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- (71) **Applicant:** FINISAR CORPORATION [US/US]; 1389
Moffett Park Drive, Sunnyvale, CA 94089 (US).
- (72) **Inventor:** FLENS, Frank; C/o Finisar Corporation, 1389
Moffett Park Drive, Sunnyvale, CA 94089 (US).
- (74) **Agents:** MASCHOFF, Eric, L. et al.; Maschoff Brennan,
1389 Center Drive, Suite 300, Park City, UT 84098 (US).
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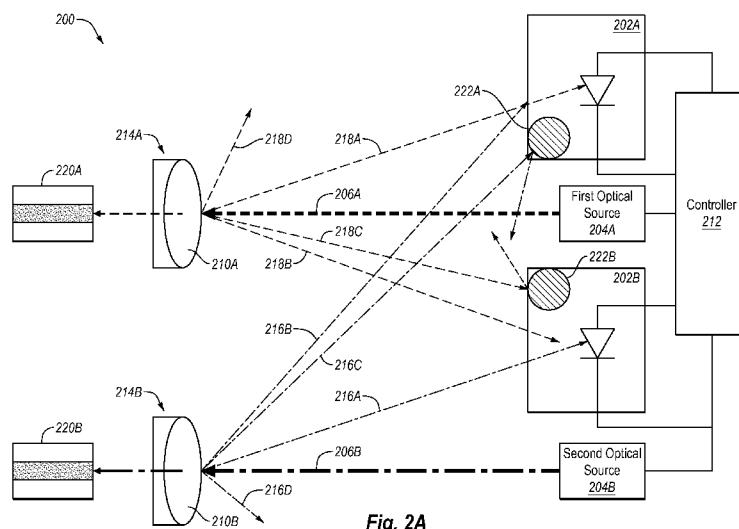


Fig. 2A

(57) **Abstract:** An example embodiment includes an optical transmission device. The optical transmission device includes an optical source, a collimator lens, and an optical monitor. The optical source is configured to transmit a channel of light. The collimator lens is configured to reflect a portion of the channel of light. The optical monitor is arranged to receive at least a first portion of the re-
flected channel of light directly from the collimator lens, and is configured to communicate a gross electrical signal representative of received light including the first portion of the reflected channel of light.

OPTICAL SOURCE MONITORING SYSTEM

FIELD

Some embodiments discussed herein are related to monitoring optical sources in optical transmission devices.

5

BACKGROUND

Optical networks may be used to communicate information as optical signals. In some optical networks, optical transmission devices may include one or more optical sources that generate the optical signals. The optical sources may include, laser photo diodes, for instance. The optical signals generally include channels of light transmitted from one or more of the optical sources.

The channels of light may diverge. For example, as the optical signal moves from the optical source, the cross-sectional area of the channel of light may increase. To compensate for divergence, the optical transmission device may include a one or more collimating lenses. For example, the collimating lenses may be included in a focusing assembly. The collimating lenses collect and/or re-organize the channel of light to form a channel of light with essentially parallel rays or a more consistent cross-sectional area.

To monitor the channel of light and/or the optical source, some optical transmission devices may include an optical monitor. The optical monitor generally receives some portion of the optical signal. Based on the received portion of the light, the optical transmission device may be able to obtain information about the optical signal and/or the optical source. For example, an optical monitor may measure power levels of the optical signal transmitted from the optical source. The optical transmission device may then adjust or maintain an operating characteristic of the optical source.

In some optical transmission devices, to receive the portion of the channel of light, a reflecting lens may be positioned between the optical source and the collimator lens. The reflecting lens may redirect the portion of the optical signal to the optical monitor. In some optical sources may emit channels of light from both ends of an optical source cavity. The channel of light emitted from one end of the optical source cavity may be communicated to the optical network. The channel of light emitted from the other end may be emitted towards the optical monitor.

