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(71) Applicant and
(72) Inventor: CONSIDINE, William, Howard [GB/GB]; Units 1-3, Floodgates, Knepp Castle Estate, West Grinstead, West Sussex RH13 8LH (GB).

(74) Agent: FRANK B. DEHN & CO.; 179 Queen Victoria Street, London EC4V 4EL (GB).

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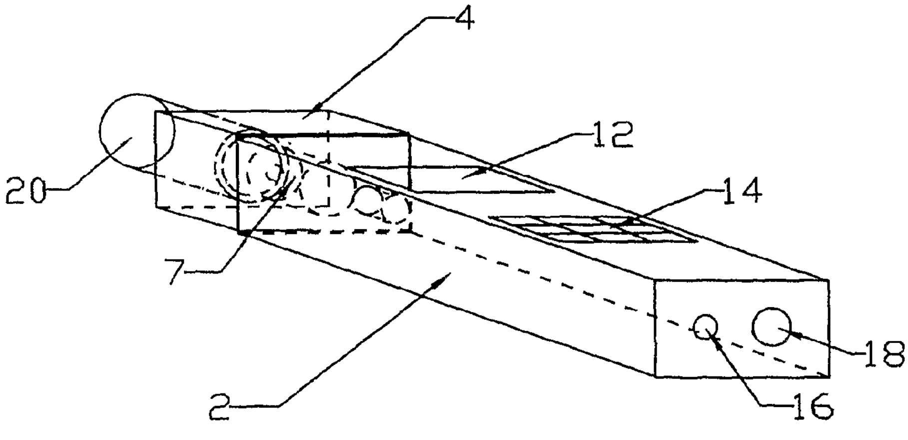
(54) Title: IMPROVEMENTS TO HAND HELD SPECTROMETERS



(57) Abstract: A hand-held spectral analyser comprises a spectrometer module (2) including a spectrometer for determining the spectral composition of incident light and a measurement module (4) for delivering light to be measured to the spectrometer module (2). The two modules are adapted for removable rigid attachment to one another to allow the analyser to be operated in one hand. The spectrometer module (2) comprises a battery, microprocessor, display (12), control keyboard (14) and entry optics (7) for the internal spectrometer optical assembly. Various measurement modules may be fitted to the spectrometer module, such as an absorbance meter, fluorimeter, radiometer or colour measurement module. The measurement module may include a light source and a cuvette to contain a liquid sample. The measurement module may include a flow-through sample cell comprising a fluid inlet and a fluid outlet to facilitate a short path length for light transmitted through opaque samples.

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IMPROVEMENTS TO HAND HELD SPECTROMETERS

Spectrometers are devices for splitting light into its constituent wavelengths, and measuring the strengths of each wavelength, or groups of adjacent wavelengths, known as wavebands . The relative strengths of these wavebands are, for instance, a measure of the colour of a surface from which light has been reflected, or the composition of a liquid sample through which light has passed, or from which light has been emitted. Precision spectrometers are large bench-mounted instruments. Thus in order to carry out spectral analysis of liquid samples such as water, drinks etc. it has conventionally been necessary to send the sample back to a laboratory for analysis which involves a significant delay. There is therefore a need for a practical, reliable way of being able to carry out spectral analysis in the field.

Some smaller, portable spectrometers have recently become available of which a few are small enough to be incorporated into battery-powered devices which may be carried by hand. However, these devices must still typically be placed on a flat surface while the sample is prepared and introduced into a cuvette in the device. Furthermore, such devices are expensive to produce since each is designed as a special purpose device containing sample devices for analysis, or optical systems for radiometry, or lighting systems for colour measurement all of which are tailored to specific measurements.

It is an object of the invention to provide an improved hand held device and thus when viewed from a first aspect the invention provides a hand-held spectral analyser comprising a spectrometer module including a spectrometer for determining the spectral composition of incident light and a measurement module for delivering light to be measured to the spectrometer module wherein the two modules are adapted for removable rigid attachment to one another to allow the analyser to be operated in one hand.

The inventor has recognised that all spectrometers have some common parts. There is an optical system, usually including a slit, one or more focussing mirrors, or lenses, a grating or prism, and a detector. There is usually some form of display to present the results to the operator. There is a microprocessor to control the detector, and the display. There is typically a keypad, or arrangement of pushbuttons to allow the operator to control the spectrometer.

In accordance with at least some preferred embodiments the present invention proposes that the spectrometer and ancillaries such as battery, microprocessor, and display, can be in a module, the spectrometer module, connected to, but separate from the module containing the sample chamber used for analysis, or the lens used for radiometry, or the illumination means used for colour measurement, or other means required for a particular type of measurement, the measurement module, in such a way that the two may be mounted and connected together for use or separated so that the spectrometer module may be used with different measurement modules suitable for different measurements, for instance liquid analysis or surface colour measurement. The measurement module might be permanently incorporated with a chemical processing plant, for instance, and the spectrometer attached to it temporarily when a measurement is required.

In accordance with the present invention is a spectrometer module small enough to be held in the hand which can have rigidly attached to it, but easily demountable, such devices as a light source for colour measurement, a lens for radiometry, a light source and sample cell for analysis, or any other required sensing device with its energy source where necessary . The spectrometer and preferably microprocessor can thus be common to many different measurements. This allows the spectrometer module to be manufactured in larger quantities than those required for any particular measurement. It will also be useful where different measurements have to be carried out, allowing one spectrometer to be carried for a number of different measurements.

It will be appreciated from the foregoing that the invention extends to the spectrometer module *per se* and thus when viewed from a second aspect the invention provides a spectrometer module for a hand held spectral analyser comprising a spectrometer for determining the spectral composition of incident light and means for removably rigidly attaching the module to a corresponding measurement module such that light from said measurement module is, in use, incident upon said spectrometer.

Spectrometers are available together with sample chambers and light sources, which can be connected by optical fibres. These are not suitable as a single portable unit. Also coupling by optical fibre is less efficient optically than direct coupling as proposed in accordance with preferred embodiments of the present invention. However, short optical fibres might be used where suitable to the optical path either internally within a module or, in another aspect of the invention, between modules. The latter could be of advantage where it is necessary to place the measurement module in situ in an awkward place. Thus when viewed from a third aspect the invention provides a spectrometer module for a hand held spectral analyser comprising a spectrometer for determining the spectral composition of incident light and means for coupling a fibre optic cable to the module such that light from said fibre optic cable is, in use, incident upon said spectrometer.

