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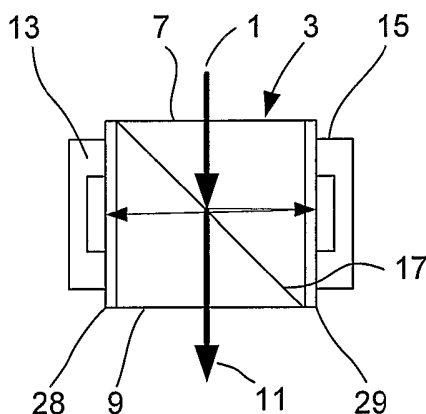
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(54) Title: LIGHT MONITORING DEVICE



(57) Abstract: A monitoring device for monitoring a light beam com-
prises a beam splitter, a photodetector and an electrical conductor mem-
ber, wherein the photodetector and the electrical conductor member are
located directly or indirectly on the beam splitter, and the electrical con-
ductor member is electrically connected to the photodetector. The elec-
trical conductor member may be a conductive track on the beam splitter
or it may be a tile or other substrate carrying a conductive track or other
electrical conductor. The monitoring device may be a wavelength locker
for a laser.

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Light Monitoring Device

The present invention relates to the monitoring of a light beam, and in particular the monitoring of the wavelength of a light beam, for example in order to detect and correct any drift in the wavelength from a predetermined wavelength (known as "wavelength locking"). The invention has particular utility in the field of optical communications (and will be described primarily in relation thereto) but at least the broadest aspects of the invention are not limited to optical communications applications.

In this specification, the terms "light" and "optical" will generally be used to refer not only to visible light but also to other wavelengths of electromagnetic radiation, for example in the wavelength range of about 200nm to about 1mm, i.e. from ultraviolet to the far infrared.

Wavelength lockers are well known and are used, for example, to ensure that an optical signal generated by a laser for transmission over an optical communications network has the correct wavelength. (Wavelength drift may otherwise occur due to ageing effects, temperature variations, or power fluctuations, for example.) This is particularly important, for example, in wavelength division multiplex (WDM) optical communications systems, and is even more important in dense wavelength division multiplex (DWDM) systems, in which a plurality of wavelength channels is used to transmit optical signals via a single optical fibre. If the wavelength of one or more of the optical signals does not fall within its correct pre-assigned wavelength channel, corruption of the signals and/or problems with detection of the signals may occur, for example.

There are currently two principal telecommunications bands, namely the C Band (191.6 – 196.2 THz) and the L Band (186.4 – 191.6 THz). Within these bands there are standard wavelength channels defined by the International Telecommunications Union (ITU) at spacings of 100 GHz (0.8nm), 50 GHz (0.4nm), or 25 GHz (0.2nm). (In the future,

additional bands, and narrower spacings of wavelength channels within the bands may be used.) There is therefore a need to "lock" optical signal wavelengths at these standardised wavelengths for example, and wavelength lockers are used for this purpose.

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Thus, a wavelength locker typically monitors the light output of a laser and provides electronic feedback to the laser to control its wavelength. The locker typically comprises an etalon and/or other filter, with one or more photodetectors. The etalon or other filter transmits light that is a function of wavelength, and the level of light that is detected by the photodetector can therefore be related to the wavelength. Figure 1 of the accompanying drawings illustrates, schematically and in plan view, a wavelength locker of the type disclosed in international patent application WO01/091756 (Bookham Technology), the entire contents of which are incorporated herein by reference. In this wavelength locker, a portion of the light beam 1 emitted from a source (e.g. a laser) is sampled from the beam by a cube-type beam splitter 3, and sampled light that is transmitted or reflected from a separate etalon or other filter 4 is detected by a pair of separate photodetectors 5. The wavelength of the light can be monitored by monitoring the difference between the photodetector signals produced by the two photodetectors. The power of the light can be determined from the sum of the two photodetector signals. In other known wavelength locker designs, one or more light splitting devices may be used, with one light path providing a power level, and another light path using an etalon or other wavelength-selective component to provide a signal for wavelength discrimination, for example.

A great many different wavelength locker designs are known. Examples of some known designs are disclosed in the following patent publications:

30 US2003/0142315; US5825792; US6639922;
US2004/0146077; US2003/0063632; US6661818; WO02/09736;
US2002/0181515; US6717682; US6487087; US6621580; and
US6353623.

