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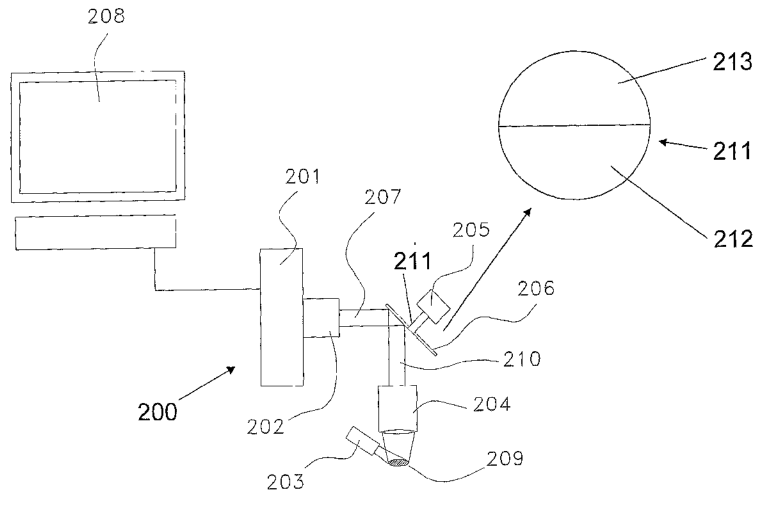

FIG. 2

(57) Abstract: A spectrum analyzing device, for spectral analysis of a region of interest, comprises a light dispersion element for spectrally analyzing a light beam to produce a spectral image thereof, a reflection element for reflection the light beam without analysis to produce a non-analyzed reflection of the beam, and an alternating unit for alternately presenting the light dispersion element and the reflection element to a light path, thereby to provide a dual mode spectrum analyzing device able to alternate between a plain image and a spectral image of a region of interest.

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METHOD AND APPARATUS FOR HIGH RESOLUTION SPECTROSCOPY AND SPECTRAL IMAGING

FIELD AND BACKGROUND OF THE INVENTION

The present invention, in some embodiments thereof, relates to a method and apparatus for spectroscopy and spectral imaging.

Spectroscopy plays an important role in a variety of applications and in numerous fields, including medicine, biology, chemistry, physics, industrial processes, and environmental monitoring. Example applications are fluorescence detection, materials characterization, reflectance measurement, Raman spectroscopy, color definition for cosmetic application and many others. Most spectroscopic instruments, e.g. prism or grating spectrometers are based on spreading the input light along a predefined direction by using a dispersive element. In early spectroscopic instruments, the light is detected by a single element photosensitive detector which is moved along the spectrum spread direction. Each detector position corresponds to a certain wavelength and a complete spectrum is created after the completion of the detector scan. Another more popular approach to the spectrum scanning is based on a static detector and angular displacement of the dispersive element.

Prior art spectrum analysis devices are based on spreading a light along a line. The spectral information along this line is either mechanically scanned or projected onto a linear detector for data acquisition. The disadvantage of this prior art system is its limited capability to observe and display the spectrum acquisition area. That is to say one can observe the spectrum but not at the same time observe what the spectrum has been taken from. Sometimes it happens that due to accidental movement the spectrum is taken of the wrong region entirely or of a less than ideal part of the region of interest, and it is not uncommon that unexpected results are in fact due to the spectrum being based on incorrect input, this not being apparent to the users. In particular, users who inspect the data after the fact have no way of knowing what the spectrum was in fact taken from.

In order to solve this problem, a prior proposal exists in which a beam splitter splits the incoming light into an image path and a dispersive path. The two paths lead to different sensors, and allow the image and the spectrum to be viewed on different imaging devices and compared.

A disadvantage of the above solution is its relative high price due, to the fact it relies on two detectors and the optics needed for two optical paths. Furthermore there is the need to record the spectral and direct images in such a way that they remain together for future reference.

SUMMARY OF THE INVENTION

The present invention provides a spectrographic analyzer with added imaging capability by providing a focused non-dispersive light path to the display location as an alternative to the dispersive path.

According to a first aspect of the present invention there is provided a spectrum analyzing device, for spectral analysis of a region of interest, comprising:

a light dispersion element for spectrally analyzing a light beam to produce a spectral image thereof,

a reflection element for reflection the light beam without analysis to produce a non-analyzed reflection of the beam, and

a dual-mode unit for dually presenting the light dispersion element and the reflection element to a light path, the light dispersion element and the reflection element both being configured to deliver light of the light path to a common target location, thereby to provide a dual mode spectrum analyzing device able to provide unified sensing of two modes of viewing a region of interest, one being a plain image and a second being a spectral image of the region of interest.

In an embodiment, the dual mode unit is an alternating unit for alternately presenting the light dispersion element and the reflection element to the light path.

In an embodiment, the light dispersion element is angled with respect to the light path to present a first order of the spectral image to the common target location.

In an embodiment, the dual mode unit is a beam splitter for sending part of the light beam via the light dispersion element and part of the light beam via the reflection element.

In an embodiment, the dual mode device is a two part reflection element comprising a first dispersive part and a second reflective part, and wherein both parts are placed in the light path simultaneously.

In an embodiment, the light dispersion element and the beam splitter are configured to provide the two modes of viewing to different regions of a single detector.

In an embodiment, the unified sensing is achieved on a single image sensor.

In an embodiment, the unified sensing is achieved on a unified group of sensor elements.

