

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
27 December 2002 (27.12.2002)

PCT

(10) International Publication Number
WO 02/103418 A2

(51) International Patent Classification⁷: **G02B 6/00**

(21) International Application Number: PCT/GB02/02834

(22) International Filing Date: 18 June 2002 (18.06.2002)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0114815.4 18 June 2001 (18.06.2001) GB
0114816.2 18 June 2001 (18.06.2001) GB

(71) Applicant (*for all designated States except US*):
BOOKHAM TECHNOLOGY PLC [GB/GB]; 90
Milton Park, Abingdon, Oxon OX14 4RY (GB).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): **ANANIA, Gior-**
gio [IT/GB]; 22, the Chestnuts, Abingdon, Oxfordshire

OX14 3YN (GB). **HOUSE, Andrew, Alan** [GB/GB]; 8
Blackstock Close, Headington, Oxford OX3 7JR (GB).
WHITE, Christopher, Richard, Hardy [GB/GB]; 35
Tismeads Crescent, Swindon SN1 4DP (GB).

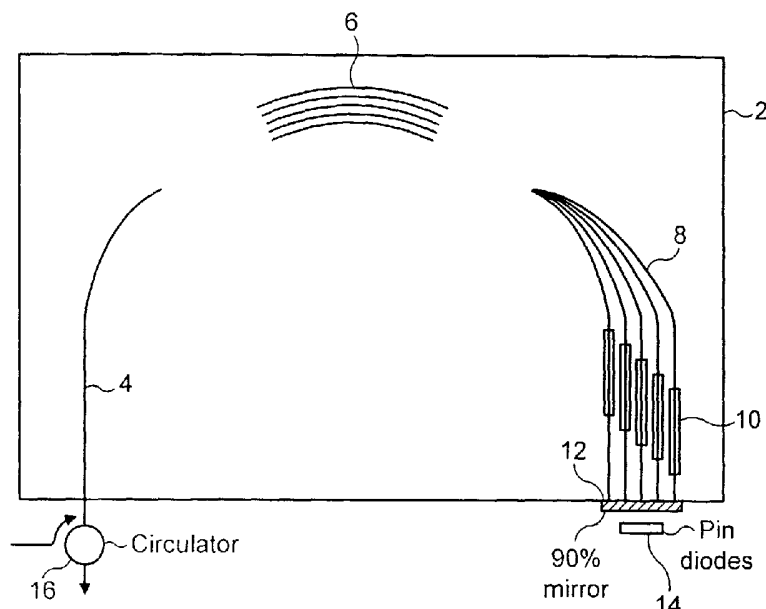
(74) Agents: **DRIVER, Virginia, Rozanne** et al.; Page White
& Farrer, 54 Doughty Street, London WC1N 2LS (GB).

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

(84) Designated States (*regional*): ARIPO patent (GH, GM,
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW),
Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR,
GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent

[Continued on next page]

(54) Title: OPTIC DEVICE



(57) Abstract: An optic device including an optic chip defining (i) a first wavelength dispersive element for receiving a wavelength-multiplexed input optical signal from an input waveguide and selectively directing the component channels to a respective one of a first array of output waveguides; (ii) a second wavelength-dispersive element; and (iii) a power-splitting element for directing a minor portion of the power of each component channel of the wavelength-multiplexed input signal to the second wavelength-dispersive element; and a light detecting device for measuring the power of at least one component channel output from the second wavelength dispersive element, wherein the first and second wavelength dispersive elements including overlapping output free propagation regions.



WO 02/103418 A2



(BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

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

OPTIC DEVICE

The present invention relates to an optic device, particularly one including an integrated device.

Optical communications systems typically involve wavelength multiplexing for increasing the data transmission capacity.

The absolute maximum power of the component channels of a multiplexed signal may not be the same, and in some instances it may be desirable to attenuate one or more of the component channels to reduce the power differences between the component channels in the transmitted signal. In some instances, this may require the absolute value of the maximum power of one or more of the input component channels to be monitored to determine to what extent the absolute maximum power of those component channels may need to be reduced.

At the data receiving end, a demultiplexer is used to resolve the wavelength-multiplexed signal into its component channels for independent measurement of the variation of the power of each component channel with time by an appropriate data-receiving element. The absolute maximum power of the component channels may not be the same, and in some instances, it may be desirable to reduce the absolute maximum power of one or more of the component channels before they reach the respective data-receiving elements.

At the transmitting end, a multiplexer is used to simultaneously direct a number of input component channels into a single optical fibre. The absolute maximum power of each input component channel may not be the same, and in some instances it is desirable to attenuate one or more of the component channels prior to transmission to reduce the power differences between the component channels in the transmitted signal.

According to a first aspect of the present invention, there is provided an optic device including (a) an integrated device including a demultiplexer for receiving a wavelength-multiplexed input optical signal from a first input waveguide and selectively directing the component channels to a respective one of a first array of output waveguides; a wavelength-dispersive element; and a power-splitting element for directing a minor portion of the power of each component channel of the wavelength-multiplexed input signal to the wavelength-dispersive element; and (b) a light detecting device for measuring the power of at least one component channel output from the wavelength dispersive element.

According to a second aspect of the present invention, there is provided an optic device including (a) an integrated device including a multiplexer for receiving a plurality of optical signals at different channels from an array of input waveguides and directing the optical signals to a single output waveguide to form a wavelength-multiplexed signal; a wavelength dispersive element; and a power-splitting element for directing a minor portion of the power of each channel of the wavelength-multiplexed signal from the output waveguide to the wavelength dispersive element; and (b) a light detecting device for measuring the power of one or more channels output from the wavelength dispersive element.

According to a third aspect of the present invention, there is provided an optic device including an integrated device, the integrated device including a demultiplexer for receiving a wavelength-multiplexed input signal comprising a plurality of component channels; a variable attenuating element for independently attenuating the power of one or more of the component channels output from the demultiplexer; a multiplexer for remultiplexing some or all of the component channels; and an element for directing at least some of the

component channels to the multiplexer after propagation through the variable attenuating element.

Embodiments of the invention are described hereunder, by way of example only, with reference to the accompanying drawings, in which:

Figures 1 to 6 show schematic plan views of six different embodiments of the present invention;

Figure 7 illustrates an example of an etched reflecting element for use in the embodiments shown in Figures 2 and 4 to 6; and

Figures 8 to 10 show schematic plan views of another three embodiments of the present invention.

Figure 1 illustrates a device according to a first embodiment of the present invention. With reference to Figure 1, a number of optical elements are defined in a single optical chip 2, for example a silicon-on-insulator chip, to create a monolithically integrated device. Alternatively, the optical chip could, for example, be an InP chip or a silica-on-silicon chip. A first input waveguide 4 extends from an edge of the chip towards a first arrayed waveguide grating 6, and an array of output waveguides 8 lead from the first arrayed waveguide grating to, for example, the same edge of the chip 2. The input waveguide 4 and the array of output waveguides 8 are separated from the arrayed waveguide grating 6 by free space regions. The arrayed waveguide grating and the positioning of the input waveguide 2 and the output waveguides 8 are designed such that the arrayed waveguide grating receives a wavelength-multiplexed signal comprising a number of component channels from the first input and selectively directs each component channel to a respective output waveguide. Only five output waveguides are shown in Figure 1, but more output waveguides would normally be provided in accordance with the large number of channels employed in communication systems.

Each output waveguide is provided a variable optical attenuator (VOA) 10, such as a pin diode. The pin diodes may be used to independently attenuate the power of each component channel by the free carrier dispersion effect. Other VOA types could also be used, in particular Mach-Zehnder based devices utilising the free carrier effect with a PIN diode as the phase modulating element or utilising the thermo-optic effect with a NIN or metal track heater as the phase shifter. A thermo-optic Mach-Zehnder would be used in the case of a silica-on-silicon optical chip.