In some preferred embodiments as well as an optical coupling between the spectrometer module and the measurement module, there is also an electrical coupling between them. This allows, for example, the spectrometer module to supply power to the measurement module to power a light source.

Similarly in some preferred embodiments there is a mechanical coupling between the spectrometer module and the measurement module. This allows, for example, an actuator to communicate a mechanical operating action to the measurement module from a motor or manually operated lever or button in the spectrometer module.

All or part of the software for operating the analyser might be supplied in the form of a removable data storage device such as an insertable memory card, so that it could be changed for different applications. The same, or a separate memory card etc. might be used for transferring data to or from the spectrometer.

The spectrometer module may comprise some or all of the optical components of a spectrometer such as a slit, mirror, grating and sensor array. It may also comprise one or more of a display, a keypad, or other control device, microprocessor, and battery. Alternatively the display and preferably a keypad and/or preferably a processor are in a separate interface module so that they may be changed for different applications. This would allow a choice between graphic and alphanumeric displays for instance. The processor might be in either part. The battery might similarly be in a separate part so that it could be changed in the event of it becoming discharged.

In at least preferred embodiments, the spectrometer module includes entry optics. Different measurement modules may be mounted on the entry optics to enable the spectrometer to be used for different functions. Each one may connect optically to the spectrometer module through a projection which might contain a shutter to adjust the strength of the incoming light, and which leads the incoming light preferably directly, or via an optical fibre, to the optical part of the spectrometer. Each one may also be connected to the spectrometer module by an electrical connector if it contains electrical components, such as a light source, as previously mentioned.

One example of a measurement module is for measuring colour by a non-contact method. The colour of the surface is defined as the spectrum of the light from the surface when illuminated by a white light. In a possible example a ring of lamps illuminate the surface whose colour is to be measured. The scattered light from the surface is collected by an input lens, and fed to the spectrometer. The spectrometer first measures the spectrum of the light from the surface in ambient light, and then in the light from the ring of lamps in addition to the ambient light. The former is then subtracted from the latter to give the spectrum of the light from the surface as if it had been illuminated in the light from the lamps only. This can be divided into the spectrum of light from a standard white surface measured in the same way. The various number systems used to define colour can be computed from this spectrum. The illuminating lamps can be powered by the batteries in the basic unit via a connector as described. The illuminating lamps may, e.g., be LEDs of different colours so adjusted in brightness that the sum of their illuminations is effectively white, or at least contains substantially similar amounts of all wavelengths in the visible spectrum. This may be done by adjusting the current through each LED.

An alternative method of measuring colour is to bring the measurement module into contact with the surface whose colour is to be measured. The face of the module in contact with the surface could then take the form of a hollow cavity and since the edge of the cavity may exclude any ambient light, it would be unnecessary to subtract the spectrum of the surface when illuminated by ambient light. The surface is preferably illuminated by a plurality, e.g. four light sources at 45 degrees to the surface. This gives a more accurate measurement of colour for surfaces which may not be smooth, or have a texture. The light from the surface enters the spectrometer through the entry optics of the spectrometer module.

In preferred embodiments the analyser or measurement module thereof comprises a flow-through sample cell by which the sample enters and leaves an enclosed cell through an inlet and outlet respectively. This type of cell is suitable for both an absorbance meter and a fluorimeter if the position of the source is arranged appropriately, or suitable filters are employed. A flow-through cell is particularly advantageous over a conventional cuvette when a short sample length is required - e.g. for a relatively opaque liquid. Successfully filling a cuvette with closely spaced walls can be tedious and require a lot of skill in order to overcome problems associated with surface tension effects and trapped air bubbles. By forcing a sample liquid through the cell however these problems are mitigated and practical one handed operation is possible. The required skill level is also reduced enhancing the usefulness of such a device.

The flow-through cell allows a continuous flow of sample should the application require it. When the measurement module is not in use, it is desirable to keep the sample cell filled with liquid to prevent air bubbles from entering and sealed to prevent contamination. The inlet and/or outlet of the sample cell is preferably fitted with a valve to prevent the sample leaking from the cell when not in use. The sampl e cell may further comprise a pressure relief valve to prevent excessive pressure in the cell.

Such an arrangement is novel and inventive in its own right and thus when viewed from a further aspect the invention provides a hand-held spectral analyser having a flow-through sample cell comprising a fluid input and a fluid output and a spectrometer for determining the spectral composition of light from the sample cell.

A mechanical or electrical pumping arrangement may be provided in the device but in one set of preferred embodiments the inlet is connected to a socket for receiving a syringe for driving the sample through the cell. Thus the syringe may be operated in one hand and the analyser in the other, making its use particularly simple.

Various embodiments of the present invention will now be described, by way of example only, and with reference to the accompanying drawings, in which:

Fig. 1 shows a spectrometer module connected to a measurement module in accordance with the present invention;
Fig. 2 shows a spectrometer module separate from a measurement module;
Fig. 3 shows an embodiment where the spectrometer module comprises an insertion slot for a memory card;
Figure 4 shows a preferred embodiment of the present invention where the spectrometer module comprises a separable interface module;
Figure 5 shows the separated and connectable interface module and spectrometer module;
Figure 6 shows an embodiment where the spectrometer module comprises an actuator handle;

Figure 7 shows a measurement module for measuring colour by a non-contact method;
Figure 8 shows a measurement module for measuring colour by a contact method;
Figure 9 shows an absorbance meter module;
Figure 10 shows a UV absorbance meter module;
Figure 11 illustrates a preferred embodiment of the invention where the measurement module comprises a flow-through sample cell;
Figure 12 shows a fluorimeter module;
Figure 13 shows an alternative arrangement of a sample cell in a measurement module;
Figure 14 shows an absorbance meter module arranged to monitor and compensate for variations in light source intensity;
Figure 15 shows a fluorimeter module arranged to monitor and compensate for variations in light source intensity;
Figure 16 shows a measurement module for measurement of remote radiation;
Figure 17 shows a measurement module for measurement of ambient radiation; and
Figure 18 shows a spectrometer module and a measurement module connected by an optical fibre.