Prior art wavelength lockers comprise separate components which take a substantial amount of space (e.g. an area of a few tens of mm²) inside an optoelectronics package. Such areas are very large in comparison to integrated optical components such as lasers, with which wavelength lockers are typically used. The available space in an optoelectronics package is normally extremely limited, and there is also a continuing need to reduce the size of such packages. Additionally, during manufacturing it is necessary for each of the components of a wavelength locker to be separately placed, aligned and bonded inside the package. Some of the components need to be aligned with a very high degree of precision, which is consequently expensive, due to the time-cost on the labour and assembly equipment.

Japanese patent application 2003-258362 discloses laser wavelength lockers in which two photodetectors are located on opposite surfaces of an etalon, in a collinear arrangement. The lockers disclosed in that document are stated to dispense with the need for a beam splitter, and to provide a compact arrangement. Because of their collinear arrangement, the lockers require the light received by one of the photodetectors to pass through the other photodetector, or require the two photodetectors to be at least partially off-set with respect to each other. The lockers disclosed in that document have a variety of problems. For example, the photodetector arranged to detect incident light that has not passed through the etalon may in fact also absorb some light that is reflected from the etalon, and hence this photodetector may produce a signal that is a composite of both of these portions of light. Also, the light received by the other photodetector may be modulated by the absorption properties of the first photodetector. Additionally, the lockers disclosed in that document require complex designs of photodetectors (in order to ensure that some light passes through one photodetector to the other photodetector), or they require complex alignment processes (in order to ensure the correct off-setting of the photodetectors).

The present invention seeks, among other things, to provide a solution to all of the above problems.

Accordingly, a first aspect of the invention provides a monitoring
5 device for monitoring a light beam, comprising a beam splitter, a
photodetector and an electrical conductor member, wherein the
photodetector and the electrical conductor member are located directly or
indirectly on the beam splitter, and the electrical conductor member is
electrically connected to the photodetector.

10

Preferably, the monitoring device is arranged such that in use the
beam splitter diverts a sample portion of the light beam, at an orientation
differing from an orientation of the light beam, to the photodetector.

15 Preferably the monitoring device is a wavelength locker for locking
the wavelength of the light beam substantially to a predetermined
wavelength.

A second aspect of the invention provides a transmitter comprising
20 a laser arranged to emit a light beam, and a monitoring device according
to the first aspect of the invention arranged to monitor the light beam
emitted by the laser.

The light beam monitored by the monitoring device may, for
25 example, be emitted from a rear facet of the laser (and a front facet of
the laser emits an output light beam). Alternatively, the monitored light
beam may be the main transmitted light beam emitted by the laser.

The invention has the advantages that it enables the provision of a
30 more compact wavelength locker (or other monitoring device) and/or
transmitter, it enables an easier alignment of its components, it enables
manufacturing cost and time to be reduced, and enables a reduction in
the number of components, compared to known devices.

The electrical conductor member may comprise at least one electrically conductive track, for example coated or otherwise applied directly on the beam splitter. In such embodiments, it can be advantageous for the track(s) to provide electrical contact to the photodetector(s) from a single surface of the beam splitter; this can simplify making the electrical contacts to the photodetector(s). Alternatively, however, the electrical conductor member may comprise a substrate carrying at least one electrical conductor (which may itself comprise an electrically conductive track, for example). Preferably, the substrate comprises a tile or other block (e.g. a ceramic tile). Advantageously, the electrical conductor carried by the substrate may extend between two surfaces, preferably two mutually substantially perpendicular surfaces, of the substrate - i.e. the conductor may extend around a corner of the substrate.

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The beam splitter (at least in the broadest aspects of the invention) may be any of a variety of different types of beam splitter. For example, the beam splitter may comprise a cube-type beam splitter, a prism-type beam splitter, a diffraction-type beam splitter (e.g. including a diffraction grating), or a walk-off-type beam splitter (e.g. a walk-off plate).

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In preferred embodiments of the invention, the monitoring device includes a wavelength-selective component, for example a filter (especially a thin-film filter) and/or an etalon. (In this specification an etalon is not regarded as being a "filter", but is instead regarded as being another type of wavelength-selective component.) Preferably the wavelength-selective component is located directly or indirectly on the beam splitter, or in the beam splitter (for example sandwiched between two or more parts of the beam splitter, as described below). In some preferred embodiments, the photodetector (or at least one of a plurality of photodetectors) may be located on the wavelength-selective component.