The subject matter claimed herein is not limited to embodiments that solve any disadvantages or that operate only in environments such as those described above. Rather,

this background is only provided to illustrate one exemplary technology area where some embodiments described herein may be practiced.

SUMMARY OF SOME EXAMPLE EMBODIMENTS

5 Some embodiments discussed herein are related to monitoring optical sources in optical devices. An example embodiment includes an optical transmission device. The optical transmission device includes an optical source, a collimator lens, and an optical monitor. The optical source is configured to transmit a channel of light. The collimator lens is configured to reflect a portion of the channel of light. The optical monitor is arranged to
10 receive at least a first portion of the reflected channel of light directly from the collimator lens, and is configured to communicate a gross electrical signal representative of received light including the first portion of the reflected channel of light.

Another example embodiment includes an optical transmission device. The optical transmission device including multiple optical sources, multiple collimator lenses,
15 multiple optical monitors, and a controller. Each of the optical sources is configured to transmit a channel of light. Each of the collimator lenses is positioned in relation to a primary optical source of the optical sources such that the channel of light transmitted by the primary optical source is reflected from the collimator lens. Each of the optical monitors is positioned in relation to the one of the collimator lenses such that the optical
20 monitor receives a first portion of a first reflected channel of light transmitted by the primary optical source and a second portion of a second reflected channel of light transmitted by a secondary optical source directly from the collimator lenses. Each of the optical monitors is configured to communicate a gross electrical signal representative of received light including the first portion of the first reflected channel of light and the
25 second portion of the second reflected channel of light. The controller is configured to determine discrete signals representative of the channels of light transmitted by the primary optical sources based on the gross electrical signals.

Another example embodiment includes a method of monitoring an optical system. The optical system includes optical sources, optical monitors, and collimator lenses. The
30 method includes generating a set of coefficients which is configured to indicate quantities of received light to attribute to each of the optical sources. The method includes receiving a gross electrical signal representative of the received light that includes reflected channels of light directly from the collimator lenses. The method includes determining a

distinct signal representative of a first channel of light transmitted by a first optical source based on the set of coefficients and the gross electrical signal.

This Summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This Summary is not intended to
5 identify key features or essential characteristics of the claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

Additional features and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by the practice of the invention. The features and advantages of the invention may be realized
10 and obtained by means of the instruments and combinations particularly pointed out in the appended claims. These and other features of the present invention will become more fully apparent from the following description and appended claims, or may be learned by the practice of the invention as set forth hereinafter.

15 BRIEF DESCRIPTION OF THE DRAWINGS

To further clarify the above and other advantages and features of the present invention, a more particular description will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. It is appreciated that these drawings depict only example embodiments and are therefore not to be considered limiting of its
20 scope. Some example embodiments of the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which: Figure 1 is a block diagram of an example optical network in which some embodiments disclosed herein may be implemented;

Figure 2A is a block diagram of an example optical source monitoring system that may be
25 implemented in the optical network of Figure 1;

Figures 2B and 2C are block diagrams the optical source monitoring system of Figure 2A in which the controller is generating an example set of coefficients;

Figure 3 is a flow diagram of an example method of monitoring an optical system; and

Figure 4 is a flow diagram of another example method of monitoring multiple optical
30 sources.

DETAILED DESCRIPTION OF SOME EXAMPLE EMBODIMENTS

Some embodiments discussed herein are related to monitor optical sources in optical devices. An example embodiment includes an optical transmission device. The optical

transmission device includes multiple optical sources. Each of the optical sources transmits a channel of light towards a collimator lens that reflects some portion of the channel of light towards multiple optical monitors. Each of the optical monitors receives the various portions of the reflected channels of light and generates a gross electrical
5 signal representative of received light including the various portions of the reflected channels of light. The gross electrical signals are communicated to a controller, which determines discrete signals. Each of the discrete signals is representative of one of the channels of light transmitted by one of the optical sources. Some additional embodiments are described herein with reference to the accompanying drawings.