In Figure 1 a spectrometer module 2 comprises a spectrometer optical assembly, entry optics 7, battery, microprocessor, display 12 and control keyboard 14. The internal components (spectrometer, battery, microprocessor) are omitted for clarity. The spectrometer module 2 is provided with power input 16 for an external power source and data connection input 18 for remote control from a PC, or for sending data to or from a PC or other data source. A remote radiometer module 4 is shown as one example of a measurement module that may be fitted to the spectrometer module 2. The remote radiometer module 4 comprises a lens 20, as illustrated in more detail in Figure 16.

Figure 2 shows the spectrometer module 2 separately. The interface between the spectrometer module 2 and a measurement module consists of the entry optics 7 of the spectrometer and an electrical connector 7a to supply power to the measurement module. A passage 6 may be provided in the spectrometer module for receiving a removable rigid attachment from a measurement module.

All or part of the operating software for the microprocessor might be fitted in the form of an insertable memory card 13, as shown in the embodiment in Figure 3. An insertion slot 15 for the memory card 13 is provided in the side of the spectrometer module 102. The memory card may be changed for different applications, or for different measurement modules. The same, or a separate, memory card might be used for transferring data to or from the spectrometer.

The spectrometer module may comprise some or all of the optical components of a spectrometer such as a slit, mirror, grating and sensor array, as well as a display 12, a keypad 14 or other control device, a microprocessor, and a battery. Alternatively, as shown in Figure 4, the display 12, keypad 14, and processor may instead be in a separate module, the interface module 17, so that they may be changed for different applications.

The interface module 17 and a spectrometer module 302 are shown separated in Figure 5. A connector 19 may be provided on one or both modules. The separate interface module 17 allows a choice between graphic and alphanumeric displays, for example. The processor may be provided in either of the spectrometer module 302 or interface module 17. The battery may similarly be provided in either module, and preferably in the separate interface module 17, so that it may be changed in the event of it becoming discharged. Alternatively, the battery may be provided in a separate module to both the spectrometer module and interface module.

As seen in Figure 5, entry optics 7 may comprise an input lens 9, mounting 11 for a measurement module and optical fibre 5 for transmitting radiation from the lens 9 to the spectrometer. A connector 21a may be used to supply power to the measurement module.

In Figure 6 the spectrometer module 202 is provided with an actuator handle comprising a lever 22 attached at a hinge 24 to the spectrometer module 2. An actuator 23 communicates a mechanical operating action from the manually operated lever 22 of the spectrometer module 402 to an attached measurement module. The hand operated lever 22 may be used to actuate a mechanical device such as a sample pump in a measurement module. Alternatively, an electric motor may be provided in the spectrometer module or in the measurement module.

Different measurement modules may be mounted on the entry optics 7 of spectrometer modules 2, 102, 202, 302 or 402 to enable the spectrometer to be used for different functions. Some possible examples are shown in Figures 7 to 18. Each measurement module may comprise a mating recess 45 which connects optically to the input lens 9 of a spectrometer module and which leads the incoming light preferably directly, or less preferably via an optical fibre 5, to the optics of the spectrometer. A shutter 26 on a mounting 25 may be used to adjust the strength of the incoming light. Each measurement module may also be connected to a spectrometer module by an electrical connector 21 if it contains electrical components, such as a light source.

A measurement module 24 for measuring colour by a non-contact method is shown in Figure 7. The colour of the surface is defined as the spectrum of the light from the surface when illuminated by a white light. A ring of lamps 28, of which 16 are shown, illuminate a spot on the surface whose colour is to be measured by lens 32. The scattered light from the surface is collected by the input lens 30 and fed to the spectrometer. The spectrometer first measures the spectrum of the light from the surface in ambient light, and then in the light from the ring of lamps 28 in addition to the ambient light. The former is then subtracted from the latter to give the spectrum of the light from the surface as if it had been illuminated in the light from the lamps only. This can be divided into the spectrum of light from a standard white surface measured in the same way. The various number systems used to define colour can be computed from this spectrum. The illuminating lamps 28 are powered by a battery in the spectrometer module via the electrical connector 21. The illuminating lamps 28 may be LEDs of different colours so adjusted in brightness that the sum of their illuminations is effectively white, or at least contains substantially similar amounts of all wavelengths in the visible spectrum. This may be done by adjusting the current through each LED.

An alternative measurement module 34 for measuring colour where the measurement module is brought into contact with the surface whose colour is to be measured is shown in Figure 8. The face of the module in contact with the surface takes the form of a hollow hemispherical cavity 36 and since the edge of the cavity excludes any ambient light, it is unnecessary to subtract the spectrum of the surface when illuminated by ambient light. The surface is illuminated by four light sources 37 inclined at 45° to the surface. This gives a more accurate measurement of colour for surfaces which may not be smooth, or have a texture. The light reflected from the surface enters the measurement module 34 through the input port 38 and is transmitted to a spectrometer through entry optics 7 of a spectrometer module.

An absorbance meter measurement module 40 is shown in Figure 9. In this case a light source 42 transmits a beam of light through the sample to be measured, shown here contained in a cuvette 44, into the input lens 9 of a spectrometer module. A mating recess 45 is provided to accommodate the input lens 9 of a spectrometer module. The strengths of the wavebands of the light from the source may be a measure of the composition of the sample.

Figure 10 shows a variation of the absorbance meter module shown in Figure 9, which is suitable for use where the source 42 is an ultra-violet lamp. In this module a cover 46 must be provided to prevent the ultra-violet radiation from escaping.