30

The monitoring device preferably includes a plurality of photodetectors located directly or indirectly on the beam splitter. In use,

the beam splitter preferably diverts a sample portion of the light beam to two or more such photodetectors, preferably at an orientation differing from an orientation of the light beam. The (or each) photodetector preferably comprises a photodiode.

5

Other preferred and optional features of the invention are described below, and in the dependent claims.

Some preferred embodiments of the invention will now be
10 described, by way of example, with reference to the accompanying drawings, of which:

Figure 1 is a plan view schematic representation of a known
wavelength locker;

15

Figure 2 is a perspective view schematic representation of a first
embodiment of the present invention;

Figure 3 is plan view schematic representation of the first
20 embodiment of the invention;

Figure 4 is a perspective view schematic representation of a second
embodiment of the invention;

Figure 5 is plan view schematic representation of the second
25 embodiment of the invention;

Figure 6 (views (a) and (b)) shows plan view schematic
representations of third and fourth embodiments of the invention; and

30

Figure 7 is plan view schematic representation of a fifth
embodiment of the invention.

Figure 1, showing a known wavelength locker, has briefly been described above.

Figures 2 and 3 show a monitoring device according to the invention, in the form of a wavelength locker arranged to monitor the wavelength of a beam of light 1 emitted from a laser (not shown) and to provide input to control the laser so that the wavelength of the light emitted by the laser can be maintained at a predetermined wavelength (or one of a series of predetermined wavelengths). The beam of light 1 emitted from the laser preferably is substantially collimated, for example by means of a collimator (not shown) situated between the laser and the wavelength locker. The wavelength locker comprises a cube-type beam splitter 3 having an input face 7 (see Figure 3) for receiving the light beam 1 and an output face 9 opposite to the input face 7, via which the (major) portion 11 of the light beam not sampled by the beam splitter exits the wavelength locker for onward transmission. Located on opposite lateral faces of the beam splitter 3 are first and second photodetectors 13 and 15 for detecting respective portions of the light beam 1 sampled by the beam splitter 3. As shown in Figure 3, the beam splitter 3 includes a diagonal interface that causes a first sample portion of the light beam 1 to be reflected substantially perpendicular to the light beam in a first direction (to the right-hand side as drawn). A portion of this first sample portion (namely a second sample portion of the beam) is reflected from a filter 29 (the function of which is explained below) located on the right-hand (as drawn) lateral face of the beam splitter 3 back across the beam splitter to its opposite lateral face. The photodetector 15 detects the first sample portion of the light and the photodetector 13 detects the second sample portion of the light.

Also located on the beam splitter 3 is an electrical conductor member in the form of a tile 19 that carries a plurality of electrical conductors in the form of tracks 21. (The tile 19 is omitted from Figure 3 for clarity, but is shown in Figure 2.) The tile 19 is located on a further face of the beam splitter, which further face extends between the input

and output faces 7 and 9, and also extends between the lateral faces on which the photodetectors 13 and 15 are located. As shown in Figure 2, the further face of the beam splitter 3 on which the tile 19 is located, is an upper face of the beam splitter. Also as shown in Figure 2, the photodetectors 13 and 15 are electrically connected to the conductive tracks 21 on the tile 19, e.g. by means of wire bonds 23. The photodetectors can therefore be electrically connected to other electronics of the wavelength locker (e.g. control electronics for a laser) via the conductive tracks 21 of the tile 19. For example, such electrical connections to other electronics via the conductive tracks 21 may be by means of further wire bonds 25 for those embodiments of the invention in which the beam splitter 3 is mounted on a base 27 with the tile 19 located on an upper surface of the beam splitter (the upper face spaced from the base by the height of the beam splitter). Alternatively, for those embodiments of the invention in which the beam splitter 3 is mounted on a base 27 via the tile 19, with the tile located on a lower surface of the beam splitter (i.e. the beam splitter is oriented 180 degrees "upside-down" with respect to the orientation shown in Figure 2), the electrical connections between the tracks 21 on the tile and the other electronics, may for example be via direct connections with tracks carried on the base.

The wavelength locker shown in figures 2 and 3 also includes a wavelength-selective component in the form of a filter 29 located on the beam splitter 3. The filter 29 is located directly (e.g. either attached or coated) on a face of the beam splitter 3. In the embodiment shown in figures 2 and 3, the filter 29 is located on the lateral face of the beam splitter 3 on which is located the photodetector 15 that detects the first sample portion of the light beam. Consequently, the photodetector 15 is actually located directly on the filter 29 and is only indirectly located on the beam splitter 3.