10 Figure 1 is a block diagram of an example optical network 100 in which some embodiments disclosed herein may be implemented. The optical network 100 may include a point-to-point optical network, a ring optical network, a mesh optical network, any other suitable optical network, or a combination of two or more optical networks. The components and functionality of the optical network 100 as depicted in Figure 1 and
15 described herein is configured to communicate multi-channel optical signals. Some details of the communication of the multi-channel optical signals are included below. However, this depiction and description of the optical network 100 is not meant to be limiting. In some embodiments, the optical network 100 may be configured to communicate a single optical signal and may accordingly include different components and functionalities than those specifically described herein.
20

The optical network 100 communicates optical signals between an optical transmission device 102 and one or more optical receivers 104 (receiver 104 or receivers 104) through optical fibers 106A-106G (generally, optical fiber 106 or optical fibers 106). The optical fibers 106 act as a waveguide for the optical signals communicated in the optical network
25 100. The optical fibers 106 may include a core surrounded by a cladding layer. The optical fibers 106 may include any suitable type of fiber including, but not limited to, a single-mode fiber (SMF) or a multi-mode fiber (MMF). For example, the optical network 100 may include a first set optical fibers 106A-106C between one or more focusing assemblies 112A-112C (generally, a focusing assembly 112 or focusing assemblies 112)
30 and a multiplexer (MUX) 110. The first set of optical fibers 106A-106C may each be SMFs. Additionally the optical network 100 may include a second optical fiber 106D between the MUX 110 and a demultiplexer (DEMUX) 114. The second optical fiber 106D may be a MMF. In addition, the optical network 100 may include a third set of

optical fibers 106E-106G between the DEMUX 114 and the receivers 104. The third set of optical fibers 106E-106G may each be SMFs.

The optical transmission device 102 may include any system, apparatus, or device that generates data carrying wavelengths or channels of light. An example of the optical transmission device 102 may be an optical engine that may include the capability of generating 12 or more channels of light at a rate 25 gigabits per second or higher. In some embodiments, different optical signals communicated over the optical network 100 may be assigned to different nominal wavelengths. For example, one channel may be at a first wavelength, with other channels being at other wavelengths spaced apart from each other at a nominal channel spacing, such as 100 gigahertz (GHz), 50 GHz, 25 GHz, or at some other channel spacing. Using different channels for different optical signals generally allows multiple optical signals to be simultaneously communicated over the same optical fiber 106 with limited interference between the multiple optical signals. Each channels of light may communicate a separate optical signal in the optical network 100. In Figure 1, the channels of light are represented by dashed arrows 122A-122C (generally, channel of light 122 or channels of light 122) that originate at the optical source 116 and end at the focusing assemblies 112. Accordingly, the optical transmission device 102 may include multiple optical transmitters 108A-108C (generally, transmitter 108 or transmitters 108). Each of the transmitters 108 may generate one of the channels of light 122. The multiple channels of light (e.g., one from each transmitter 108) may be combined through a process referred to as wavelength division multiplexing (WDM). WDM generally occurs in the MUX 110. For example, the MUX 110 receives the individual channels of light and combines them into a multi-channel optical signal. The MUX 110 may be positioned within the optical transmission device 102 or the MUX 110 may be positioned outside the optical transmission device 102.

After combining the channels of light, the MUX 110 may output the multi-channel optical signal onto the second optical fiber 106D. Specifically, the multi-channel optical signal may be communicated through the second optical fiber 106D to the DEMUX 114 or to other locations (not shown) in the optical network 100. The DEMUX 114 may be included at one or more destinations of the optical network 100. The DEMUX 114 may be configured to demultiplex or split the multi-channel optical signal into the individual channels included therein. In some embodiments, the DEMUX 114 may be similar to the MUX 104 but configured to split the optical signal into individual channels instead of combine individual channels into one multi-channel optical signal.

The optical network 100 may include the receivers 104 coupled to the DEMUX 114. Each of the receivers 104 may be configured to receive a one of the optical signals output by the DEMUX 114 and process the optical signal for the information contain thereon.