An embodiment may comprise further comprising an optical pick-up assembly capable of collimating input light of the region of interest into the light path.

In an embodiment, the light dispersion element comprises a diffraction grating.

In an embodiment, the diffraction grating comprises a reflective diffraction grating.

In an embodiment, the reflection element comprises a mirror.

In an embodiment, the alternating unit comprises a moving element on which the reflection element and the light dispersion element are mounted, the moving element being configured to alternately move one of the elements into the light path.

In an embodiment, the alternating unit comprises:

a rotating motor element, and

a disc mounted for rotation by the motor element, the disc being divided into two parts, one part forming the reflection element and the second part forming the light dispersion element.

In an embodiment, the motor element is mounted such that an axis for the rotation is substantially 45 degrees to the light path.

An embodiment may comprise a sensing element for monitoring a current orientation of the motor element.

According to a second aspect of the present invention there is provided a method for spectral analysis comprising:

setting up a light path from a region of interest to a detector,

inserting a light dispersion element into the light path to produce a spectrum at the detector;

alternating the light dispersion element with a reflection element,

thereby to alternate the spectrum with an image of the region of interest for dual mode viewing.

In an embodiment, the alternating comprises beam splitting, and the dual mode viewing comprises setting the image and the spectrum on different parts of the detector.

In an embodiment, the alternating comprises replacing of one of the light dispersion element and the reflection element with the other of the light reflection element and the rotation element.

In an embodiment, the replacing comprising rotating a disk carrying both of the light dispersion element and the reflecting element between a first position in which the light dispersion element is in the light path and a second position in which the reflection element is in the light path.

Unless otherwise defined, all technical and/or scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which the invention pertains. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of embodiments of the invention, exemplary methods and/or materials are described below. In case of conflict, the patent specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and are not intended to be necessarily limiting.

Implementation of the method and/or system of embodiments of the invention can involve performing or completing selected tasks manually, automatically, or a combination thereof. This refers in particular to tasks involving the control of the spectral equipment.

Moreover, according to actual instrumentation and equipment of embodiments of the method and/or system of the invention, several selected tasks could be implemented by hardware, by software or by firmware or by a combination thereof using an operating system.

For example, hardware for performing selected tasks according to embodiments of the invention could be implemented as a chip or a circuit. As software, selected tasks according to embodiments of the invention could be implemented as a plurality of software instructions being executed by a computer using any suitable operating system. In an exemplary embodiment of the invention, one or more tasks according to exemplary embodiments of method and/or system as described herein are performed by a data processor, such as a computing platform for executing a plurality of instructions. Optionally, the data processor includes a volatile memory for storing instructions and/or data and/or a non-volatile storage, for example, a magnetic hard-disk and/or removable media, for storing instructions and/or data. Optionally, a network connection is provided as well. A display and/or a user input device such as a keyboard or mouse are optionally provided as well.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments of the invention are herein described, by way of example only, with reference to the accompanying drawings. With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of embodiments of the invention. In this regard, the description taken with the drawings makes apparent to those skilled in the art how embodiments of the invention may be practiced.

In the drawings:

FIG. 1A is a simplified diagram showing a prior art spectrum analysis unit;

FIG. 1B is a simplified diagram showing an alternative prior art spectrum analysis unit in which detector arrays are used;

FIG. 2 is a simplified block diagram showing a first embodiment of a dual mode spectrum analysis unit according to the present invention, in which a rotating or alternating element is provided to rotate between two modes of vision;

FIG. 3 is a simplified block diagram showing a motorized version of the alternating element of FIG. 2;

FIG. 4 is a simplified block diagram of a second embodiment of a dual mode spectrum analysis mode according to the present invention in which a beam splitter is used to provide the two modes of imaging;

FIG. 5 is a simplified block diagram of a third embodiment of the present invention in which a single static element placed across the light path comprises dispersive and reflective elements to produce the two modes of imaging simultaneously; and

FIG. 6 is a simplified block diagram showing an embodiment of the disk element of FIGs. 2 or 3 wherein the dispersive element is angled in order to reflect the first order of the spectral image to the imaging target.

DESCRIPTION OF SPECIFIC EMBODIMENTS OF THE INVENTION

The present invention, in some embodiments thereof, relates to a method and apparatus for high resolution spectroscopy and spectral imaging.

The present invention relates to the art of spectrometry, and spectroscopic instruments. Embodiments utilize a two dimensional imaging sensor and a specific optical system for image and spectrum observation on the sensor in order to utilize all parts of the sensor area. The above may provide a low cost spectrometer instrument. The present embodiments further enable creation of a simple and reliable system for spectroscopy applications able to display the relevant image and its spectrum using the same sensor.

There is thus provided in accordance with the preferred embodiment of the present invention a spectrometric device comprising:

- an optical pick-up assembly capable of collimating input light from an area of interest to an optical processing location;
- a moving element capable of alternately providing at the optical processing location a mirror and a dispersing element for alternate optical path processing, alternatively a beam splitter for splitting the beam to the mirror and the dispersing element;
- a camera system or web camera capable of imaging the input light reflected by the mirror element and/or diffracted by the diffracting element;
- a preferably white illuminating device directed at the area of interest for spectral analysis;
- an electronic analyzing system to process the image generated by the camera system into a high resolution spectrum and/or image data; and
- image processing and display software to display and analyze the resulting images and/or spectral images.