Preferably, the photodetector 15 is located directly on the filter 29, and the photodetector 13 is located directly on the beam splitter 3, or directly on an anti-reflection coating 28 on the beam splitter, by means of

"stand-off bumps" or other attachment means, either fabricated as part of the photodetectors, or provided separately (e.g. as "blobs" or other portions of epoxy resin or the like). This arrangement is preferred because it is preferable not to have a direct optical contact between the filter or the beam splitter and the respective photodiode. Also, it is preferred that the photodetectors are slightly tilted with respect to the surface of the filter or beam splitter on which they are located. This tilting may be achieved by means of the stand-off bumps or other separator means, for example. The tilting is to prevent the formation of a "parasitic" optical cavity between the photodetector and the filter or beamsplitter, which might affect the correct functioning of the device. Additionally or alternatively, the light beam from the laser may be oriented at a non-perpendicular angle with respect to the input face of the beam splitter.

15

It will be understood from the above that the expression "located directly on" in this specification means "located on, without an intervening component", and "located indirectly on" means "located on, with an intervening component". (The beam splitter and/or other optical components may include anti-reflection coatings; such coatings are deemed to be an integral part of the beam splitter or other optical component, and thus do not constitute an "intervening component" in the context of the present specification. Also, the means by which components are attached to each other – e.g. stand-off bumps – are not regarded as components.)

25

The filter 29 (which could instead be an etalon) is a wavelength-selective component, that is, the proportion of received light that it transmits and reflects is a function of the wavelength of the light. By means of such wavelength selection, the wavelength of the light beam 1 may be monitored in a known way. Preferably, a difference signal obtained from a difference between photocurrent signals emitted by the two photodetectors 13 and 15 is used to monitor the wavelength of the light beam, whereas a sum signal obtained from a sum of the two

30

photocurrent signals of the photodetectors preferably is used to monitor the power of the light beam. Alternatively, a separate optical power monitor may be used, in which case either a single photodetector 15 may be used to monitor the wavelength of the light beam, or two
5 photodetectors 13 and 15 (and their difference signal) may be used.

Figures 4 and 5 show a second embodiment of the invention which is similar to the first embodiment, but which differs from it in the positions of the filter 29 and the photodetector 13. In this embodiment, the filter
10 29 is located in the beam splitter 3, i.e. sandwiched between two prism-type parts 31, 33 of the beam splitter. Preferably this is achieved by coating one of the parts of the beam splitter to form the filter 29, prior to bonding the two parts together to form the cube-type beam splitter. This second embodiment of the invention is adapted to monitor either light
15 emitted from a rear facet of a laser or light "tapped off" from the main beam of a laser (emitted from the front facet of a laser). Consequently, unlike the embodiment shown in figures 2 and 3, there is no requirement for light to pass through the beam splitter 3 for onward propagation. Thus, a first sample portion of the light beam 1 received by the beam
20 splitter 3 propagates through the filter 29, through an anti-reflection coating 28 on a face of the beam splitter opposite to the input face 7, and is detected by the photodetector 13. A second sample portion of the light beam 1 is reflected from the diagonal interface inside the beam splitter 3, propagates through another anti-reflection coating 30 on a lateral face of
25 the beam splitter, and is detected by the photodetector 15. (For clarity, filter 29 and anti-reflection coating 28 are not shown in figure 4.)

In Figure 5, the tile 19 is omitted, for clarity, but the tile is shown in Figure 4. As described above, Figure 4 shows an arrangement of the
30 invention in which the beam splitter 3 is mounted on a base 27, with the tile 19 located on an upper surface of the beam splitter. Alternatively, the tile may be situated between the beam splitter and the base, for example.

Figure 6 (views (a) and (b)) shows plan view schematic representations of third and fourth embodiments of the invention. In these embodiments of the invention, the beam splitter is a "walk-off-type" beam splitter 35, e.g. in the form of a walk-off plate. In the embodiment shown in view (a) of Figure 6, the two photodetectors 37 and 39 are located on opposite faces of the walk-off plate 35, with the photodetector 37 located on the filter 29, and the photodetector 39 located on an anti-reflection coating 30. In this arrangement, power monitoring may be achieved by means of a sum signal of the sums of the photocurrents emitted by both photodetectors (similarly to the first and second embodiments of the invention described above). Alternatively, the filter 29 could be located beneath photodetector 39, in which case photodetector 37 (i.e. the photodetector not located on the filter 29) may be used for monitoring the power of the light beam 1.