Figure 11 shows a preferred embodiment of the invention where the measurement module 48 contains a flow-through cell 50. The sample enters the enclosed cell 50 through a fluid inlet 51 and exits through a fluid outlet 52. The inlet and outlet may preferably be fitted with valves to prevent the sample leaking from the cell when not in use. A pressure relief valve may also be fitted to prevent excessive pressure in the cell. This type of cell is suitable for both an absorbance meter and a fluorimeter if the position of the source is arranged appropriately, or suitable filters are employed. The advantage of the flow-through cell depicted in this embodiment is that it allows a very short effective sample length to be used, e.g. where the sample liquid is relatively opaque, without the difficulties in filling the cell that are normally encountered with thin cells as a result of surface tension, bubbles, etc. The flow-through cell allows a continuous flow of sample should the application require it.

Figure 12 shows a similar measurement module, in this case a fluorimeter 54. In this module the light source 42 transmits its beam through a sample contained in cuvette 44 at right angles to the input lens 9 of the spectrometer module, which sits in mating recess 45. Light from the source 42 does not enter the spectrometer module directly. The light from the source excites the sample, which emits light, usually at a different wavelength from that of the source. This emitted light enters the spectrometer module via the lens 9. If the emitted light is of comparable intensity to that from the source 42, an arrangement similar to that in Figure 7 may be used, the emitted light being separated from the exciting light by an arrangement of filters. The fluorimeter 54 may optionally be used to measure light scattered from particles in a liquid sample.

Figure 13 shows another possible arrangement of the sample cell of the absorbance meter 40 or fluorimeter 54. In this case the sample flows along a direction 55 through a transparent tube 56 which may be a permanent part of a process plant. There is no separate sample chamber in the measurement module, but a gap which allows the module to be fitted round the transparent tube 56.

Figure 14 shows an arrangement used to compensate for variations in the intensity of the light source 42 which may occur through ageing, variation in temperature, or other causes. This arrangment may be used in any of the measurement modules shown in Figures 9 to 13. A portion of the light from the source 42 is taken by an optical fibre 58 directly to the spectrometer where it may be used to illuminate a few pixels at the end of a sensing array. The measured value of these pixels may be used as a reference for the remainder of the spectrum. The fibre 58 in the measurement module may be coupled to the spectrometer module by means of one or more ball lenses 60. This is more reproducible than a normal optical face-to-face coupling, and will allow for slight misalignment between the units. This method of compensation includes compensation for variations in the efficiency of the sensing array of the spectrometer. Figure 15 shows the same method of compensation applied to the fluorimeter module 54 of Figure 12.

Figure 16 shows a measurement module 4 for measuring radiation from a distant object. A lens 20 focuses the radiation from the distant object into the input lens 9 of the spectrometer module. A mating recess 45 is provided to accommodate the input lens 9, and a shutter 26 may be used to to adjust the strength of the incoming light. The spectrometer module then measures the spectrum of the light from the distant object.

Figure 17 shows a measurement module 62 for measuring ambient radiation levels. The ambient radiation is collected by a translucent hemisphere 64 from where it passes to the input lens 9 of the spectrometer. This device is often called a cosine collector as the light entering the spectrometer has a cosine relationship with the angle of incidence on the hemisphere.

Figure 18 shows an arrangement of the spectrometer module 2 and measurement module 34 in which the measurement module 34 is connected to the spectrometer module 2 by a flexible or rigid optical fibre 66 to facilitate measurements in awkward places. The optical fibre 66 is connected between the mating recess 45 of the measurement module 34 and a shutter 26 provided at the optical input to the spectrometer module 2. Any of the measurement modules 24, 34, or 4 shown in figures 7, 8, or 16 respectively could be connected in this way.

Other devices could be built as attachments either to existing measurement modules or to fit in the position of the measurement module to measure other properties of a sample such as electrical or thermal conductivity, specific heat, specific gravity, or chemical composition. For instance the flow cell 50 shown in Figure 11 might be fitted with electrodes to measure the conductivity of a sample, or a gas chromatography unit might be fitted to measure the chemical composition of a sample.

Claims:

1. A hand-held spectral analyser comprising a spectrometer module including a spectrometer for determining the spectral composition of incident light and a measurement module for delivering light to be measured to the spectrometer module wherein the two modules are adapted for removable rigid attachment to one another to allow the analyser to be operated in one hand.

2. A spectral analyser as claimed in claim 1 wherein said measurement module includes a flow-through sample cell comprising a fluid inlet and a fluid outlet.

3. A spectral analyser as claimed in claim 2 wherein said fluid inlet communicates with a socket in a wall of the module for receiving the tip of a syringe to allow the fluid sample to be injected into the sample cell from a syringe.

4. A spectral analyser as claimed in claim 2 or 3 wherein at least one of said fluid inlet and said fluid outlet is fitted with a valve for selectively preventing the sample escaping from the sample cell.

5. A spectral analyser as claimed in any of claims 1 to 4 wherein said measurement module comprises a light source.

6. A spectral analyser as claimed in claim 5 wherein said light source comprises an ultra-violet lamp.

7. A spectrometer module for a hand held spectral analyser comprising a spectrometer for determining the spectral composition of incident light and means for removably rigidly attaching the module to a corresponding measurement module such that light from said measurement module is, in use, incident upon said spectrometer.

8. A spectrometer module for a hand held spectral analyser comprising a spectrometer for determining the spectral composition of

incident light and means for coupling a fibre optic cable to the module such that light from said fibre optic cable is, in use, incident upon said spectrometer.

9. A spectral analyser or spectrometer module as claimed in any preceding claim further comprising an interface module arranged for connection to said spectrometer module, said interface module comprising means for displaying a result of an analysis of light entering the spectrometer module.

10. A spectral analyser or spectrometer module as claimed in any preceding claim comprising a processor for analysing said spectral composition of incident light.

11. A spectral analyser or spectrometer module as claimed in claim 10 comprising means for receiving a removable data storage device in data communication with said processor.

12. A hand-held spectral analyser having a flow-through sample cell comprising a fluid inlet and a fluid outlet and a spectrometer for determining the spectral composition of light from the sample cell.

13. A spectral analyser as claimed in claim 12 wherein said fluid input communicates with a socket in a wall of the analyser for receiving the tip of a syringe to allow the fluid sample to be injected into the sample cell from a syringe.

14. A spectral analyser as claimed in claim 12 or 13 wherein at least one of said fluid inlet and said fluid outlet is fitted with a valve for selectively preventing the sample escaping from the sample cell.