A partially transmitting mirror 12 is provided at the portion of the edge of the chip to which the output waveguides 8 lead. This mirror may for example be designed to reflect about 90% of the power of each component channel back down the respective output waveguide 8 with at least part of the remaining 10% of power being transmitted through the mirror. Behind the mirror is arranged an array of photodiodes, each photodiode arranged to receive a respective component channel from a respective output waveguide. The photodiodes are used as light-detecting elements to determine the average optical power of each component channel.

The portion of the component channels reflected by the mirror is directed back to the arrayed waveguide grating 6 via the output waveguides 8 where it is remultiplexed into the input waveguide 4. A circulator is connected to the input waveguide to allow the simultaneous connection of input and output optical fibres to the input waveguide 4 and thus allow the simultaneous transmission of the multiplexed signal between the input waveguide and the input and output optical fibres.

Although not shown in Figure 1, circuitry is provided for controlling each of the variable optical attenuating elements in accordance with the power value measured by the light-detecting element for the respective component channel.

In the device shown in Figure 1, the partially transmitting mirror is provided to reflect a major portion of all the component channels back down the respective output waveguides, and to transmit a minor portion of all the component channels to the respective photodiode. In those cases where it is desired to drop one or more of the component channels from the multiplexed signal, the mirror or other reflecting structure(s) is positioned such that all or a major portion of the power of only those component channels to be remultiplexed are reflected back down the waveguides, and such that none of the power of the component channels to be dropped is reflected back down the respective output waveguides but is directed to a light-detecting element or to an optical fibre for further separate transmission to a destination different to that of the remultiplexed signal.

Such a device is shown in Figure 2. This device is similar to that shown in Figure 1 except that three of the output waveguides lead to a respective integrated reflecting element 20 which reflects all the light in the respective output waveguide back to the demultiplexer for remultiplexing and the remaining two output waveguides have no reflecting element whereby all the light in the respective output waveguide may be directed to a respective photodiode of the photodiode array 14 designed for detection of the signal carried by the component channel.

Figure 7 shows an example of an integrated reflecting element defined in a silicon-on-insulator chip. The epitaxial silicon layer 200 is deep etched down to the silicon oxide optical confinement layer 202 supported on a silicon substrate 204 to form a V-shaped facet 208 at the end of the rib waveguide 206. In order to minimise loss at the mirror associated with fabrication tolerances, the area of the reflecting surface is increased by tapering out the end portion 210 of the waveguide rib. For example, the rib is tapered from a width of $4\mu\text{m}$ to $15\mu\text{m}$ over a length of $740\mu\text{m}$.

According to one variation (not shown) of the device shown in Figure 2, some waveguides could lead to integrated reflecting elements of the kind shown in Figure 7 and other waveguides could lead via a partially transmitting mirror element to a respective photodiode, with, for example, 90% of the power being reflected back to the demultiplexer for remultiplexing and 10% of the power being transmitted to a respective photodiode designed for measurement of the average optical power, which measured value could be used to control the respective VOA 10. This variation allows for monitoring of the average optical power of only a selected number of the component channels but remultiplexing of all the component channels.

Figure 3 shows a device according to a further embodiment of the present invention. As in the case of Figure 1, a number of optical elements are defined in a single optical chip 22, for example a silicon-on-insulator chip, to create a monolithically integrated device. A first input waveguide 24 extends from an edge of the chip 22 towards a first array waveguide grating 26 via a power-splitting element 34 such as a y-junction or evanescent coupler, and an array of output waveguides 28 leads from the first array waveguide grating to an opposite edge of the chip 2 via variable optical attenuating elements 30 and an AWG multiplexer. The input waveguide 24 and the array of output waveguides 28 are separated from the arrayed waveguide grating 26 by free space regions. The arrayed waveguide grating and the positioning of the input waveguide 24 and the output waveguides 28 are designed such that the arrayed waveguide grating receives a wavelength-multiplexed signal comprising a number of component channels from the first input and selectively directs each component channel to a respective output waveguide. Only five output waveguides are shown in Figure 3, but more output waveguides would normally be provided in accordance with the large number of channels employed in communication systems.

Each output waveguide is provided with a variable optical attenuating element 30, such as a pin diode. The pin diodes may be used to independently attenuate the power of each component channel by the free carrier dispersion effect.

A second arrayed waveguide grating 46 is provided for receiving each component channel from the output waveguides 28 via the variable optical attenuating elements 30 and directing them to a common output waveguide 48.

A minor portion of the power of each mode of each component channel is diverted from the first input waveguide 24 into a second input waveguide 32 using a power splitting element 34. The power splitting element may, for example, be a Y-junction or an evanescent coupler. The second input waveguide 32 leads the minor portion of each component channel to a third arrayed waveguide grating 36, and an array of output waveguides 38 lead from the second arrayed waveguide grating to an opposite edge of the chip 22. The input waveguide 32 and the array of output waveguides 38 are separated from the third arrayed waveguide grating 36 by free space regions. The arrayed waveguide grating 36 and the positioning of the input waveguide 32 and the output waveguides 38 are designed such that the arrayed waveguide grating 38 selectively directs the minor portion of each component channel to a respective output waveguide. As above, only five output waveguides are shown in Figure 1, but more output waveguides would normally be provided in accordance with the large number of channels employed in communication systems. A relatively compact layout is achieved by, as shown in Figure 3, arranging the first and third array waveguide gratings such that the free space regions at the output ends of the gratings overlap with the optical paths from each of the two array waveguide grating to the respective array of output waveguides crossing each other.

Light detecting elements 40, such as photodiodes, are provided at the edge of the chip for independently measuring the power of the minor portion of a

respective component channel directed thereto by the respective output waveguide, as described in pending UK application no. 0021240.7. A processor 50 is used to control the variable optical attenuating elements 30 in a predetermined manner on the basis of the electrical signals generated by the photodiodes 40.

Figure 4 shows a device according to a further embodiment of the present invention. The device is similar to that of Figure 3 except that a single dispersive array 60 is used for both demultiplexing and remultiplexing, with an array of integrated reflecting facets 64 of the kind shown in Figure 7 being formed in the optical chip for redirecting each component channel back to the dispersive array 60 for remultiplexing.

As an alternative to the use of an array of individual integrated reflecting facets of the kind shown in Figure 7, the array of output waveguides 28 could, as shown in Figure 8, lead to a polished edge of the optic chip adapted for reflection according to a technique such as metal evaporation, sputtering or wet etching. Locating the terminations of the input/output waveguide 24 and the array of output waveguides 38 leading to the array of photodiodes at one edge of the optic chip and the termination of the array of output waveguides 28 provided with attenuators at the opposite edge of the optic chip, as shown in Figure 8, facilitates production of the device. For example, it facilitates the process of polishing the ends of each waveguide. It also facilitates the polishing of the end of the input/output waveguide 24 in a different way to those of the array of output waveguides 28 provided with attenuators; for example, it may be desired to polish the end of the input/output waveguide 24 at an angle for attachment to a fibre block, whereas it may be desired to polish the ends of the array of output waveguides 28 provided with attenuators at a flat angle (i.e. perpendicular to the plane of the optic chip) in order to optimise reflection. It also facilitates the selective application of a reflective coating to the ends of the array of output waveguides 28 provided with attenuators.

Figure 5 shows a device according to yet a further embodiment of the present invention. This device is similar to that of Figure 4 except that a single dispersive array is used for both demultiplexing and remultiplexing and for the directing the minor portion of the input signal from the power splitting element to the array of monitoring photodiodes. A power splitting element 74 directs a minor portion of the mode of each component channel of a multiplexed signal received in input waveguide 72 into an additional input waveguide 76. An array of output waveguides 79 positioned at the other end of the dispersive array 78 includes a main set of output waveguides 80 that each lead to a respective variable optical attenuating element 84 and on to a respective integrated reflecting element 88 of the kind shown in Figure 7 for redirecting all light back to the dispersive array via the variable optical attenuating element 84, and an auxiliary set of waveguides 82 which lead to an array of photodiodes arranged, for example, at the edge of the chip. The termination of the input waveguides 72, 76 and the output waveguides 79 at the free propagation regions on either side of the dispersive array 78 are positioned such that each of the component channels received from the additional input waveguide 76 is selectively directed to a respective one of the auxiliary output waveguides 82 and on to a respective photodiode array 86, and such that each of the component channels received from the main input waveguide 72 is selectively directed to a respective one of the main set of output waveguides and on to a reflecting element 88 via a variable optical attenuating element 84. A processor (not shown) controls the variable optical attenuating elements 84 in a predetermined manner on the basis of the electrical signals generated at the photodiode array. In this way, the maximum power of each component channel of a multiplexed signal can be controlled independently.