Furthermore, the device may comprise a mechanical motorized assembly capable of alternating between the dispersing element and mirror element. Such a motorized element may comprise:

- a rotating motor element, mounted at about 45 degrees to an input optical pick-up assembly;
- a disc mounted on the motor shaft and divided into two halves, one being a mirror element and the second a dispersive reflecting element; and
- a sensor element for monitoring the motor position.

Furthermore, the illuminating device may be capable of monochromatic illumination as well as broad band spectral illumination.

Furthermore, the camera system may be equipped with an optical zooming element to optimize the camera's field of view.

A method and its implementation for dual mode spectroscopy is disclosed. Conventional spectroscopic instruments do not show the image that the spectrum is taken from. By contrast, the presently disclosed instrument operates by showing the spectrum as well as its image. The disclosed method displays the area of interest in parallel with its spectrum using the same imaging detector.

For purposes of better understanding some embodiments of the present invention, as illustrated in Figures 2 - 4 of the drawings, reference is first made to the construction and operation of a standard spectrometer as illustrated in Figures 1a and 1b. A typical spectrometer instrument based on standard spectrometry is described in Fig. 1(a). Incoming light is focused on the entrance slit 101 and then collimated by a collimating element 102. The spectral resolution of the instrument is determined in particular by the divergence angle of the beam after the collimation, which depends on the slit width and collimating element quality. The collimated light is then incident on dispersive element 103, typically a prism or diffraction grating. The dispersive element causes an extra tilt to the beam depending on wavelength. The diffracted and refracted beam is then refocused by the focusing element 104 on the exit slit 105 and detected by detector 106. The exit slit width together with the entrance slit width affect the instrument resolution. For example, consider a first order diffraction grating based spectrometer with a grating of 600 grooves/mm, 250 mm collimating and refocusing elements and 200μm entrance and exit slits. The total instrument resolution may then be derived from the following considerations. The diffraction grating deflects the beam incident at the angle α_0 by the angle α in relation to the grating parameters according to the following formula:

$$\sin\alpha_0 + \sin\alpha = \frac{m\lambda}{d}, \qquad (1)$$

Where m – is the diffraction order, λ - the light wavelength and d – the grating period.

The entrance slit width Δx creates the diffraction grating incident beam divergence according to the formula below:

$$\Delta\alpha_0 = \frac{\Delta x}{f}, \qquad (2)$$

where f is the effective focal length of the collimating optics.

The uncertainty in the incident angle creates a wavelength resolution limit described by the below expression:

$$\Delta\lambda = \frac{d\cos\alpha_0}{mf}\Delta x. \qquad (3)$$

In the example described above, the limitation on the spectral resolution due to the entrance slit is about: $\Delta\lambda$=1.3 nm. The exit slit width may correspond to the entrance slit width, since by increasing the exit slit the spectral resolution degrades, while the resolution does not gain from a decrease in the exit slit width.

Another resolution limitation specific to diffraction gratings is the diffraction grating resolution limit, described by the following equation:

$$\frac{\lambda}{\Delta\lambda} = \frac{mL}{d}, \qquad (4)$$

where L is the beam size on the diffraction grating. Typically the diffraction grating limit is far below the resolution limit due to the entrance / exit slits and imperfections in the focusing elements. For example, a 10 mm beam on the grating results in a $\Delta\lambda < 0.1$ nm resolution limit.

Both the dispersion element and the detector scanning methods are capable of providing high resolution spectra, but have several disadvantages. First, since each wavelength is detected independently, the acquisition of the whole spectrum requires a considerably period of time. Due to this fact, scanning spectrometers are not suitable for measuring pulsed light spectra and transient effects that may only last for very short time intervals. Secondly, scanning mechanisms are costly, have low reliability, and are thus undesirable.

Reference is now made to Fig. 1b, which illustrates an alternative known approach for spectrum detection. A typical spectrometer instrument based on standard spectrometry is described in Fig. 1(a). Incoming light is focused on the entrance slit 101 and then collimated by a collimating element 102. The spectral resolution of the instrument is determined in particular by the divergence angle of the beam after the collimation, which depends on the slit width and collimating element quality. The collimated light is then incident on dispersive element 103, typically a prism or diffraction grating. The dispersive element causes an extra tilt to the beam depending on wavelength. The diffracted and refracted beam is then refocused by the focusing element 104 on detector arrays 107 placed at the system output. The spectrum spread by the dispersive element is simultaneously detected by multiple detector array channels at 107. The detector array approach allows the construction of a non-scanning spectrometer, capable of measuring a continuous and pulsed light spectrum within a short amount of time.

Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not necessarily limited in its application to the details of construction and the arrangement of the components and/or methods set forth in the following description and/or illustrated in the drawings and/or the Examples. The invention is capable of other embodiments or of being practiced or carried out in various ways.

In the present invention, a 2D imaging detector array or a camera follows a specially designed optical system, in order to construct a novel dual mode spectrometer with the capability of alternating between showing the pick-up spectrum on the one hand and imaging the area the spectrum was taken from on the other hand.

The basic principle of operation is shown in Fig. 2.