15

In the fourth embodiment of the invention shown in Figure 6(b) both photodetectors 37 and 39 are located on the same face of the walk-off plate 35, and a mirror 34 (or other highly reflective coating) located on the opposite face of the walk-off plate is used to direct light to the photodetector 39. While this embodiment uses a slightly larger walk-off plate than does the third embodiment (shown in Figure 6(a)), the fourth embodiment has the advantage of potentially simplifying assembly and the electrical tracking.

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Figure 7 is plan view schematic representation of a fifth embodiment of the invention. In this embodiment, the beam splitter is a diffraction-type beam splitter 41 that incorporates a diffraction grating 43. The diffraction grating splits the incoming light beam 1 as shown, such that a main portion 11 of the light continues through the beam splitter and two sampled portions are directed at respective acute angles to the main portion, on opposite sides of the main portion. As with the fourth embodiment, this version has the advantage that both photodetectors 45 and 47 may be located on the same face of the beam splitter (either the input face 49 or the output face 51). When (as illustrated) the

25

30

photodetectors are located on the input face 49, highly reflective coatings 34 and 36 on the output face 51 of the beam splitter 41 preferably are used to direct the sampled portions of the light beam to the photodetectors.

5

As mentioned above, all of the described embodiments of the invention have the significant advantages over known wavelength lockers (or other monitors) in that they can be more compact and they can enable an easier alignment of the optical components. Each locker (or other
10 monitor) may form part of a laser transmitter according to a second aspect of the invention, for example.

Claims

1. A monitoring device for monitoring a light beam, comprising a beam splitter, a photodetector and an electrical conductor member, wherein the photodetector and the electrical conductor member are located directly or indirectly on the beam splitter, and the electrical conductor member is electrically connected to the photodetector, and wherein the device is arranged such that in use the beam splitter diverts a sample portion of the light beam, at an orientation differing from an orientation of the light beam, to the photodetector.
2. A monitoring device according to claim 1, wherein the electrical conductor member comprises at least one electrically conductive track.
3. A monitoring device according to claim 1, wherein the electrical conductor member comprises a substrate carrying at least one electrical conductor.
4. A monitoring device according to claim 3, wherein the electrical conductor comprises an electrically conductive track.
5. A monitoring device according to claim 3 or claim 4, wherein the substrate comprises a tile or other block.
6. A monitoring device according to any one of claims 3 to 5, wherein the electrical conductor carried by the substrate extends between two surfaces, preferably two mutually substantially perpendicular surfaces, of the substrate.
7. A monitoring device according to any preceding claims, wherein the beam splitter comprises a cube-type beam splitter.
8. A monitoring device according to any one of claims 1 to 6, wherein the beam splitter comprises a prism-type beam splitter.

9. A monitoring device according to any one of claims 1 to 6, wherein the beam splitter comprises a diffraction-type beam splitter including a diffraction grating.

5

10. A monitoring device according to any one of claims 1 to 6, wherein the beam splitter comprises a walk-off-type beam splitter.

11. A monitoring device according to any preceding claim, wherein the
10 photodetector comprises a photodiode.

12. A monitoring device according to any preceding claim, further comprising a wavelength-selective component.

13. A monitoring device according to claim 12, wherein the wavelength-selective component is located directly or indirectly on the beam splitter, or in the beam splitter.
15

14. A monitoring device according to claim 13, wherein a said
20 photodetector is located on the wavelength-selective component.

15. A monitoring device according to any one of claims 12 to 14, wherein the wavelength-selective component comprises a filter.

16. A monitoring device according to any one of claims 12 to 15, wherein the wavelength-selective component comprises an etalon.
25

17. A monitoring device according to any preceding claim, comprising a plurality of said photodetectors located directly or indirectly on the beam
30 splitter.

18. A monitoring device according to claim 17, arranged such that in use the beam splitter diverts a sample portion of the light beam to two or more said photodetectors.

19. A monitoring device according to any preceding claim, including a further component of the device, to which the electrical conductor member is electrically connected.

5

20. A monitoring device according to claim 19, in which the further component comprises a base on which the beam splitter is mounted.