Figure 6 shows a device according to another embodiment of the present invention. The device is similar to that shown in Figure 1 except that each of the output waveguides 8 leads to an optical switch 102 for selectively directing

the light received in the respective output waveguide 8 to either an integrated reflecting element 106 of the kind shown in Figure 7 (for reflecting all the power back to the AWG) or a photodiode 110 provided at the edge of the chip for monitoring the average optical power of the respective component channel and controlling the respective VOA element 10. Each switch could be a monolithically integral part of the chip. For example, it may be a 1x2 DOS switch or a Mach-Zehnder switch using the free carrier dispersion or thermo-optic effect.

The integration of a demultiplexing element, a multiplexing element, a variable attenuating element, and other optional optic elements on a single SOI platform according to these embodiments of the present invention provides for a compact device. Furthermore, only low power is needed to realise detection of the absolute maximum power of each component channel, and automatic attenuation control is possible.

Figure 9 illustrates another embodiment of the present invention. With reference to Figure 9, a number of optical elements are defined in a single optical chip 2, for example a silicon-on-insulator chip, to create a monolithically integrated device. A first input waveguide 4 extends from an edge of the chip towards a first arrayed waveguide grating 6, and an array of output waveguides 8 leads from the first arrayed waveguide grating to an opposite edge of the chip 2. The input waveguide 4 and the array of output waveguides 8 are separated from the arrayed waveguide grating 6 by free space regions. The arrayed waveguide grating and the positioning of the input waveguide 2 and the output waveguides 8 are designed such that the arrayed waveguide grating receives a wavelength-multiplexed signal comprising a number of component channels from the first input and selectively directs each component channel to a respective output waveguide. Only five output waveguides are shown in Figure 9, but more output waveguides would normally be provided in accordance with the large number of channels

employed in communication systems. The output waveguides may, for example, be connected to respective optical fibres at the edge of the chip for directing each component channel to a respective data-receiving device.

Each output waveguide is provided with a variable optical attenuating (VOA) element 10, which might, for example, consist of a PIN diode or alternatively a Mach-Zehnder based element. The PIN diodes may be placed laterally across the waveguide so that carrier injection into the waveguide will provide independent attenuation of the component channel via the free carrier dispersion effect. Alternatively, the VOA element might consist of a Mach-Zehnder based attenuator whereby the Mach-Zehnder based element has a phase-shifting element in at least one arm, which imposes an attenuation onto the component channel via interference. The phase-shifter may be based upon the free carrier dispersion effect (PIN diode) or thermooptic effect (metal track or NIN heater) if a silicon-on-insulator substrate is used. It may exploit the electro-optic (Pockels) effect in a III-V semiconductor substrate such as InGaAsP or GaAs.

A minor portion of the power of each mode of each component channel is diverted from the first input waveguide 4 into a second output waveguide 6 using a power splitting element 14. The power splitting element may, for example, be a Y-junction or an evanescent coupler. The second input waveguide 12 leads the minor portion of each component channel to a second arrayed waveguide grating 16, and an array of output waveguides 18 lead from the second arrayed waveguide grating to an opposite edge of the chip 2. The input waveguide 12 and the array of output waveguides 18 are separated from the arrayed waveguide grating 16 by free space regions. The arrayed waveguide grating 16 and the positioning of the input waveguide 12 and the output waveguides 18 are designed such that the arrayed waveguide grating 18 selectively directs the minor portion of each component channel to a respective output waveguide. As above, only five output waveguides are shown in Figure

9, but more output waveguides would normally be provided in accordance with the large number of channels employed in communication systems.

Light detecting elements 20, such as photodiodes, are provided at the edge of the chip for independently measuring the power of the minor portion of a respective component channel directed thereto by the respective output waveguide, as described in pending UK application no. 0021240.7.. Although not shown in Figure 9, circuitry is provided for controlling each of the variable optical attenuating elements in accordance with the power value measured by the light-detecting element for the respective component channel.

Figure 10 shows a view of an optic device according to another embodiment of the present invention. As in the previous embodiments, a number of optical elements are defined in a single optical chip 60. A first arrayed waveguide grating 64 is provided to direct a number of input signals at different carrier frequencies from an array of input waveguides 62 into a common output waveguide 66, which leads to an edge of the chip 60. A minor portion of the power of each mode at each carrier frequency is diverted from the output waveguide 66 into another waveguide 70 by power-splitting element 68. The light not tapped off by the power splitting element 68 passes into an exit waveguide from the chip. A second arrayed waveguide grating is provided to receive the multiplexed signal from waveguide 70 and selectively direct each carrier frequency to a respective one of an array of output waveguides 74, which lead to an array of photodiodes 76. Each of the array of input waveguides 62 is provided with a variable optical attenuating element 78, such as a pin diode. A processor (not shown) is used to control the variable attenuating elements, and thus the maximum power at each carrier frequency, in a predetermined manner in accordance with the electric signals generated at the photodiodes 76.

For all configurations of waveguide layouts shown in Figures 3, 9 and 10 the waveguides emerge at opposing chip edges. In each case, appropriate waveguide bends could be introduced such that all waveguides, both inputs and outputs, terminate at the same edge. This saves the need to polish more than one edge of the chip, makes testing easier and allows the number of expensive fibre blocks to be minimised.

The integration of the two demultiplexers and the variable attenuating elements on a single SOI platform has a number of advantages. Other than providing for a compact device, only low power is needed to realise detection of the absolute maximum power of each component channel, and automatic attenuation control is possible.

In each of the above-described devices, wavelength dispersive elements based on an array waveguide grating are used. However, other types of wavelength dispersive elements such as ones based on reflective-type gratings of the kind described in EP0365125 may alternatively be used.

Furthermore, each of the photodiodes could be hybridised onto the chip, using, for example, 45° photodiode mirrors as described in PCT/GB98/00382, rather than being provided as a separate element adjacent an edge of the chip.

In the embodiments described above, each monitoring photodiode has light directed thereto via an output waveguide. Alternatively, in each of the embodiments illustrated in Figures 3, 4, 8, 9 and 10, light could be directed to the respective photodiode without the use of output waveguides, by for example, one of the techniques described in copending UK patent application nos. 0107112.5 filed March 21, 2001 and 0109656.9 filed April 19, 2001.

The applicant draws attention to the fact that the present invention may include any feature or combination of features disclosed herein either implicitly or

explicitly or any generalisation thereof, without limitation to the scope of any definitions set out above. In view of the foregoing description it will be evident to a person skilled in the art that various modifications may be made within the scope of the invention.

CLAIMS:

1. An optic device including (a) an integrated device including a demultiplexer for receiving a wavelength-multiplexed input optical signal from a first input waveguide and selectively directing the component channels to a respective one of a first array of output waveguides; a wavelength-dispersive element; and a power-splitting element for directing a minor portion of the power of each component channel of the wavelength-multiplexed input signal to the wavelength-dispersive element; and (b) a light detecting device for measuring the power of at least one component channel output from the wavelength dispersive element.
2. An optic device according to claim 1 wherein the light-detecting device includes an array of light-detecting elements, each light-detecting element positioned for selectively receiving a respective component channel from the wavelength dispersive element.
3. An optic device according to claim 1 wherein the integrated device further includes a variable attenuating element associated with each output waveguide for independently varying the power of the respective component channel; and further comprising circuitry for controlling the variable attenuating elements in accordance with the power values measured by the light-detecting device for one or more of the component channels so as to control the power of one or more of the component channels in a predetermined manner.
4. An optic device according to claim 1 wherein the integrated device further includes a multiplexer for receiving each component channel from the first array of output waveguides after propagation through the respective variable attenuating element and directing them to a common output waveguide.

