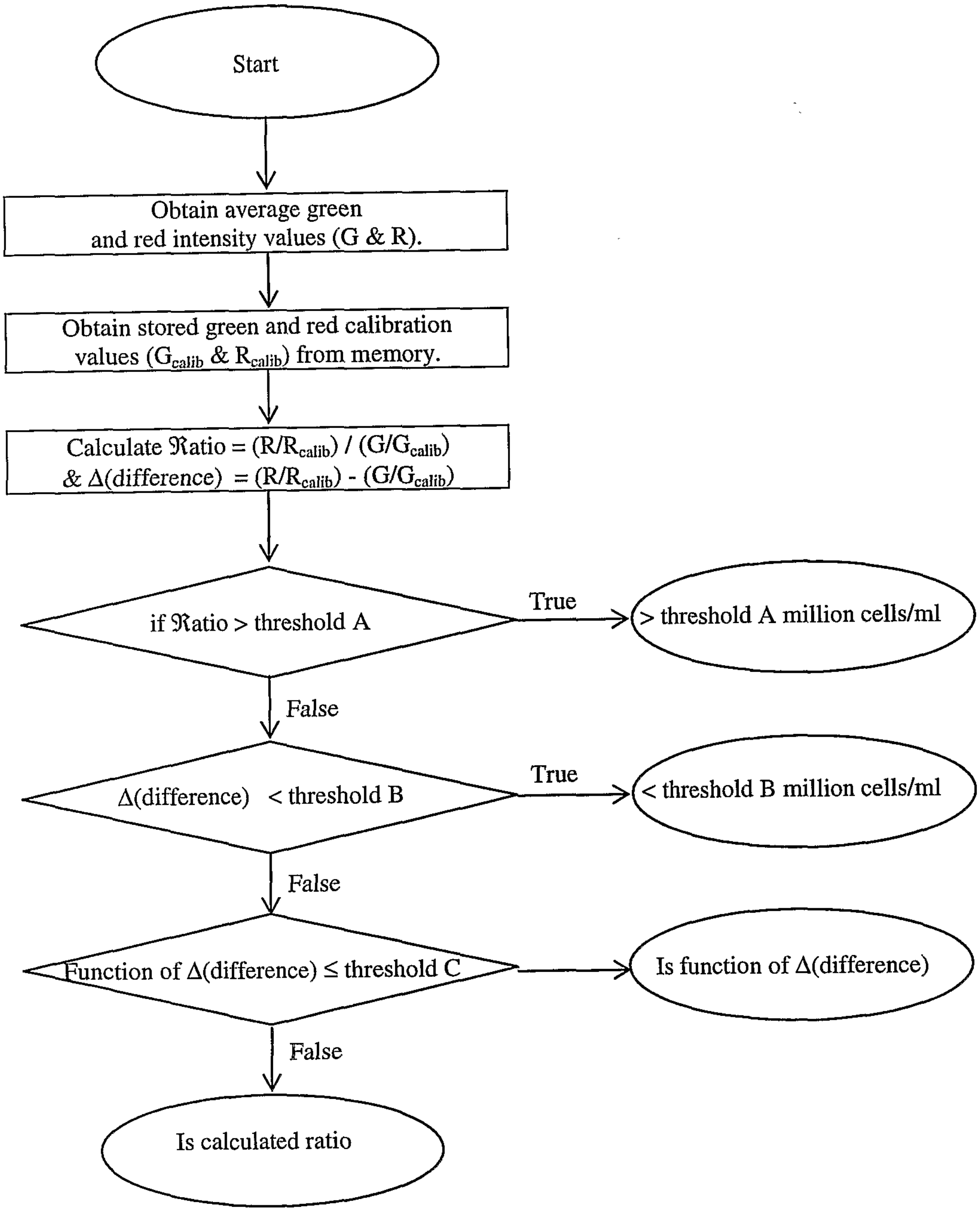


FIGURE 3


Start
Obtain average green and red intensity values (G & R).
Obtain stored green and red calibration values (G_{calib} & R_{calib}) from memory.
Calculate ℜatio = $(R/R_{calib}) / (G/G_{calib})$ & Δ(difference) = $(R/R_{calib}) - (G/G_{calib})$
if ℜatio > threshold A
True
> threshold A million cells/ml
False
Δ(difference) < threshold B
True
< threshold B million cells/ml
False
Function of Δ(difference) ≤ threshold C
Is function of Δ(difference)
False
Is calculated ratio