Generally, the transmitters 108 may include any system, apparatus, or device configured to convert one or more electrical signals into an optical signal and to transmit an optical signal. Each of the transmitters 108 may include an optical monitor 118A-118C (generally, optical monitor 118 or optical monitors 118) an optical source 116A-116C (generally optical source 116 or optical sources 116), and one of the focusing assemblies 112. Specifically, a first transmitter 108A may include a first optical monitor 118A, a first optical source 116A, and a first focusing assembly 112A. Additionally, a second transmitter 108B may include a second optical monitor 118B, a second optical source 116B, and a second focusing assembly 112B. Additionally, a third transmitter 108C may include a third optical monitor 118C, a third optical source 116C, and a third focusing assembly 112C.

The optical sources 118 may include any system or apparatus that is configured to generate a channel of light (e.g., 122). For example, the optical sources 118 may include a laser diode, a Fabry-Perot (FP) laser, a distributed feedback (DFB) laser, a vertical-cavity surface-emitting laser (VCSELs) or any other laser that generates a channel of light.

The focusing assemblies 112 may be configured to focus the channel of light prior to communication of the channel of light 122 to one of the first set of optical fibers 106A-106C. For example, when exiting the optical sources 116 the channels of light 122 may diverge or be otherwise disorganized such that the width of the channel of light 122 is too great to be introduced effectively in to one of the first optical fibers 106A-106C. Accordingly, the focusing assemblies 112 may collimate and/or focus the channels of light.

The focusing assemblies 112 may include one or more lenses. For example, the focusing assemblies 112 may include a collimator lens 124A-124C (generally, collimator lens 124 or collimator lenses 124) through which the channel of light 122 may enter the focusing assembly 112. As the channels of light 122 enter the focusing assemblies 112 through the collimator lenses 124, a reflection of some portion of the channel of light 122 may occur. The reflection from the collimator lens 124 may be described as a Fresnel reflection.

The optical monitors 118 may include any system or apparatus configured to measure, sense, or otherwise quantify an amount of light that is received by the optical monitor 118. For example, the optical monitors 118 may include a monitor photodiodes, a PIN

photodiode, or the like. The optical monitors 118 may be arranged to receive some portion of the reflected channel of light (not shown) directly from the collimator lens 124. As used herein, directly from the collimator lens is intended to mean that the portion does not enter, pass through, refract from, or further reflect off any other object, structure, surface, etc.

For example, the first focusing assembly 112A may be configured to focus a first channel of light 122A prior to communication of the channel of light to one of the first set of optical fibers 106A-106C (e.g., in Figure 1, the optical fiber 106 coupled to the first focusing assembly 112A). A Fresnel reflection may occur as the first channel of light 122A enters the first focusing assembly 112A through the collimator lens 124A. The first optical monitor 118A may be arranged to receive a portion of the reflected first channel of light directly from the collimator lens 124A.

Likewise, a second focusing assembly 112B may be configured to focus the second channel of light 122B prior to the communication of the second channel of light 122B to another of the first set of optical fibers 106A-106C. A second Fresnel reflection of the second channel of light 122B may occur as the second channel of light 122B enters the second focusing assembly 112B through the second collimator lens 124B. The second optical monitor 118B may be arranged to receive a portion of the second reflected channel of light directly from the collimator lens 124B.

The optical monitors 118 may be configured to communicate a gross electrical signal representative of received light. In the above example, the first optical monitor 118A may communicate a first gross electrical signal representative of at least the portion of the reflected first channel of light.

The optical transmission device 102 may also include a controller 120. The controller 120 may be communicatively coupled to one or more of the optical monitors 118 and/or one or more of the optical sources 116. The controller 120 may further be communicatively coupled to a host system (not shown). The gross electrical signals communicated from the optical monitors 118 may be received and processed by the controller 120. The controller 120 may accordingly monitor the performance of the optical sources 116 through processing the gross electrical signals communicated from the optical monitors 118.