5. An optic device according to claim 1 wherein the light-detecting device is a part of the integrated device and comprises an array of photodiodes, each photodiode positioned for selectively receiving a respective component channel from the wavelength dispersive element.

6. An optic device according to claim 5 wherein the light detecting device further comprises a second array of output waveguides, each output waveguide of the second array positioned for selectively receiving a respective component channel from the wavelength dispersive element and guiding it to a respective one of the array of photodiodes.

7. An optic device according to claim 1 further including an array of data-receiving devices optically connected to the first array of output waveguides.

8. An optic device including an optic chip defining (i) a first wavelength dispersive element for receiving a wavelength-multiplexed input optical signal from an input waveguide and selectively directing the component channels to a respective one of a first array of output waveguides; (ii) a second wavelength-dispersive element; and (iii) a power-splitting element for directing a minor portion of the power of each component channel of the wavelength-multiplexed input signal to the second wavelength-dispersive element; and a light detecting device for measuring the power of at least one component channel output from the second wavelength dispersive element, wherein the first and second wavelength dispersive elements including overlapping output free propagation regions.

9. An optic device including (a) an integrated device including a multiplexer for receiving a plurality of optical signals at different channels from an array of input waveguides and directing the optical signals to a single output waveguide to form a wavelength-multiplexed signal; a wavelength

dispersive element; and a power-splitting element for directing a minor portion of the power of each channel of the wavelength-multiplexed signal from the output waveguide to the wavelength dispersive element; and (b) a light detecting device for measuring the power of one or more channels output from the wavelength dispersive element.

10. An optic device according to claim 9 wherein the light-detecting device includes an array of light-detecting elements, each light-detecting element positioned for selectively receiving a respective channel from the wavelength dispersive element.

11. An optic device according to claim 10, the integrated device further including a variable attenuating element associated with each of the array of input waveguides for independently varying the power of each channel in the array of input waveguides; and the optic device further including circuitry for controlling the variable attenuating elements in accordance with the power values measured by the light-detecting device for one or more of the channels so as to control the power of one or more of the channels in a predetermined manner.

12. An optic device according to claim 9 wherein the light-detecting device is a part of the integrated device and comprises an array of photodiodes, each photodiode positioned to selectively receive a respective component channel from the wavelength dispersive element.

13. An optic device according to claim 12 wherein the light detecting device further comprises an array of output waveguides respectively leading to the array of photodiodes, each output waveguide positioned for selectively receiving a respective channel from the wavelength dispersive element.

14. An optic device including an integrated device, the integrated device including a demultiplexer for receiving a wavelength-multiplexed input signal comprising a plurality of component channels; a variable attenuating element for independently attenuating the power of one or more of the component channels output from the demultiplexer; a multiplexer for remultiplexing some or all of the component channels; and an element for directing some or all of the component channels to the multiplexer after propagation through the variable attenuating element.

15. An optic device according to claim 14, the optic device further including a light detecting element, and a power-splitting element for directing a minor portion of the power of one or more of the component channels to the light detecting element for measuring the power of one or more of the component channels.

16. An optic device according to claim 15, the optic device further including circuitry for controlling the variable attenuating element in accordance with the power measured by the light-detecting element for one or more of the component channels so as to control the power of one or more of the component channels in a predetermined manner.

17. An optic device according to claim 14 wherein the multiplexer and the demultiplexer are constituted by a common wavelength dispersive element, and including an element for redirecting some or all of the component channels back through the wavelength dispersive element via the variable attenuating element.

18. An optic device according to claim 17 including a partially reflecting element for receiving some or all of the component channels from the variable attenuating element, reflecting a major portion of the power of the respective component channel back to the wavelength dispersive element via the variable

attenuating element; and transmitting a minor portion of the power of the respective component channel therethrough to a respective light detecting element.

19. An optic device according to claim 14, the integrated device including an input waveguide; an array of output waveguides; and a wavelength dispersive element for receiving a wavelength-multiplexed input signal from the input waveguide and selectively directing each component channel to a respective one of the array of output waveguides; a variable optical attenuating element associated with one or more of the output waveguides for independently attenuating the power of the respective component channel; and the optic device including a reflecting element associated with some or all of the output waveguides for redirecting at least a portion of the power of the respective component channels back to the wavelength dispersive element via the respective variable optical attenuating element.

20. An optic device according to claim 19 further including a light detecting element associated with each output waveguide; and wherein the reflecting element is a partially reflecting element that reflects a major portion of the power of the respective component channel back through the respective output waveguide to the wavelength dispersive element via the respective variable optical attenuating element and transmits a minor portion of the power of the respective component channel therethrough to the respective light detecting element.

21. An optic device according to claim 19 wherein the reflecting element is constituted by an edge of the optic chip adapted for reflection, or is constituted by an array of individual reflecting facets at the ends of the output waveguides.

22. An optic device according to claim 20 further comprising circuitry for controlling the variable optical attenuating elements in accordance with the

power values measured by the light-detecting elements, so as to control the power of one or more of the component channels in a predetermined manner.

23. An optic device according to claim 14 wherein the integrated device further includes a wavelength dispersive element; a power splitting element for directing a minor portion of the power of each component channel of the wavelength-multiplexed signal to the wavelength dispersive element; and a number of light-detecting elements for selectively receiving a respective one of the component channels from the wavelength dispersive element.

24. An optic device according to claim 23, the optic device further including circuitry for controlling the variable attenuating element in accordance with the power measured by the light-detecting elements for one or more of the component channels so as to control the power of one or more of the component channels in a predetermined manner.

25. An optic device according to claim 23 wherein the multiplexer and the first demultiplexer are constituted by a common wavelength dispersive element and including an element for redirecting some or all of the component channels back through the wavelength dispersive element via the variable attenuating element.

26. An optic device according to claim 25 wherein the multiplexer, the demultiplexer and the wavelength dispersive element are constituted by a common wavelength dispersive element.

27. An optic device according to claim 14 wherein the integrated device includes one or more switching elements associated with one or more of the component channels, each switching element allowing the power of the respective component channel output from the demultiplexer to be selectively

directed to a light-detecting element for optical power measurement or to the multiplexer for remultiplexing.

28. An optic device according to claim 14 wherein the multiplexer and demultiplexer are constituted by a common dispersive array, and wherein each switching element allows the power of the respective component channel output from the demultiplexer to be selectively directed to a light-detecting element for optical power measurement or to a reflecting element for transmission back to the common dispersive array via the switching element and the variable attenuating element.

29. An optic device according to claim 23, wherein the demultiplexer and the wavelength dispersive element have overlapping free propagation regions at their output ends.

30. An optic device including an optic chip, said optic chip defining (a) an input waveguide; (b) a wavelength dispersive element having an input coupled to the input waveguide; (c) an array of output waveguides coupled to the output of the wavelength dispersive element and extending to an edge of the optic chip adapted for reflection; and (d) a variable optical attenuating element associated with at least one output waveguide for, in use, independently controlling the optic power in said at least one output waveguide; whereby, in use, a wavelength multiplexed signal introduced into the input waveguide is demultiplexed into its component channels by the wavelength-dispersive element, each channel being directed to a respective one of the outputs waveguides and reflected back at said edge of the chip to the wavelength dispersive element where the channels are remultiplexed back into the input waveguide.

31. An optic device including an optic chip, said optic chip defining (a) an input waveguide; (b) a wavelength dispersive element having an input coupled

to the input waveguide; (c) an array of output waveguides coupled to the output of the wavelength dispersive element; (d) a variable optical attenuating element associated with at least one output waveguide for, in use, independently controlling the optic power in said at least one output waveguide; and (e) a partially reflecting element associated with at least those waveguides with which are associated an optical light attenuating element; the partially reflecting element functioning, in use, for directing a major portion of the optic power propagated through the output waveguides associated with it back to the wavelength dispersive element via the respective variable attenuating element, but transmitting a minor portion of the power therethrough to a light detecting element for measuring the optic power.