Fig. 2 illustrates an exemplary spectrum analyzing device 200, for spectral analysis of a region of interest 209, according to a first preferred embodiment of the present invention. The device includes an alternating element 211, which has two halves. On one half, see insert, is mounted a light dispersion element 212 which spectrally analyzes a light beam to produce a spectral image thereof. Typically light dispersion element 212 is a diffraction grating and may be a reflective diffraction grating producing a specular reflection. The other half of the alternating element is a reflection element, typically a mirror, which reflects the light beam without analysis to produce a non-analyzed reflection of said beam, in other words it produces a simple image of the region of interest. The alternating unit is able to alternately present the light dispersion element and the reflection element to light path 210 to reflect the light onto detection optics 201 – 202 via continued light path 207.

The result is a dual mode spectrum analyzing device that is able to alternate between a plain image and a spectral image of a region of interest.

Light from the region of interest is gathered by an optical pick-up assembly 204 which collimates this input light into light path 210.

The alternating unit as illustrated comprises a rotating motor element, and a disc mounted for rotation by the motor element. The disc is divided into two parts, one part forming the reflection element and the second part forming the light dispersion element, as illustrated. It will however be appreciated that a rotating disc is not the only way of alternating between the two elements, which could alternatively be mounted on a linear moving element or elements.

The disc and its axis of rotation, that is the motor axis, may be substantially 45 degrees to the light path, so that both the mirror and the reflective diffraction grating reflect the light in the same direction, namely to the detectors.

The motor may include a sensing element for monitoring the current orientation of the motor element.

Fig. 2 is now considered in greater detail. The incident light from light source 203 illuminates an area of interest denoted as 209. Reflected light from the illuminated area of interest is collected by first collimating optics element 204. Collimated light beam 210, thus contains the reflected spectrum from the area of interest (ROI).

Collimated light beam 210 then arrives at optical subsystem 205. The optical system 205 comprises a rotating disc 206, which is split into two optical elements, one a diffraction grating and the second a reflecting mirror. Note that a reflective diffraction grating may be used so that the beam reaches the same sensor in both cases. Element 205 rotates the disk 206 about axis 211. Depending upon the rotation state of the element the light beam 210 meets either the mirror or the grating. As disc 206 is rotated along the rotation axis denoted as 211, the reflected image to the camera optics 202 alternates between an image of the region of interest and a diffracted spectrum, or specular reflection, thereof. The reflected beams are imaged onto imaging optics 201 such as a camera using a CCD or CMOS sensor. An embodiment may use a web camera. The imaging optics or camera system streams the resulting image data to a computer for spectrum analysis and image display.

In an embodiment, the computer shows the plain and spectral images synchronized, say one on top of the other, or they may alternate, that is one after the other.

Reference is now made to Fig. 3 which shows a variation of the implementation shown in Fig. 2. In Fig. 3 rotating optical element 301 is rotated by a motor 302.

In one alternative embodiment the optical element 202 is a zoom lens capable of changing the size of the region of interest (ROI), that is to say, changing the size of the field of view.

Software is provided to display and analyze data, typically using a computer, so that graphs may be constructed of the spectra, so that the spectra may be interpreted as per the current circumstances or specific application. Thus in one specific application the images may be of hair and the spectra may be used to determine potential dyes and hair coloring results.

Illumination of the region of interest may be by monochromatic illumination as well as broad band spectral illumination.

Fig 4 is a simplified block diagram showing a second embodiment of the present invention. Here the motor element of Fig. 2 is replaced by a beam splitter element with two optical surfaces. The first surface, denoted as 401 splits, the beam, one part reflecting the beam and being directed to the camera. Element 401 thus creates the image of the object whereas the second part is directed to a dispersion element, typically a grating element, and herein denoted as 402, thereby creating a spectrum of the illuminated object area.

The orientation of the beam splitter element is such that both the image and the first order of the spectrum are directed to the camera, the end result being a combination of images created on the CCD surface. The two images are separated and displayed on two different areas. The computer then analyzes the area on the CCD where the spectrum forms and creates a spectrum graph as before. The result is a spectrum next to an image of the area of interest from which the spectrum has been taken.

Reference is now made to Fig. 5, which is a simplified diagram showing a further embodiment of the present invention, wherein a doubled reflecting element 50 reflects light from the light path to the camera 52. As shown in the insert, the element 50 comprises two regions, a grating or dispersive region 54 and a pure reflecting region or mirror 56. The result is to provide at the camera an image of the source 58 alongside a spectrum thereof.

Reference is now made to Fig. 6 which shows an embodiment of the apparatus of Fig. 2. The rotating disk 60 includes a dispersive element 62 and a pure reflective element 64 as before, one on each of two parts of the disk. However the disk is not flat and the part of the disk carrying the dispersive element is angled with respect to the mirror part so as to ensure that the first order of the spectrum reaches the camera. Both the zeroth order and the second order may be discarded.

It is expected that during the life of a patent maturing from this application many relevant spectroscopy and spectral imaging methods and systems will be developed and the scopes of the corresponding terms are intended to include all such new technologies *a priori*.

The terms "comprises", "comprising", "includes", "including", "having" and their conjugates mean "including but not limited to".

The term "consisting of means "including and limited to".

As used herein, the singular form "a", "an" and "the" include plural references unless the context clearly dictates otherwise.

It is appreciated that certain features of the invention, which are, for clarity, described in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the invention, which are, for brevity, described in the context of a single embodiment, may also be provided separately or in any suitable subcombination or as suitable in any other described embodiment of the invention. Certain features described in the context of various embodiments are not to be considered essential features of those embodiments, unless the embodiment is inoperative without those elements.

Although the invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art. Accordingly, it is intended to embrace all such alternatives, modifications and variations that fall within the spirit and broad scope of the appended claims.