In the depicted embodiment, the optical transmission device 102 includes three transmitters 108, each of which includes a single optical source 116, a signal optical monitor 118, and a single focusing assembly 112. However, this depiction is not meant to be limiting. The optical transmission device 102 may include any number of transmitters

108. For example, in some embodiments, the optical transmission device 102 includes four transmitters 108 each of which generates a channel of light. Additionally, the transmitters 108 may include various types and varying numbers of the optical monitors 118, the optical sources 116, the focusing assemblies 112, etc.

5 The optical network 100 may additionally include other network element or may include some subset of the elements discussed herein. For example, the optical network 100 may include amplifiers (not shown) and optical add drop multiplexers (OADMs) (not shown). The amplifiers may be positioned throughout the optical network 100 to amplify the multi-channel optical signal. Some examples of the amplifiers may include, but are not
10 limited, to optical repeaters, which may additionally perform opto-electrical or electro-optical conversion; optical fibers doped with a rare-earth element, which excite atoms of the rare-earth element to increase the intensity of the optical signal; erbium-doped fiber amplifiers (EDFA); semiconductor optical amplifier (SOA); or any other suitable amplifier.

15 The OADMs may include any system, apparatus, or device configured to add and/or drop optical signals from optical fiber 106. For example, each of the OADMs may be configured to add an optical signal of a specific channel to the multi-channel optical signal, and/or to remove (e.g., drop) an optical signal of a specific channel from the multi-channel optical signal. After passing through an OADM, an optical signal may travel
20 along the optical fiber 106 directly to a destination, or the optical signal may be passed through one or more additional OADMs before reaching a destination.

Figure 2A is a block diagram of an optical source monitoring system (monitoring system) 200 that may be implemented in the optical network 100 of Figure 1. More specifically the monitoring system 200 may be included in the optical transmission device 102 of the
25 optical network 100. In the monitoring system 200, a first and a second optical monitor 202A and 202B (generally, optical monitor 202 or optical monitors 202) measure characteristics of a first and a second channel of light 206A and 206B (generally, channel of light 206 or channels of light 206) originating at a first and a second optical source 204A and 204B (generally, optical source 204 or optical sources 204). The optical
30 monitors 202 receive portions of reflected channels of light 216A-216D and 218A-218D directly from a first and a second collimator lens 210A and 210B (generally, collimator lens 210 or collimator lenses 210).

In addition, the monitoring system 200 may include a controller 212 and a first and a second focusing assembly 214A and 214B (generally, focusing assembly 214 or focusing

assemblies 214). Each of the focusing assemblies 214 may include one of the collimator lenses 210. The focusing assemblies 214 may focus and/or collimate the channels of light 206 prior to communication of the channels of light 206 along the optical fibers 220A and 220B. With combined reference to Figures 1 and 2A, the optical sources 204 may be similar to and/or correspond to the optical sources 116 of Figure 1. The focusing assemblies 214 may be similar to and/or correspond to the focusing assemblies 112 of Figure 1. The optical monitors 202 may be similar to and/or correspond to the optical monitors 118 of Figure 1. The controller 212 may be similar to and/or correspond to the controller 120 of Figure 1.

Referring back to Figure 2A, the monitoring system 200 includes two optical sources 204, two optical monitors 202, and two focusing assemblies 214. This depiction is not meant to be limiting. The monitoring system 200 may include two or more optical sources 204, optical monitors 202, and focusing assemblies 214. Figures 2A-2C will be described referencing the monitoring system 200 as depicted. However, the description may be applicable to monitoring systems 200 having two or more of optical sources 204, optical monitors 202, and focusing assemblies 214.