32. An optic device including an optic chip, the optic chip defining: (a) an input waveguide; (b) a first demultiplexer for receiving from the input waveguide a wavelength-multiplexed input signal comprising a plurality of component channels; (c) at least one variable attenuating element for independently attenuating the power of at least one component channel output from the first demultiplexer; (d) a multiplexer for remultiplexing some or all of the component channels; (e) an element for directing some or all of the component channels to the multiplexer after propagation through the variable attenuating element; (f) a channel monitoring element for monitoring the power of at least one channel; and (g) a power splitting element for directing a portion of the power of each component channel from the input waveguide to the channel monitoring element.

33. An optic device including an optic chip, the optic chip defining: (a) an input waveguide; (b) a demultiplexer for receiving from the input waveguide a wavelength-multiplexed input signal comprising a plurality of component channels; (c) at least one variable attenuating element for independently attenuating the power of at least one component channel output from the demultiplexer; (d) a multiplexer for remultiplexing some or all of the

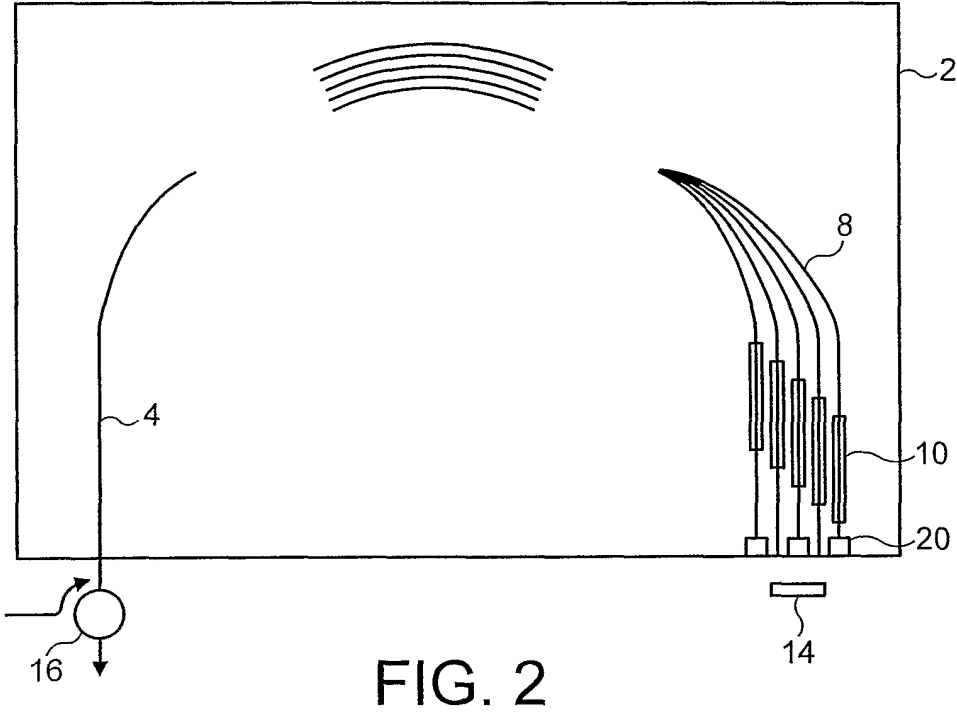
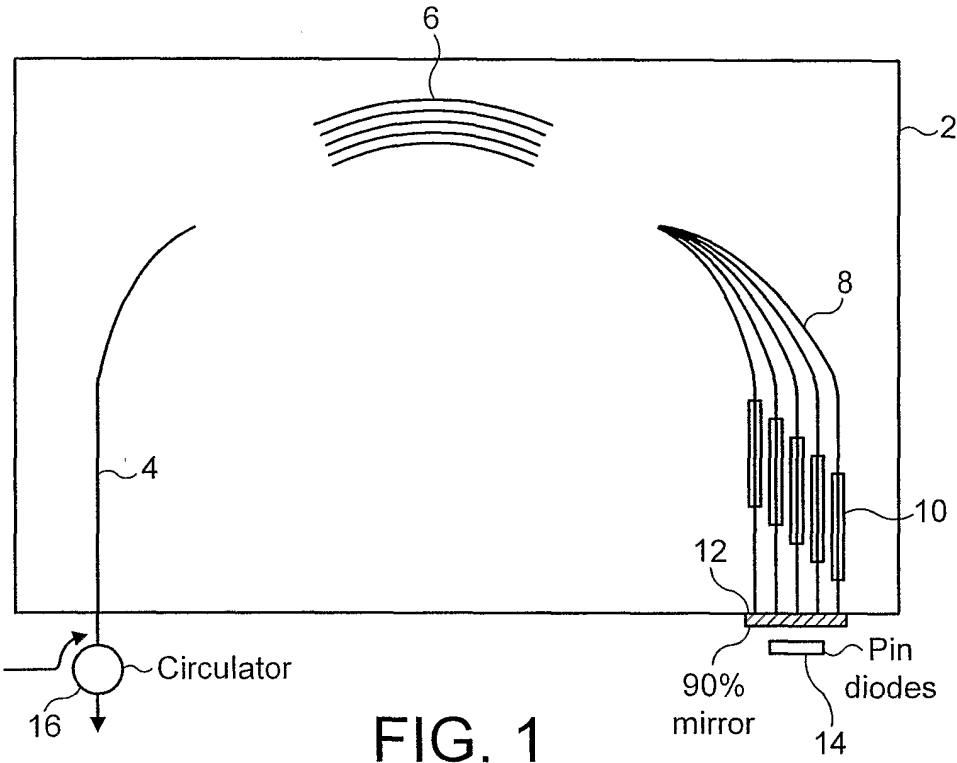
component channels; (e) an element for directing some or all of the component channels to the multiplexer after propagation through the variable attenuating element; (f) a channel monitoring element for monitoring the power of at least one channel; and (g) a power splitting element for directing a portion of the power of each component channel from the input waveguide to the channel monitoring element; wherein the channel monitoring element comprises a wavelength dispersive element and at least one light detecting element at the output end of the wavelength dispersive element; and wherein the demultiplexer and the wavelength dispersive element include overlapping output free propagation regions.

34. An optic device including an optic chip, the optic defining: (a) a wavelength dispersive element having at least first and second inputs for receiving respective first and second portions of the power of each component channel of an input wavelength multiplexed signal; (b) a first set of output waveguides at the output end of the wavelength dispersive element each positioned for selectively receiving a respective component channel from the first input; (c) a second set of output waveguides at the output end of the wavelength dispersive element each positioned for selectively receiving a respective component channel from the second input; and (d) at least one variable attenuating element associated with at least one of the first set of waveguides; and further including a reflecting element for directing light propagated through the first set of waveguides back to the wavelength dispersive element via the at least one variable attenuating element for remultiplexing, and at least one light detecting element for measuring the power of light propagated through at least one of the second set of waveguides.

35. An optic device including an optic chip, said optic chip defining (a) an input waveguide; (b) a wavelength dispersive element having an input coupled to the input waveguide; (c) an array of output waveguides coupled to the output of the wavelength dispersive element and each having an outwardly tapered

end portion terminating at a respective reflecting facet defined by the optic chip; and (d) a variable optical attenuating element associated with at least one output waveguide for, in use, independently controlling the optic power in said at least one output waveguide; whereby in use, a wavelength multiplexed signal introduced into the input waveguide is demultiplexed into its component channels by the wavelength-dispersive element, each channel directed to a respective one of the outputs waveguides and reflected back at the respective reflective facet to the wavelength dispersive element where the channels are remultiplexed back into the input waveguide.