All publications, patents and patent applications mentioned in this specification are herein incorporated in their entirety by reference into the specification, to the same extent as if each individual publication, patent or patent application was specifically and individually indicated to be incorporated herein by reference. In addition, citation or identification of any reference in this application shall not be construed as an admission that such reference is available as prior art to the present invention. To the extent that section headings are used, they should not be construed as necessarily limiting.

WHAT IS CLAIMED IS:

1. A spectrum analyzing device, for spectral analysis of a region of interest, comprising:

a light dispersion element for spectrally analyzing a light beam to produce a spectral image thereof,

a reflection element for reflection said light beam without analysis to produce a non-analyzed reflection of said beam, and

a dual-mode unit for dually presenting said light dispersion element and said reflection element to a light path, said light dispersion element and said reflection element both being configured to deliver light of said light path to a common target location, thereby to provide a dual mode spectrum analyzing device able to provide unified sensing of two modes of viewing a region of interest, one being a plain image and a second being a spectral image of said region of interest.

2. The spectrum analyzing device of claim 1, wherein said dual mode unit is an alternating unit for alternately presenting said light dispersion element and said reflection element to said light path.

3. The spectrum analyzing device of claim 2, wherein said light dispersion element is angled with respect to said light path to present a first order of said spectral image to said common target location.

4. The spectrum analyzing device of claim 1, wherein said dual mode unit is a beam splitter for sending part of the light beam via said light dispersion element and part of said light beam via said reflection element.

5. The spectrum analyzing device of claim 1, wherein said dual mode device is a two part reflection element comprising a first dispersive part and a second reflective part, and wherein both parts are placed in said light path simultaneously.

6. The spectrum analyzing device of claim 4, wherein said light dispersion element and said beam splitter are configured to provide said two modes of viewing to different regions of a single detector.

7. The spectrum analyzing device of claim 1, wherein said unified sensing is achieved on a single image sensor.

8. The spectrum analyzing device of claim 1, wherein said unified sensing is achieved on a unified group of sensor elements.

9. The spectrum analyzing device of claim 1, further comprising an optical pick-up assembly capable of collimating input light of said region of interest into said light path.

10. The spectrum analyzing device of claim 1, wherein said light dispersion element comprises a diffraction grating.

11. The spectrum analyzing device of claim 10, wherein said diffraction grating comprises a reflective diffraction grating.

12. The spectrum analyzing device of claim 1, wherein said reflection element comprises a mirror.

13. The spectrum analyzing device of claim 2, wherein said alternating unit comprises a moving element on which said reflection element and said light dispersion element are mounted, said moving element being configured to alternately move one of said elements into said light path.

14. The spectrum analyzing unit of claim 2, wherein said alternating unit comprises:

a rotating motor element, and

a disc mounted for rotation by said motor element, said disc being divided into two parts, one part forming said reflection element and the second part forming said light dispersion element.

15. The spectrum analyzing unit of claim 14, wherein said motor element is mounted such that an axis for said rotation is substantially 45 degrees to said light path.

16. The spectrum analyzing unit of claim 15, further comprising a sensing element for monitoring a current orientation of said motor element.

17. A method for spectral analysis comprising:

setting up a light path from a region of interest to a detector,

inserting a light dispersion element into said light path to produce a spectrum at said detector;

alternating said light dispersion element with a reflection element,

thereby to alternate said spectrum with an image of said region of interest for dual mode viewing.

18. The method of claim 17, wherein said alternating comprises beam splitting, and said dual mode viewing comprises setting said image and said spectrum on different parts of said detector.

19. The method of claim 17, wherein said alternating comprises replacing of one of said light dispersion element and said reflection element with the other of said light reflection element and said rotation element.

20. The method of claim 19, wherein said replacing comprising rotating a disk carrying both of said light dispersion element and said reflecting element between a first position in which said light dispersion element is in said light path and a second position in which said reflection element is in said light path.

FIG. 1B

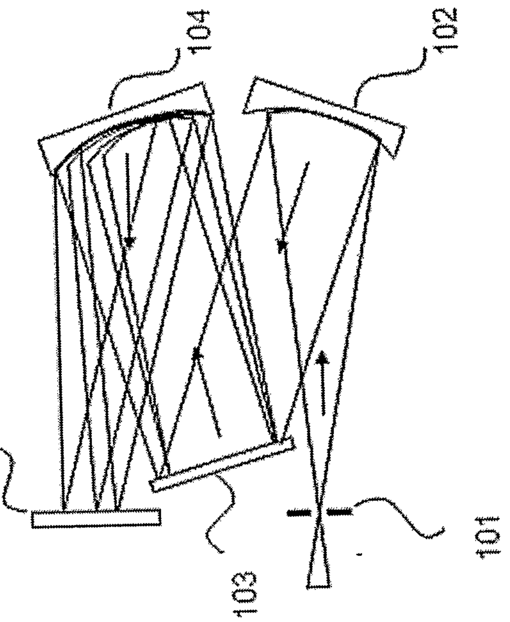
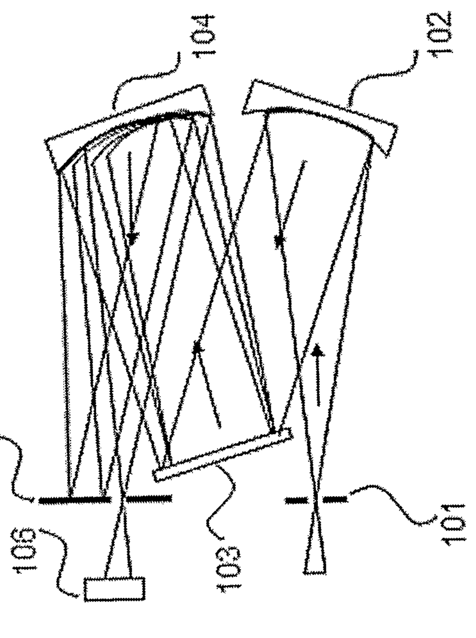