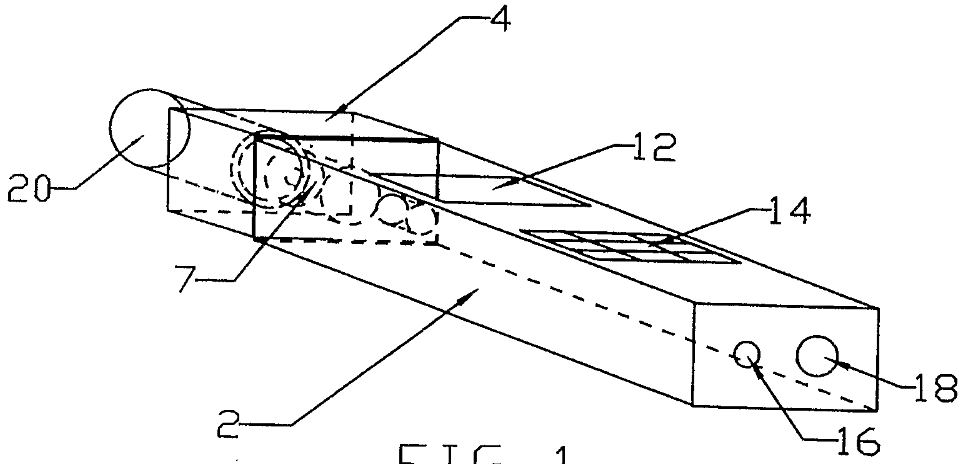

FIG. 1

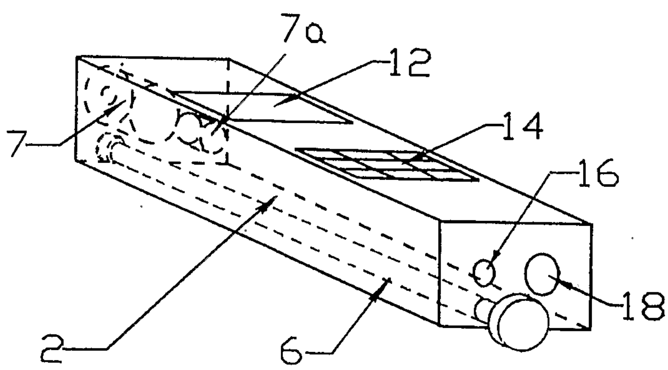

FIG. 2

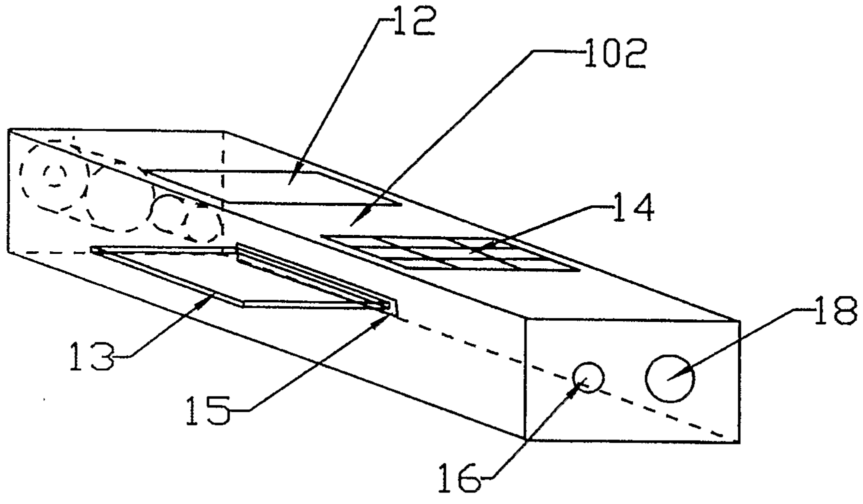

FIG. 3

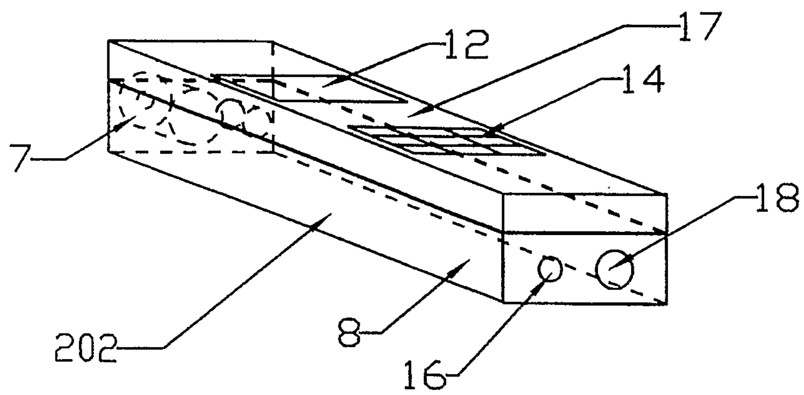

FIG. 4

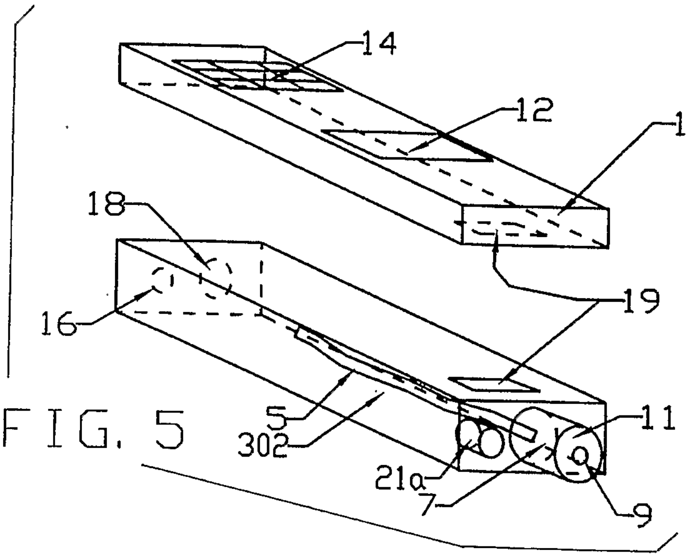

FIG. 5

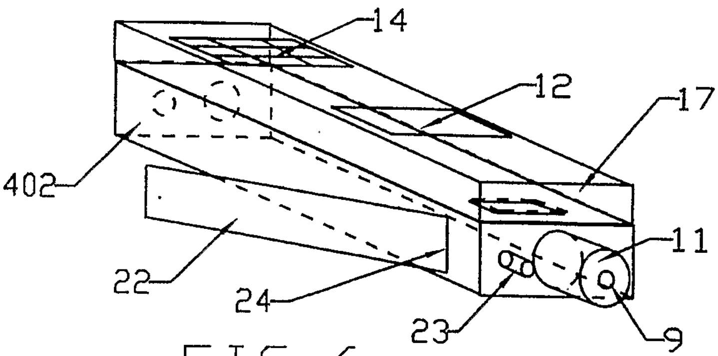

FIG. 6

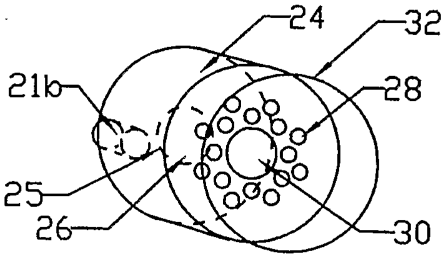

FIG. 7

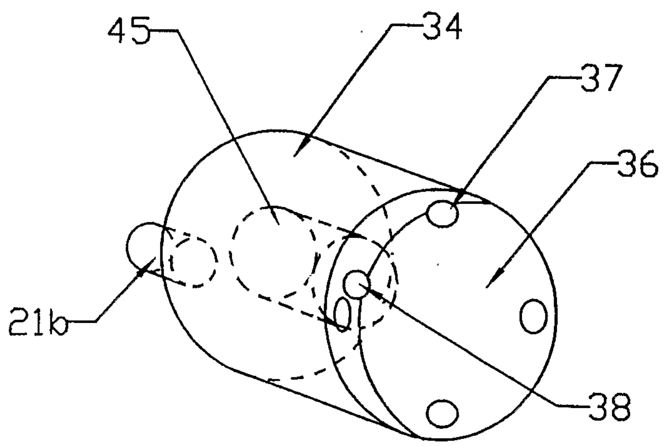

FIG. 8

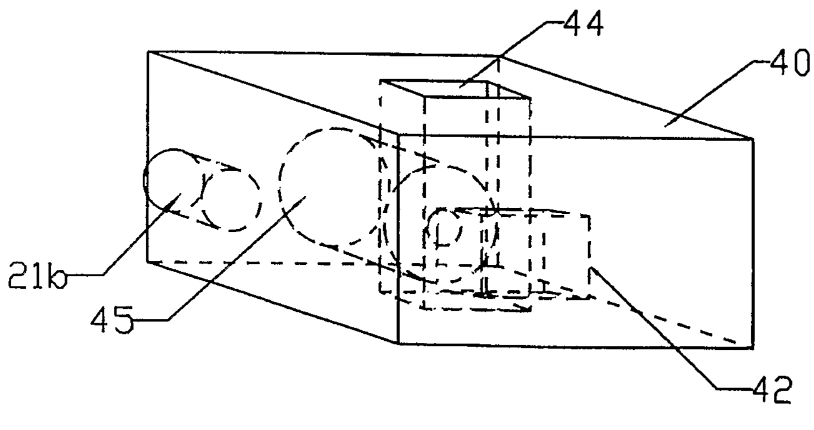

FIG. 9

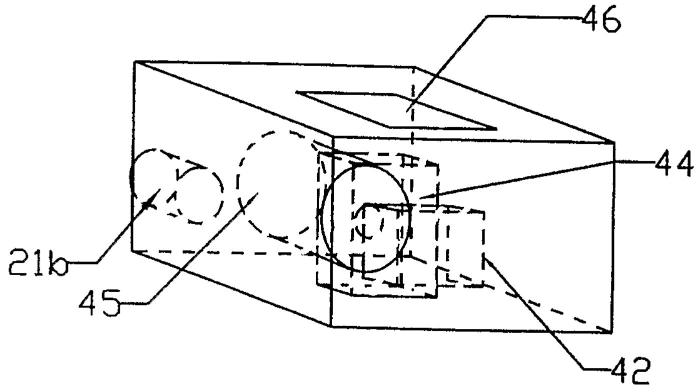

FIG. 10

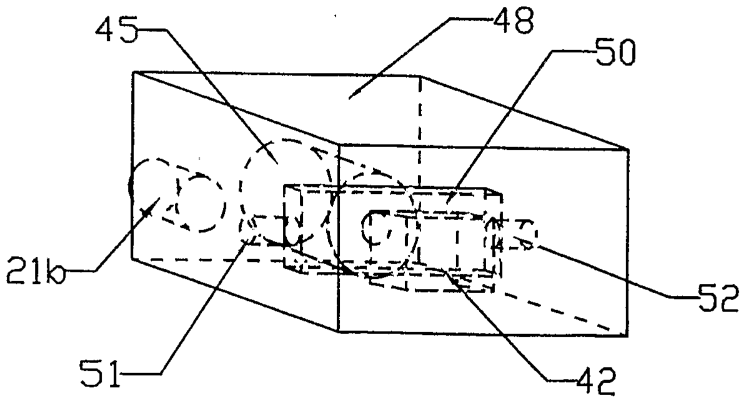

FIG. 11

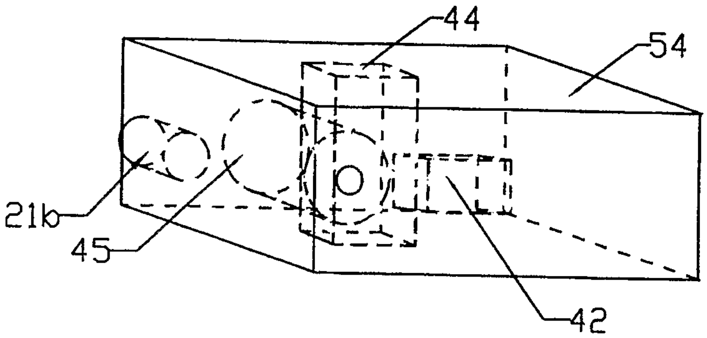

FIG. 12

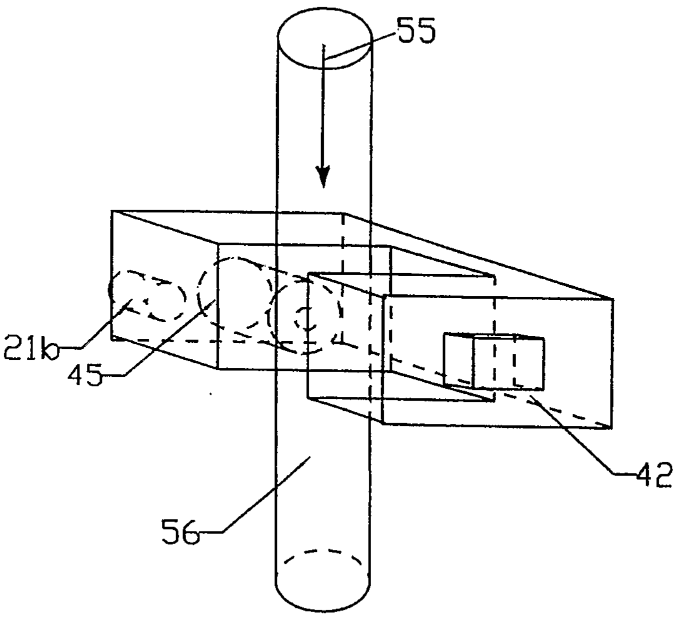

FIG. 13

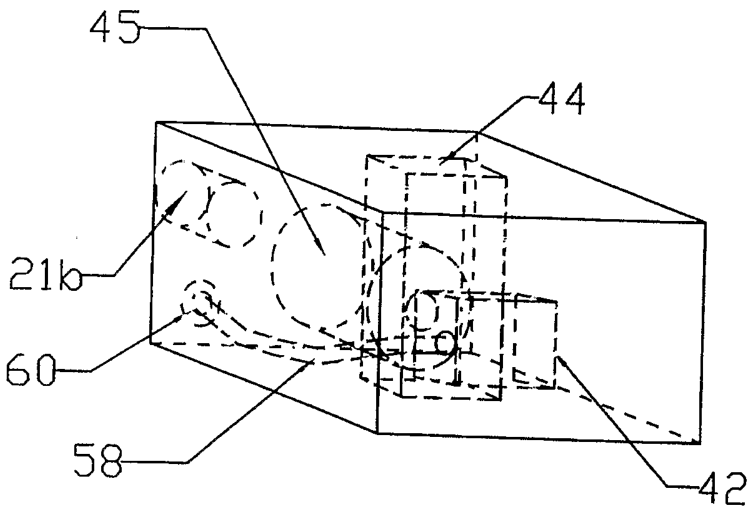

FIG. 14

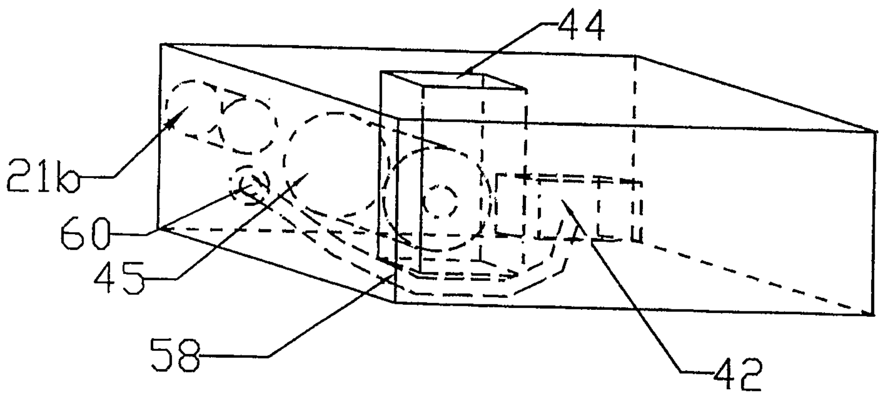

FIG. 15

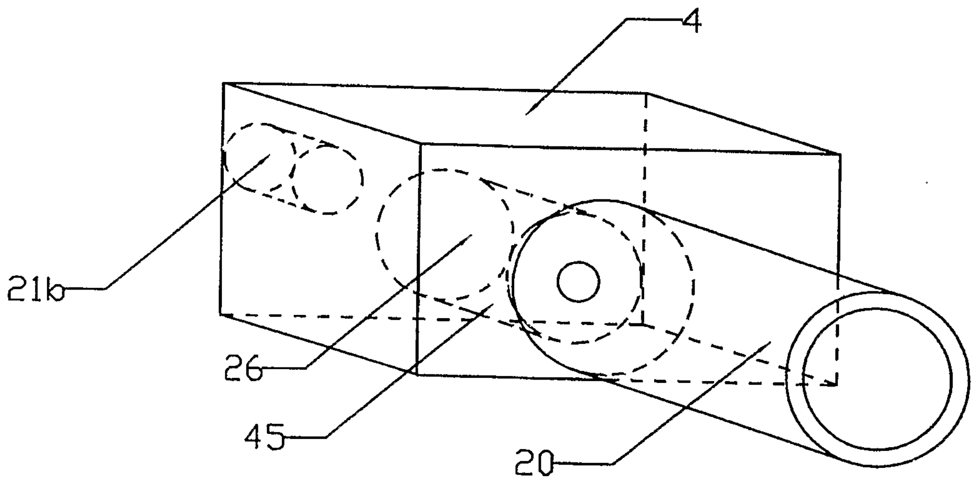

FIG. 16

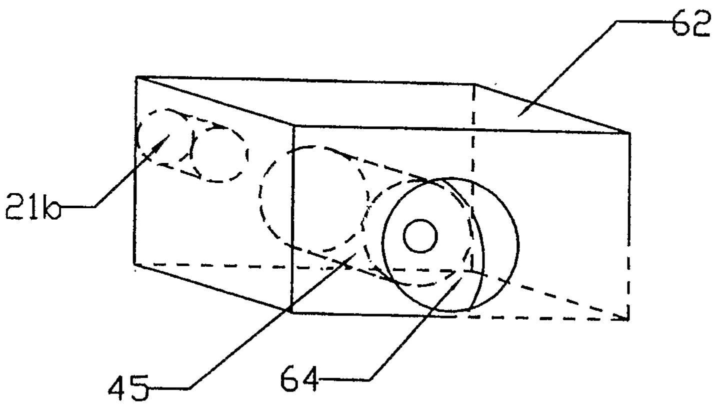

FIG. 17