21. A monitoring device according to any preceding claim, comprising a
10 wavelength locker for locking the wavelength of the light beam substantially to a predetermined wavelength.

22. A transmitter comprising a laser arranged to emit a light beam, and a monitoring device according to any preceding claim arranged to monitor
15 the light beam emitted by the laser.

23. A transmitter according to claim 22, in which the light beam monitored by the monitoring device is emitted from a rear facet of the laser, a front facet of the laser emitting a transmitted light beam.

20

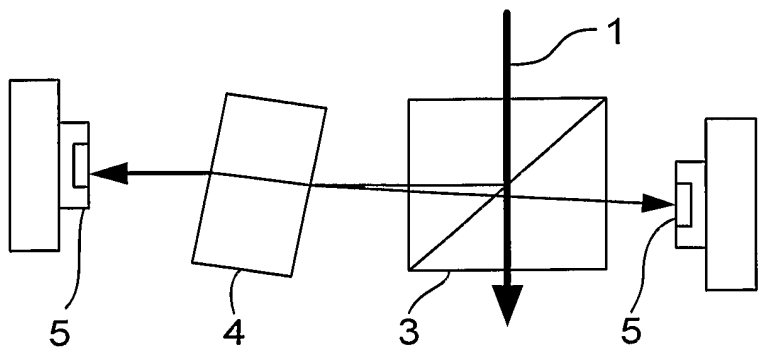


Figure 1

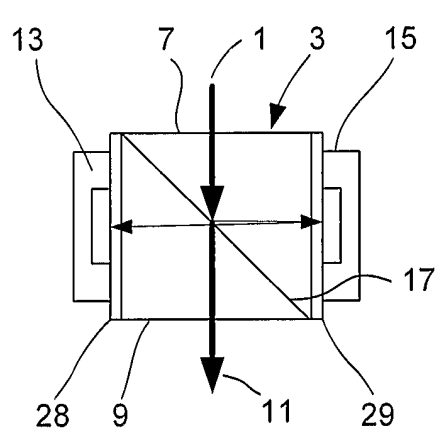


Figure 3

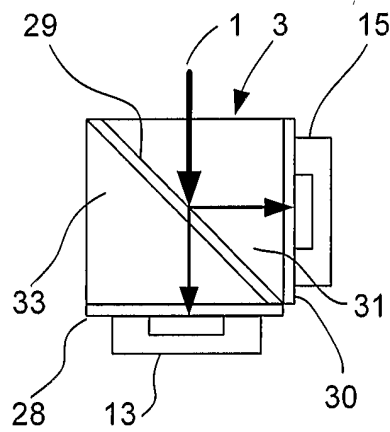


Figure 5

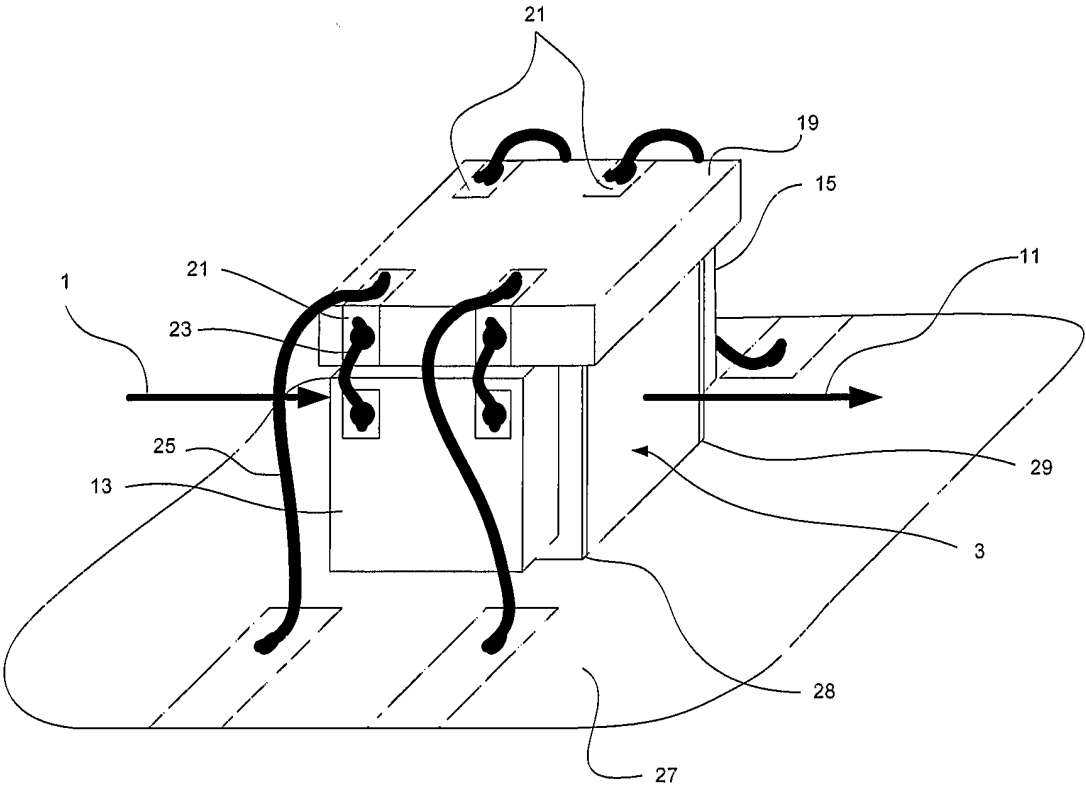
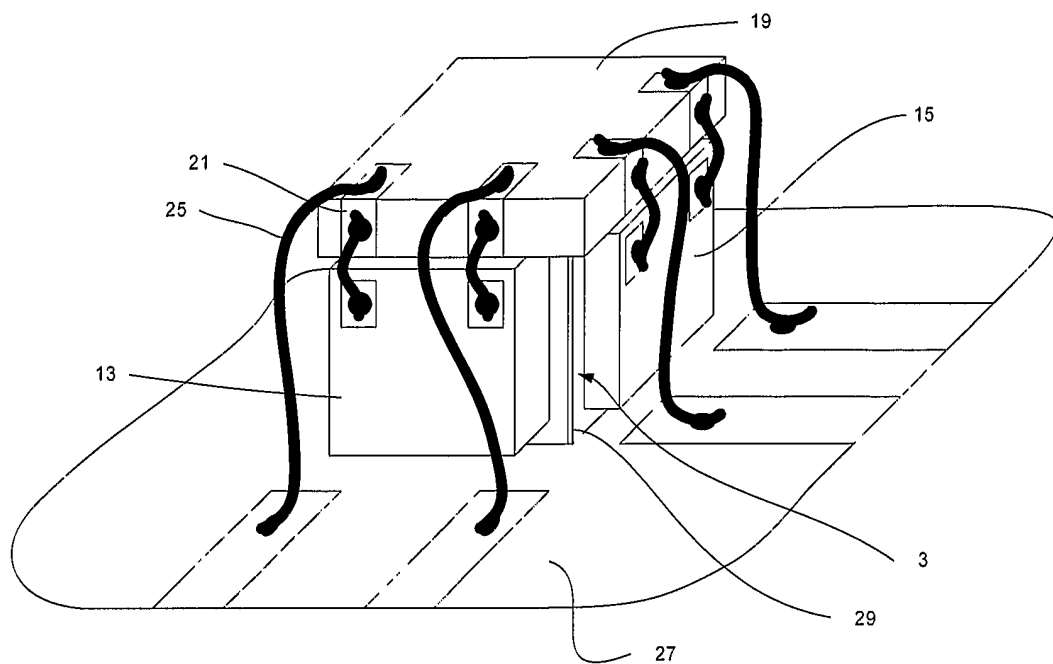


Figure 2

3/4

**Figure 4**

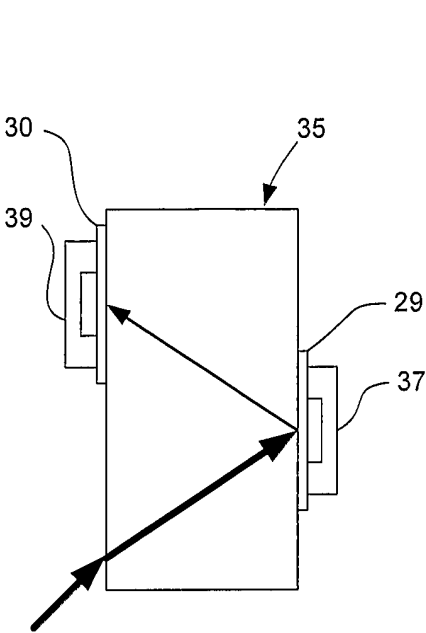


Figure 6(a)