FIG. 1A



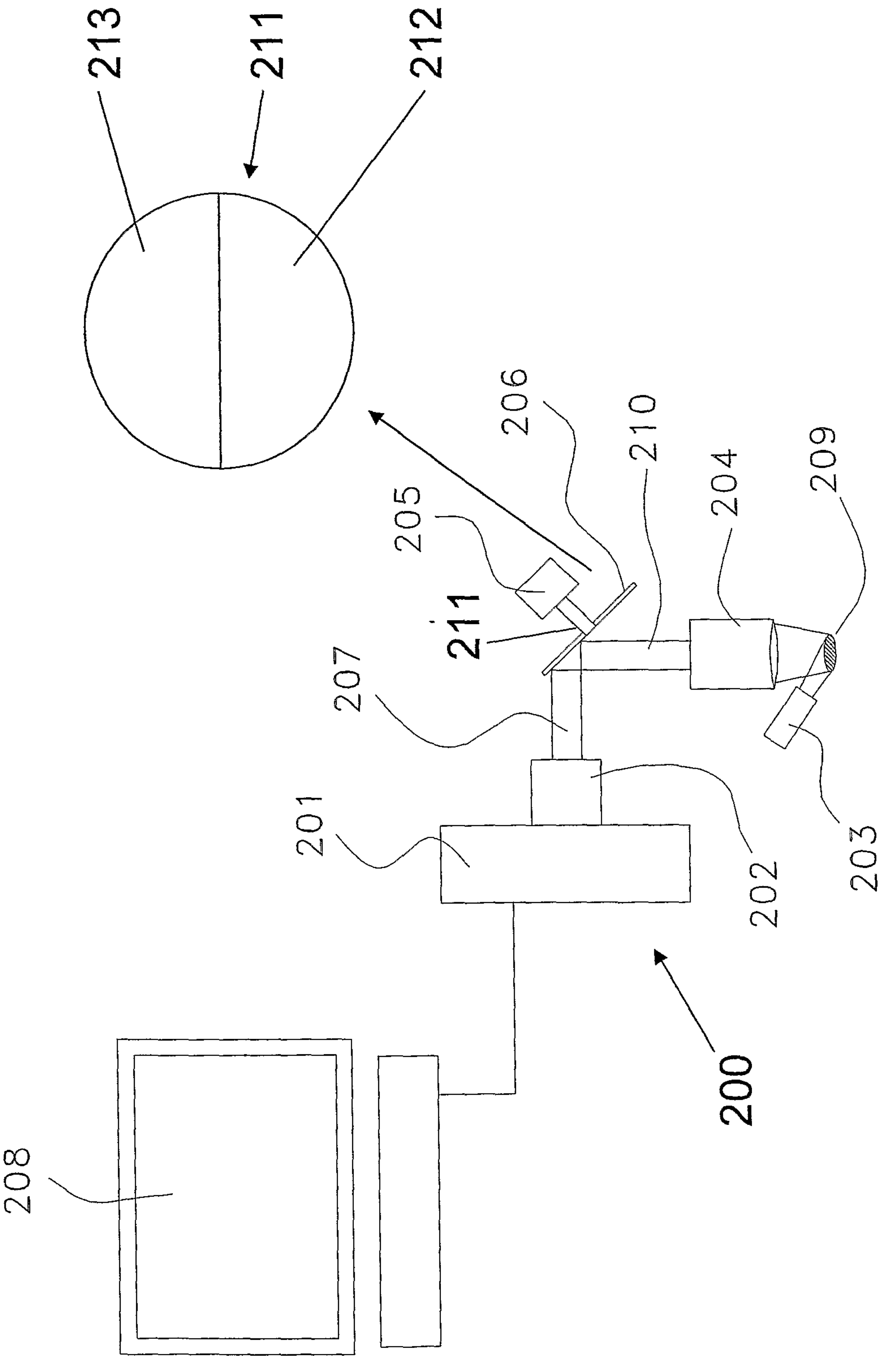


FIG. 2

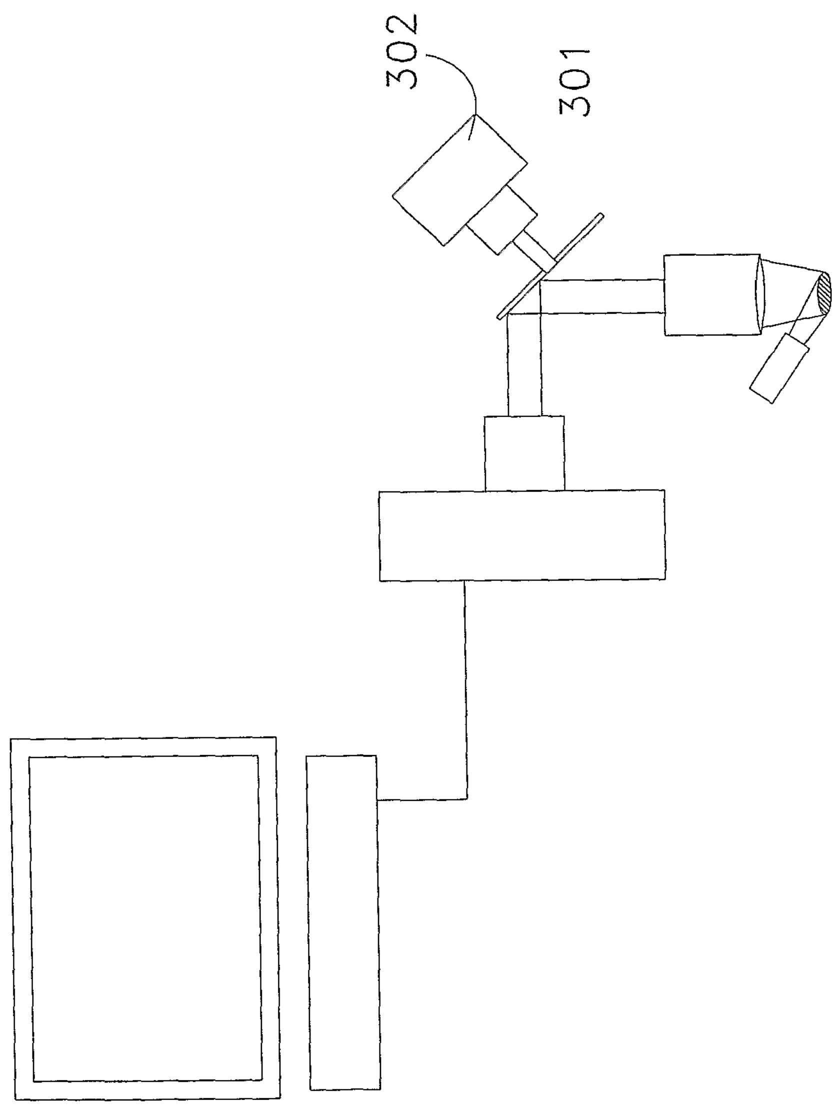


FIG. 3

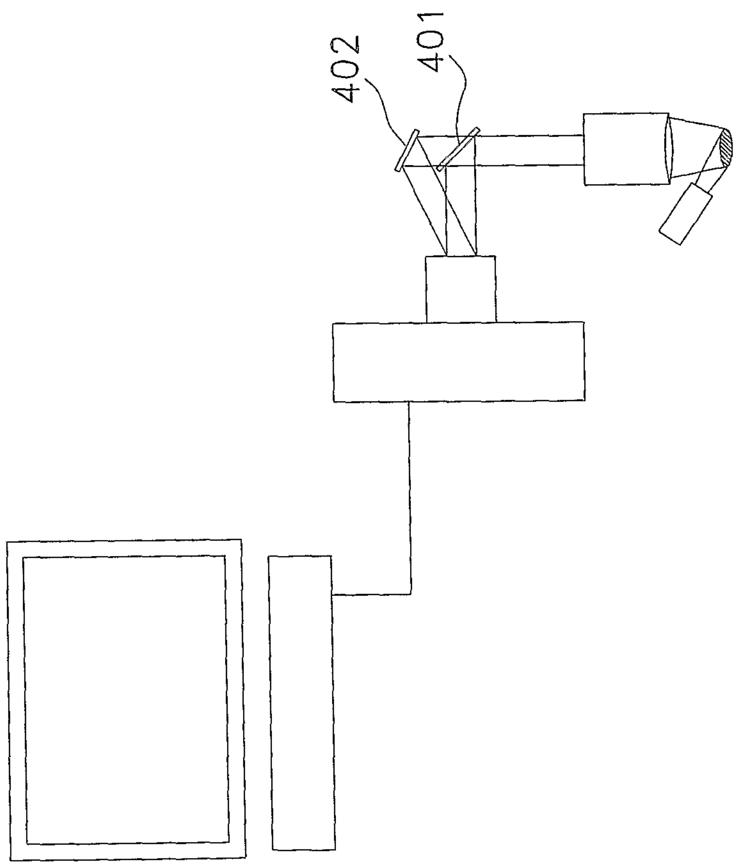


FIG. 4

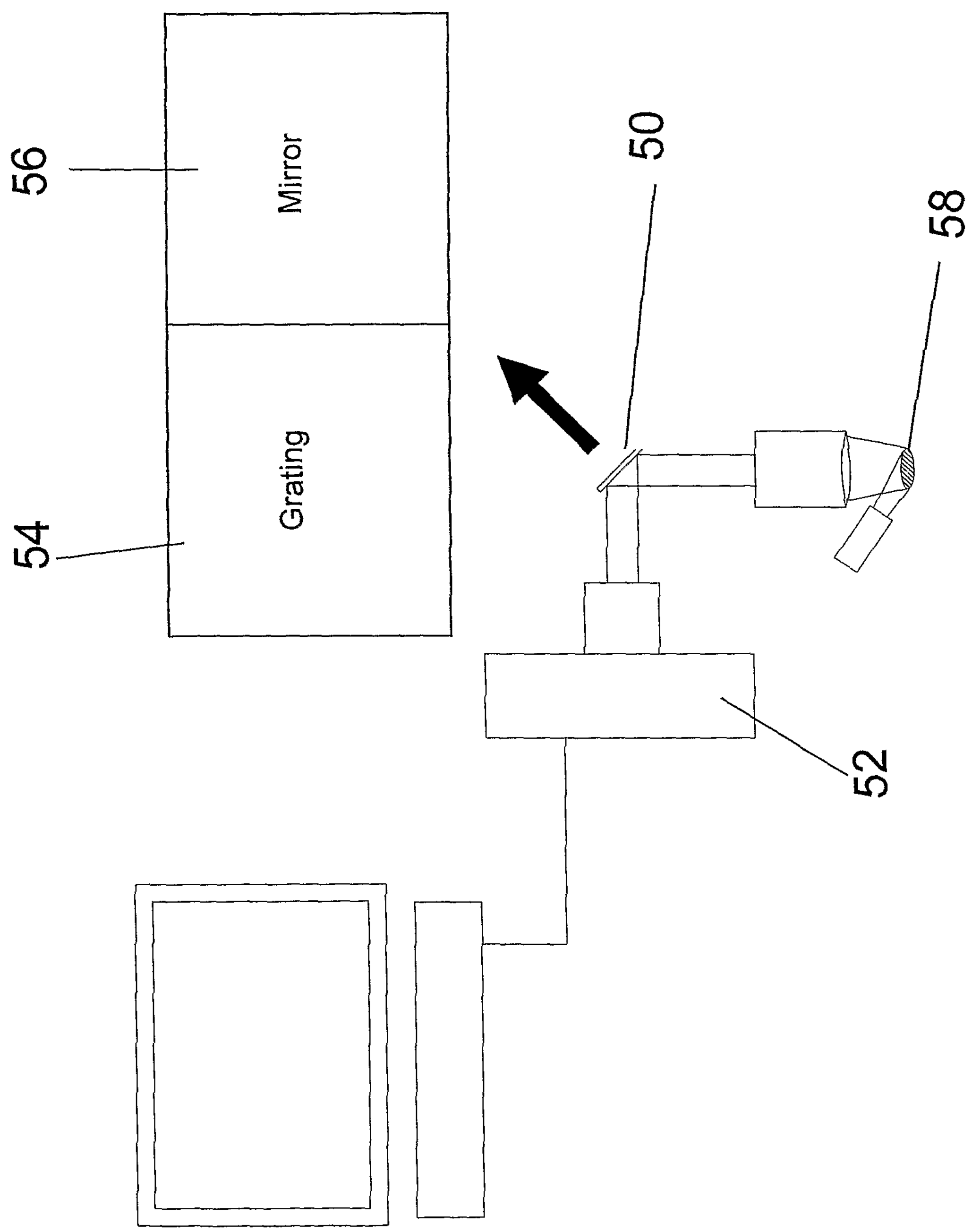


FIG. 5

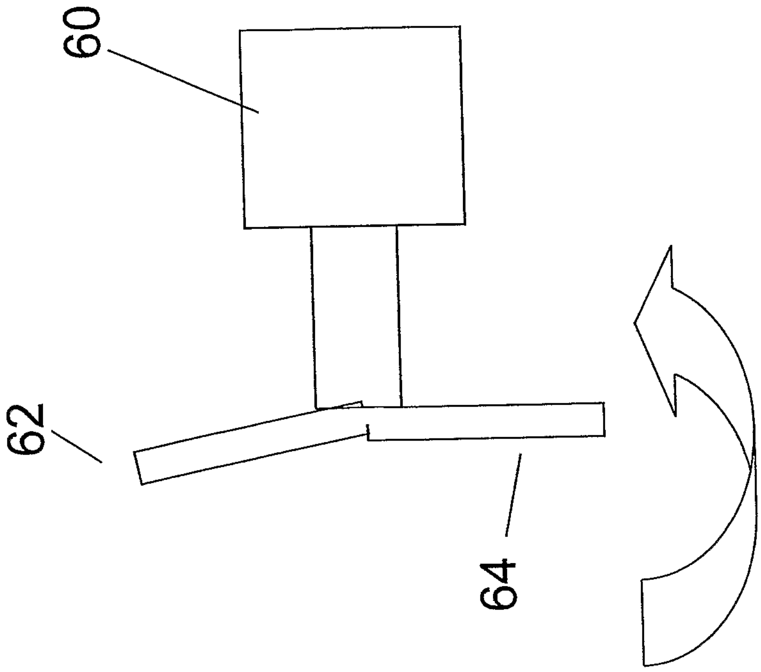


FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/IL2009/000015

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01J3/18 G01J3/28 G01J3/32

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)
G01J G02B

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 038 024 A (BERNER MARKUS [CH]) 14 March 2000 (2000-03-14) abstract; figure 1 column 4, line 34 - column 6, line 32 column 7, lines 7-20 column 8, lines 5-32	1-20
X	US 4 917 492 A (KOISHI MUSUBU [JP]) 17 April 1990 (1990-04-17) abstract; figures 1,2 column 2, line 39 - column 3, line 52 column 4, lines 15-34	1-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family 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

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"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
27 April 2009	07/05/2009

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IL2009/000015

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 6038024	A	14-03-2000	NONE		
US 4917492	A	17-04-1990	GB	2220479 A	10-01-1990
			JP	1320441 A	26-12-1989
			JP	2033655 C	19-03-1996
			JP	7052122 B	05-06-1995