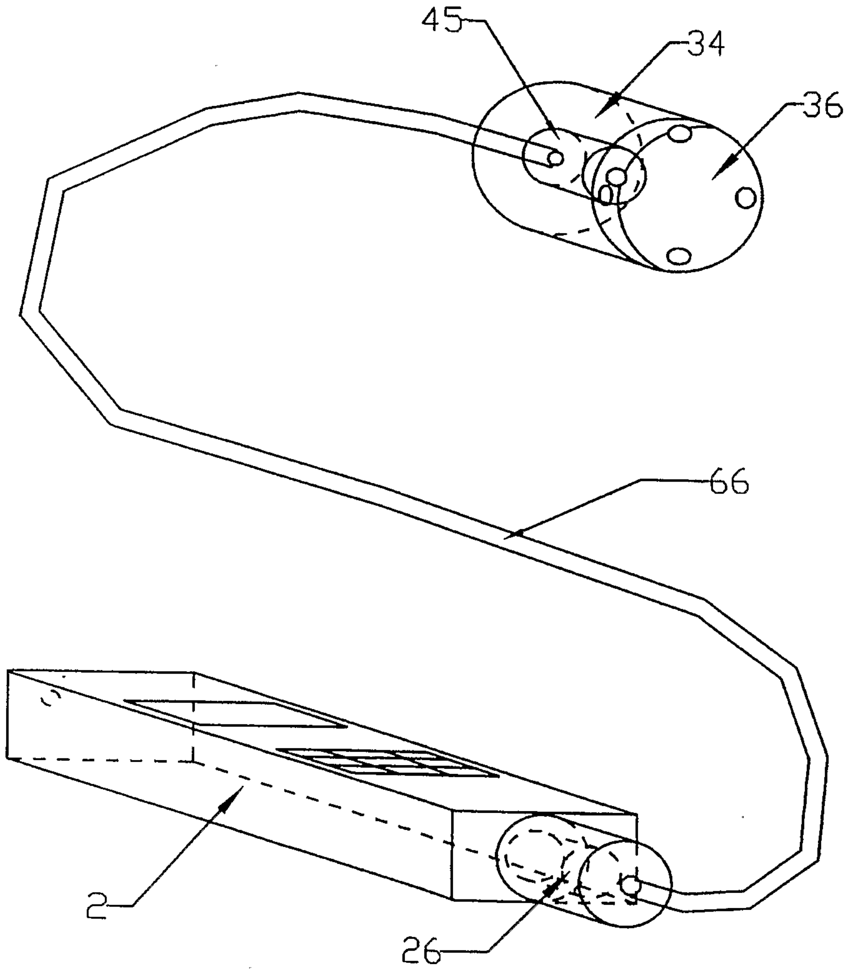

FIG. 18

INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB2004/002280

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01J3/02 G01N21/11

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 G01J G01N

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, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 1 278 049 A (SUISSE ELECTRONIQUE MICROTECH) 22 January 2003 (2003-01-22) paragraphs '0026!, '0028!, '0029!, '0035! figure 2A	1,5,7,9, 10 2-4,6,11
Y	EP 0 994 342 A (SYSMEX CORP) 19 April 2000 (2000-04-19) paragraphs '0041!, '0106! - '0108! figure 1	2-4, 12-14
X	DE 100 10 514 A (MICROPARTS GES FUER MICROSTRUK) 14 September 2000 (2000-09-14) column 7, line 7 - line 10 figure 1	8

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 September 2004	07/09/2004

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Jacquin, J