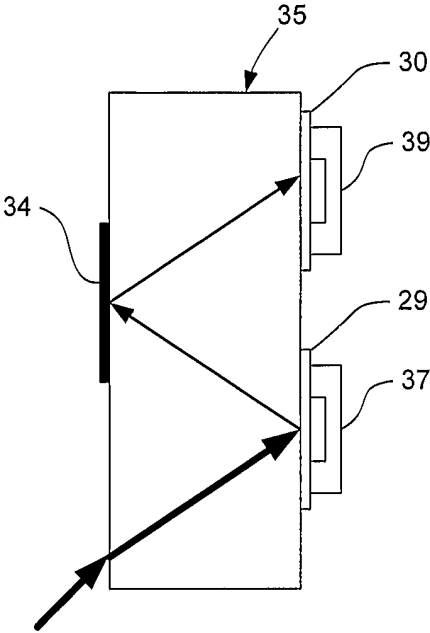


Figure 6(b)

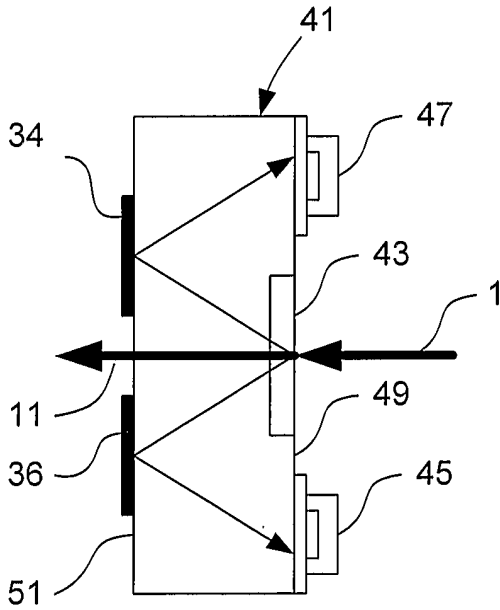


Figure 7

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2005/004574

A. CLASSIFICATION OF SUBJECT MATTER
H01S5/0687 G01J9/00

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 H01S

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	US 6 587 214 B1 (MUNKS TIMOTHY C) 1 July 2003 (2003-07-01) column 7, line 1 - line 55 column 8, line 25 - line 57 column 9, line 66 - column 10, line 31 figures 6,8,10	1-5,7, 11-22
X	US 2003/035119 A1 (MYATT CHRIS ET AL) 20 February 2003 (2003-02-20) cited in the application paragraph '0061! figure 12	1,17,18
X	US 6 661 818 B1 (FELDMAN MICHAEL R ET AL) 9 December 2003 (2003-12-09) cited in the application column 4, line 30 - line 40 figure 1A	1,9
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Further documents are listed in the continuation of Box C.



See patent family annex.

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 2003, no. 12, 5 December 2003 (2003-12-05) & JP 2003 258362 A (TOSHIBA CORP; TOSHIBA ELECTRONIC ENGINEERING CORP), 12 September 2003 (2003-09-12) cited in the application abstract figures 2,3,7,15,16 -----	1-6,22, 23
X	US 2003/112837 A1 (VAKHSHOORI DARYOOSH ET AL) 19 June 2003 (2003-06-19) cited in the application paragraphs '0031! - '0034! figures 3,4 -----	1,10
X	US 6 353 623 B1 (MUNKS TIMOTHY C ET AL) 5 March 2002 (2002-03-05) cited in the application column 4, line 31 - line 51 figure 1 -----	1

INTERNATIONAL SEARCH REPORT

International application No
T/GB2005/004574

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 6587214	B1	01-07-2003	CA 2381793 A1 EP 1236293 A2 JP 2004502141 T WO 0201765 A2	03-01-2002 04-09-2002 22-01-2004 03-01-2002
US 2003035119	A1	20-02-2003	WO 02090881 A1	14-11-2002
US 6661818	B1	09-12-2003	AU 5315401 A WO 0177626 A2 US 2004146077 A1	23-10-2001 18-10-2001 29-07-2004
JP 2003258362	A	12-09-2003	NONE	
US 2003112837	A1	19-06-2003	CA 2411300 A1 EP 1321750 A2 JP 2003202506 A	13-06-2003 25-06-2003 18-07-2003
US 6353623	B1	05-03-2002	NONE	