Between the first optical source 204A, the first collimating lens 210A, and the first optical monitor 202A a spatial relationship may exist. Likewise, between the second optical source 204B, the second collimating lens 210B, and the second optical monitor 202B a second spatial relationship may exist. In the context of the first and the second spatial relationships described above, the optical source (e.g. the first or the second optical source 204A or 204B) may be referred to as a primary optical source 204 with respect to the corresponding collimating lens 210 and the corresponding optical monitor 202. For example, the first optical source 204A may be the primary optical source 204 for the first collimating lens 210A and the first optical monitor 202A. Additionally, the second optical source 204B may be a secondary optical source with respect to the first collimating lens 210A and the first optical monitor 202A. Likewise, the second optical source 204A may be the primary optical source 204 for the second collimating lens 210B and the second optical monitor 202B, while the first optical source may be a secondary optical source to the second collimating lens 210B and the second optical monitor 202B.

In monitoring systems 200 including three or more optical sources 204, optical monitors 202, and collimating lenses 210, there may be one optical source 204 which is the primary optical source 204 while all other optical sources 204 may be designated as secondary optical sources. For example in a monitoring system 200 including three

optical sources 204, three optical monitors 202, and three collimating lenses 210. Each of the optical monitors 202 and focusing assemblies 214 may have one primary optical source 204 and two secondary optical sources 204.

5 The collimating lens 210 may be positioned in relation to the primary optical sources 204 such that the channel of light 206 transmitted by the primary optical source may enter the focusing assembly 214 through the collimator lens 210. As the channel of light 206 enters the focusing assembly 214, at least a portion of the channel of light 206 transmitted by the primary optical source 204 may be reflected from the collimator lens 210.

For example, the first focusing assemblies 214A may be positioned in relation to the
10 primary optical sources 204A (e.g., the first optical source 204A) such that the first channel of light 206A is transmitted by the primary optical source 204A may enter the first focusing assembly 214A through the first collimator lens 210A. As the first channel of light 206A enters the first focusing assembly 214A, a portion (e.g., 218A-218D) of the first channel of light 206A transmitted by the first optical source 204A is reflected from
15 the first collimator lens 210A.

Likewise, the second focusing assemblies 214B may be positioned in relation to the primary optical sources 204B (e.g., the second optical source 204B) such that the second channel of light 206B is transmitted by the primary optical source 204B may enter the second focusing assembly 214B through the second collimator lens 210B. As the second
20 channel of light 206B enters the second focusing assembly 214B, a portion (e.g., 216A-216D) of the second channel of light 206B transmitted by the second optical source 204B is reflected from the second collimator lens 210B. The transmission of the first channel of light and the second channel of light may occur with some temporal overlap.

The reflection of the channels of light 206 from the collimator lenses 210 may generate
25 multiple portions of the reflected channels of light 216A-216D and 218A-218D. Specifically, the first channel of light 206A may reflect off of the first collimator lens 210A creating a first portion of a first reflected channel of light 218A, a second portion of a first reflected channel of light 218B, a third portion of a first reflected channel of light 218C, and a fourth portion of a first reflected channel of light 218D. Likewise, the second
30 channel of light 206B may reflect off of the second collimator lens 210B creating a first portion of a second reflected channel of light 216A, a second portion of a second reflected channel of light 216B, a third portion of a second reflected channel of light 216C, and a fourth portion of a second reflected channel of light 216D.

In some embodiments, one or more of the collimator lenses 210 may be shaped to direct the portions of the reflected channels of light 216A-216D and 218A-218D towards one of the optical monitors 202. For example in some embodiments, the collimator lenses 210 may be is laterally symmetric and rotationally asymmetric.