36. An optic device substantially as hereinbefore described with reference to the accompanying drawings.



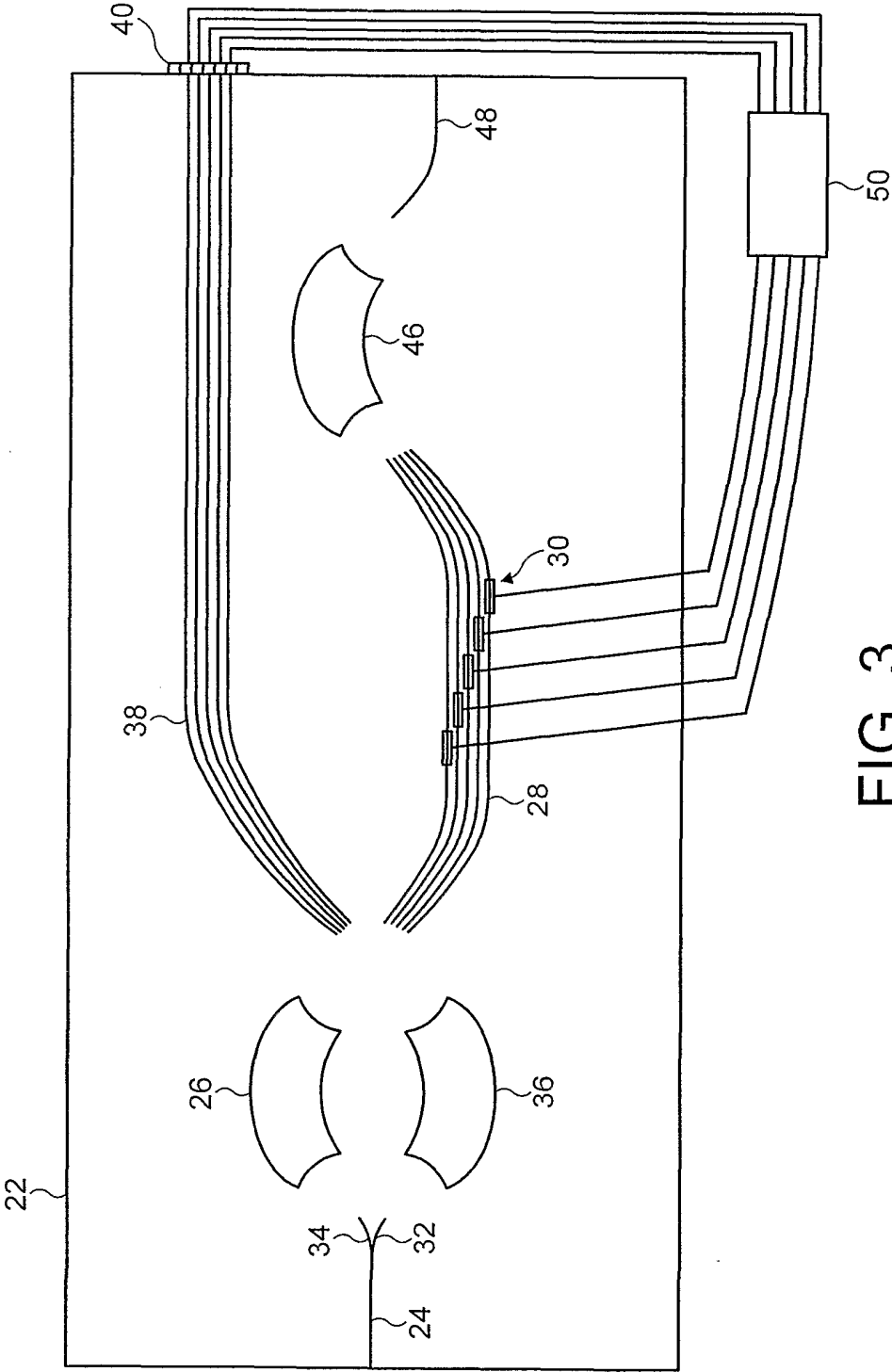


FIG. 3

3 / 7