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

In ional Application No
PCT/GB2004/002280

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 1 037 025 A (HERAEUS NOBLELIGHT GMBH) 20 September 2000 (2000-09-20) abstract figure 1	6
Y	EP 0 841 555 A (SPECTRONIC INSTR INC) 13 May 1998 (1998-05-13) abstract	12-14
Y	WO 02/25234 A (APPLIED COLOR SYSTEMS INC ; BROWN LARRY (US); MERLE CORMIC K (US); SLO) 28 March 2002 (2002-03-28) paragraph ‘0027!	11

Form PCT/ISA/210 (continuation of second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

ternational application No.
PCT/GB2004/002280

Box II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.

2. ☒ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-7,9-11

   A hand-held spectral analyzer having a spectrometer module and an illumination module being removably rigidly attached to one another.

   ---

2. claim: 8

   A spectrometer module having a spectrometer and means for coupling a fiber optic cable to the module.

   ---

3. claims: 12-14

   A hand-held spectral analyzer having a flow-through sample cell with an inlet and an outlet.

INTERNATIONAL SEARCH REPORT

Information on patent family members

In tional Application No
PCT/GB2004/002280

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
EP 1278049	A	22-01-2003	EP	1278049	A1	22-01-2003
EP 0994342	A	19-04-2000	EP	0994342	A2	19-04-2000
			JP	2000186999	A	04-07-2000
			US	6707555	B1	16-03-2004
DE 10010514	A	14-09-2000	DE	10010514	A1	14-09-2000
EP 1037025	A	20-09-2000	DE	19909631	A1	14-09-2000
			EP	1037025	A2	20-09-2000
			JP	2000266599	A	29-09-2000
EP 0841555	A	13-05-1998	US	5774209	A	30-06-1998
			EP	0841555	A2	13-05-1998
WO 0225234	A	28-03-2002	AU	9461001	A	02-04-2002
			WO	0225234	A1	28-03-2002