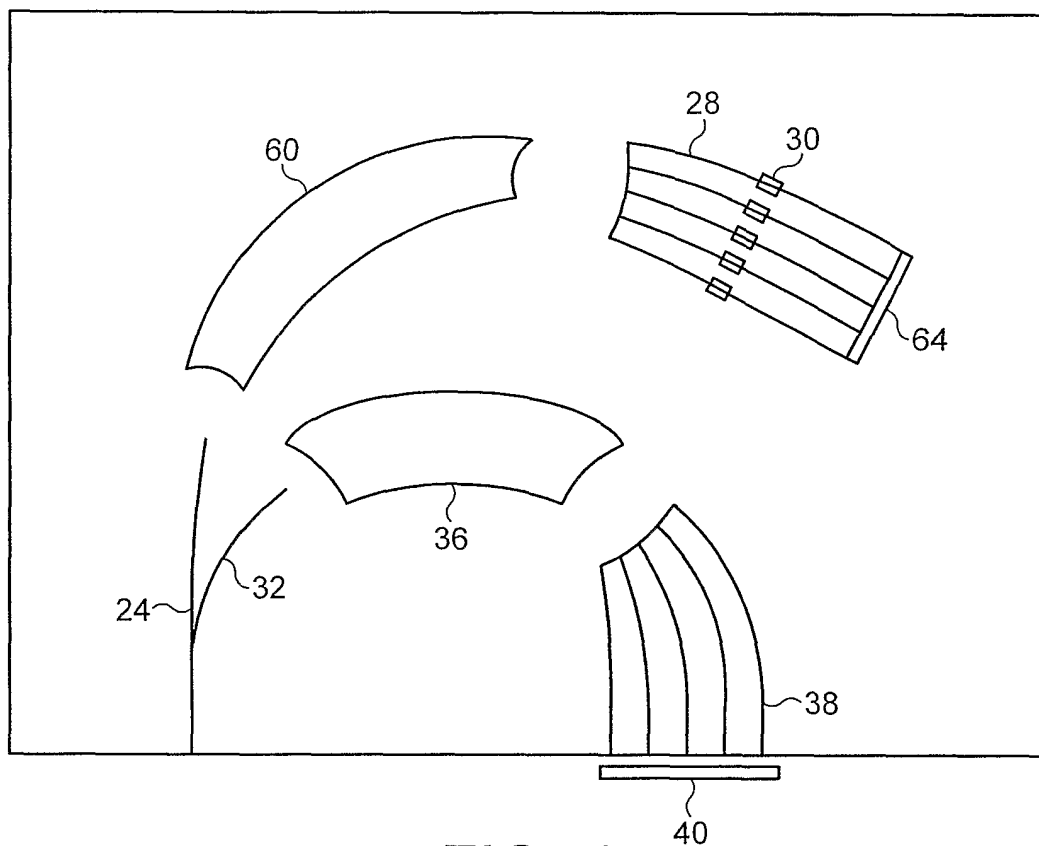


FIG. 4

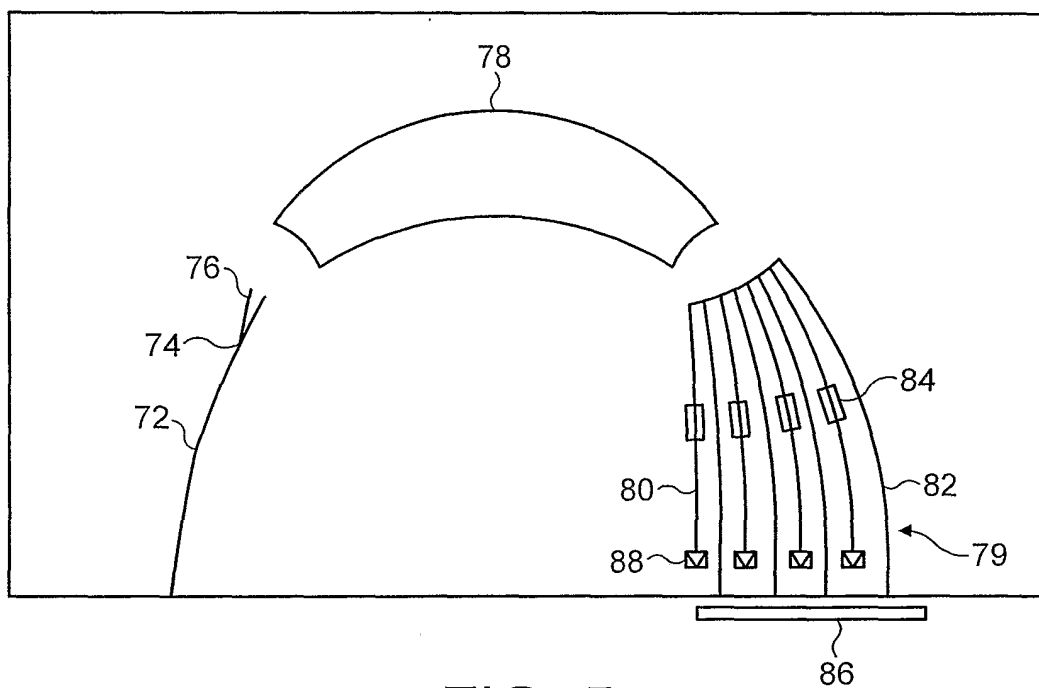


FIG. 5

4 / 7

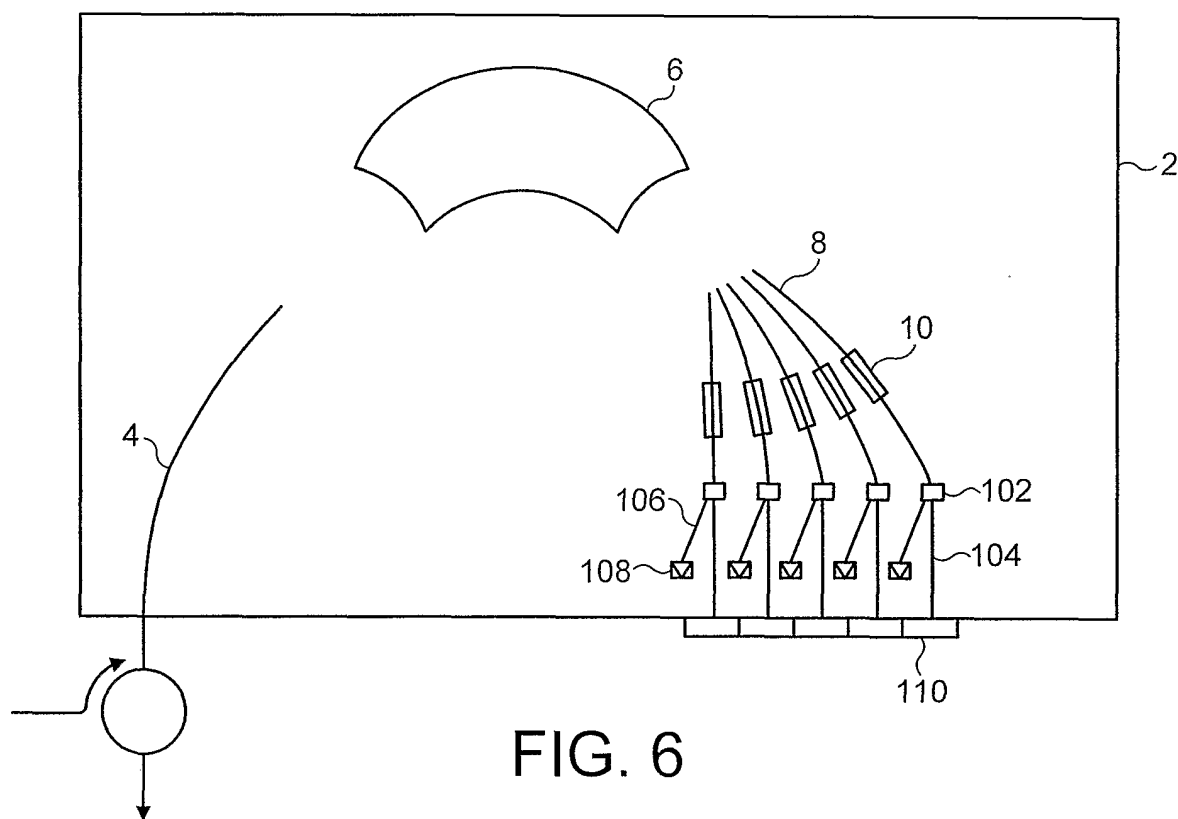


FIG. 6

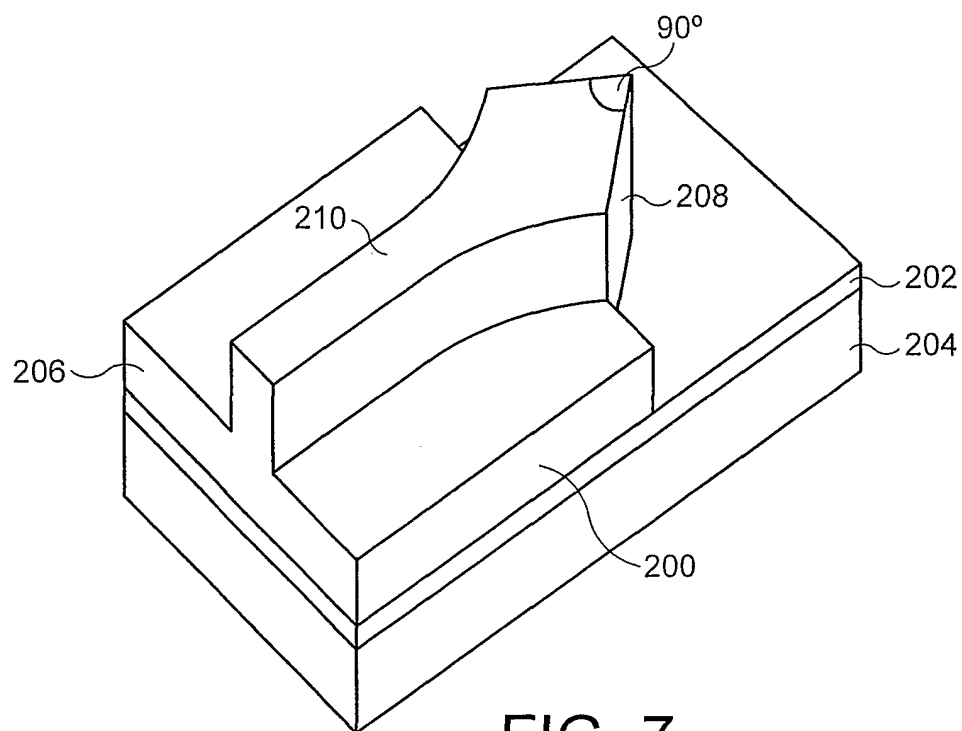


FIG. 7

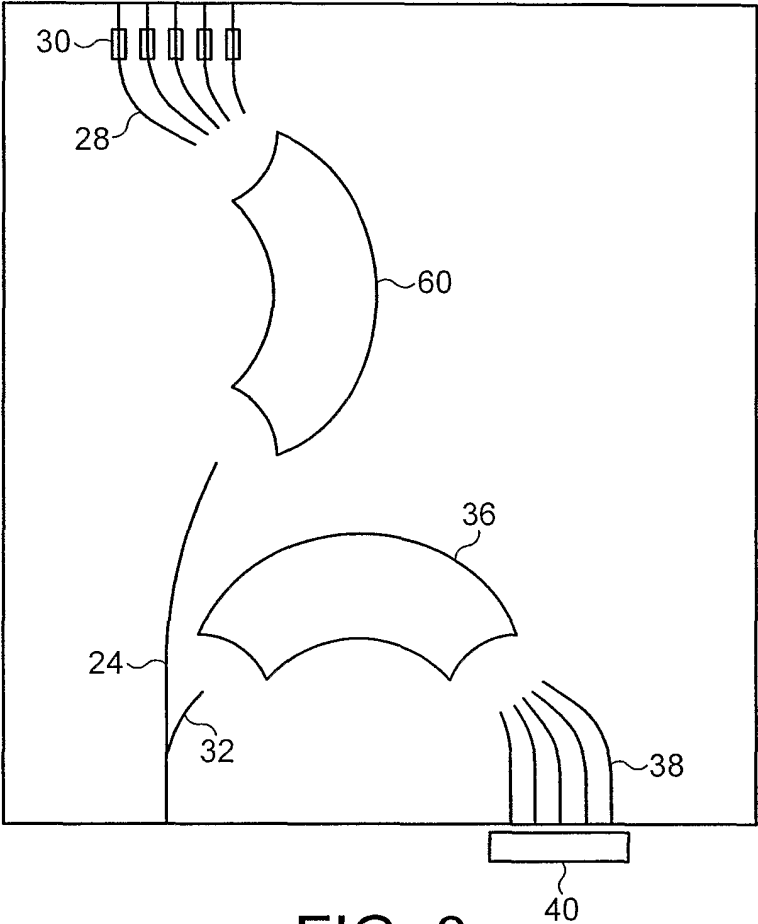


FIG. 8

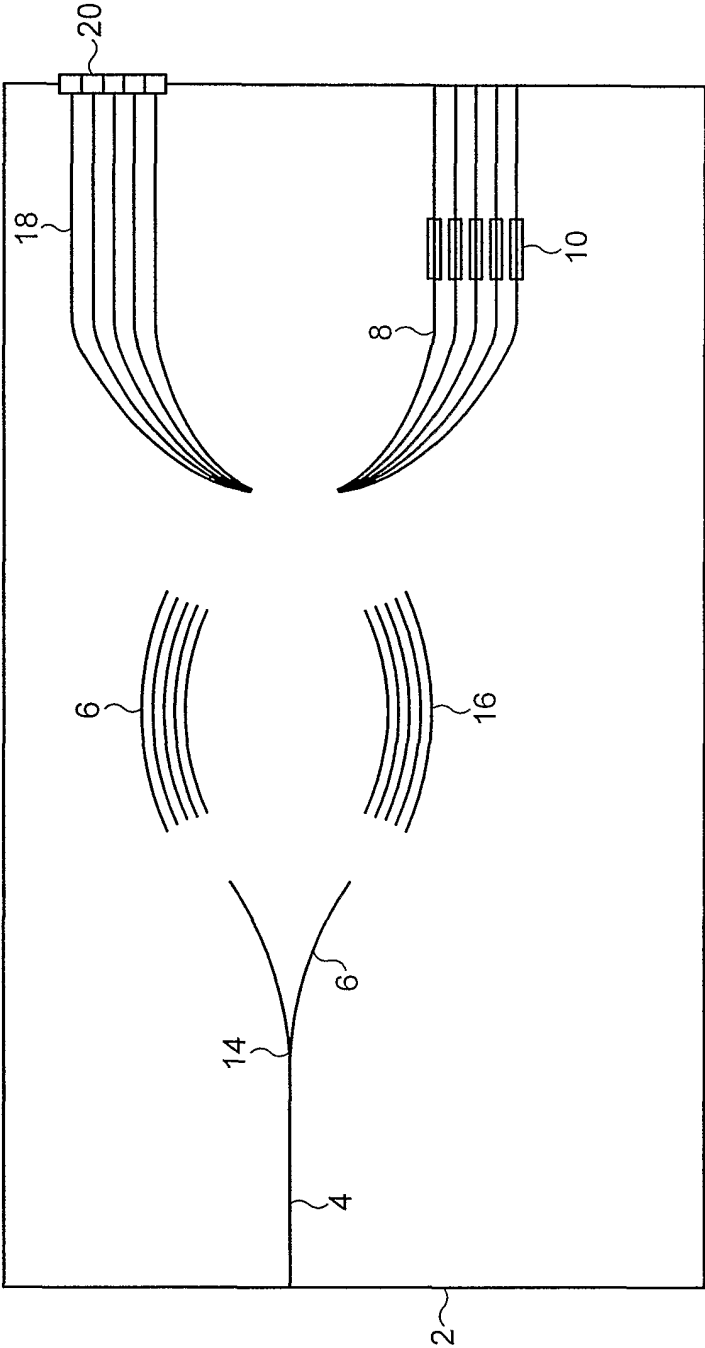


FIG. 9

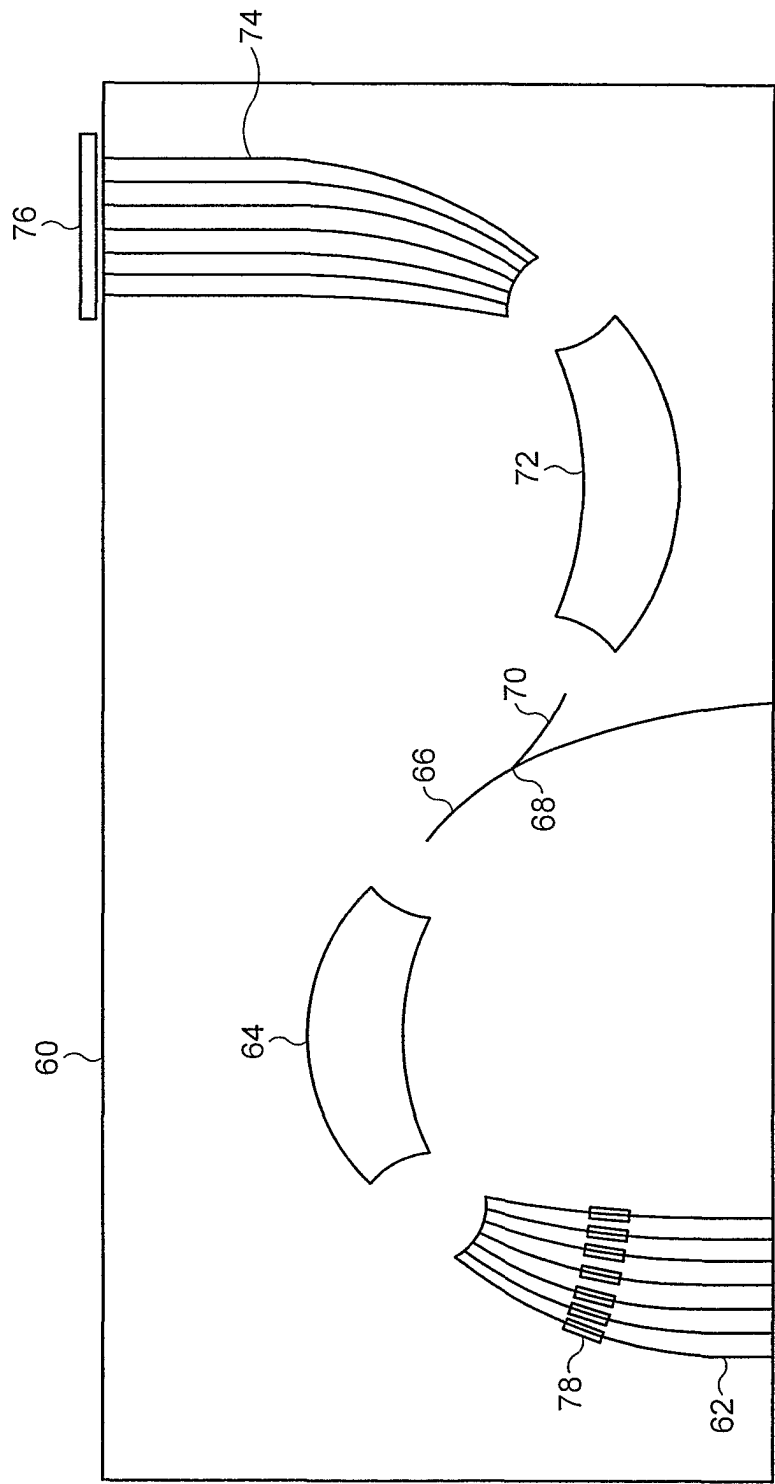


FIG. 10