5 Additionally, the collimator lenses 210 may be positioned in relation to a corresponding optical monitor 202. The collimator lenses 210 may be positioned such that the optical monitor 202 receives the first portion of the reflected channel of light 218A or 216A of the primary optical source 204 and a second portion of a reflected channel of light 218B or 216B of a secondary optical source. For example, the first optical monitor 202A may
10 be positioned with respect to the first collimator lenses 210A such that the first optical monitor 202A receives the first portion of the first reflected channel of light 218A and the second portion of the second reflected channel of light 216B. Likewise, the second optical monitor 202B may be positioned with respect to the second collimator lenses 210B such that the second optical monitor 202B receives the first portion of the second reflected
15 channel of light 216A and the second portion of the first reflected channel of light 218B. The optical monitors 202 may receive the portions of the reflected channels of light (e.g. first portion of the first reflected channel of light 218A and the second portion of the second reflected channel of light 216B or the first portion of the second reflected channel of light 216A and the second portion of the first reflected channel of light 218B) directly
20 from the collimator lenses 210.

The optical monitors 202 may generate gross electrical signals representative of received light. For example, the optical monitors 202 may be monitor photodiodes that generate an electrical signal that corresponds to the amount of light received by a photo-sensitive element. Accordingly, the gross electrical signals may be representative of the first
25 portion of the reflected channel of light 218A or 216A of the primary optical source 204 and a second portion of a reflected channel of light 218B or 216B of a secondary optical source. Each of the optical monitors 202 may communicate the gross electrical signals representative of received light to the controller 212.

The controller 212 may receive the gross electrical signals from each of the optical
30 monitors 202. The controller 212 may be configured to determine discrete signals from the gross electrical signals. Generally, the discrete signals may be representative of the first portion of the reflected channel of light 218A or 216A transmitted by the primary optical source.

For example, the first optical monitor 202A may communicate a first gross electrical signal representative of the first portion of the first reflected channel of light 218A and the second portion of the second reflected channel of light 216B. The controller 212 may determine a first discrete signal representative of the first portion of the first reflected channel of light 218A from the first gross electrical signal. Likewise, the second optical monitor 202B may communicate a second gross electrical signal representative of the first portion of the second reflected channel of light 216A and the second portion of the first reflected channel of light 218B. The controller 212 may determine a second discrete signal representative of the first portion of the second reflected channel of light 216A from the second gross electrical signal.

In some embodiments, the controller 212 may determine the discrete signals by generating a set of coefficients indicating quantities of the gross electrical signals to attribute to each of the optical sources 204. For example, the set of coefficients may indicate that a certain percentage or proportion of the first gross electrical signal may be attributed to the second optical source 204B. The controller 212 may then subtract a corresponding quantity from the first gross electrical signal to determine the first discrete signal. Some additional details of generating the set of coefficients are included below.

The monitoring system 200 may include one or more protrusions 222A and 222B. The protrusions 222A and 222B may be configured to interrupt a third portion of the reflected channel of light (e.g., 218C and 216C) of one or more secondary optical sources. Specifically, the first protrusion 222A included in the first optical monitor 202A may be configured to interrupt the third portion of the second reflected channel of light 216C. Likewise, the second protrusion 222B included in the second optical monitor 202B may be configured to interrupt the third portion of the first reflected channel of light 218C. As illustrated in Figure 2A, the protrusions 222A and 222B may be included on the optical monitors 202. Additionally or alternatively, the protrusions 222A and 222B may be an independent or semi-independent structure and may take any shape. Some examples of protrusions 222A and 222B may include, but are not limited to, posts, solder bumps, reflective surfaces, and absorptive surfaces.

Figures 2B and 2C depict the monitoring system 200 of Figure 2A in which the controller 212 is generating a set of coefficients in some embodiments. With specific reference to Figure 2B, the controller 212 may be configured to generate the set of coefficients by energizing the first optical source 204A such that a first channel of light 206A of a first known power level is transmitted towards the first collimator lens 210A. During this time

the second optical source 204B is not energized, thus the light in the monitoring system 200 is transmitted by the first optical source 204A.

The first channel of light 206A may be reflected from the first collimator lens 210A creating multiple reflected beams of light 224A-224D, some subset of which may be received by the first optical monitor 202A and the second optical monitor 202B. The controller 212 may measure a first gross calibration electrical signal at the first optical monitor 202A representative of a first reflected beam of light 224A. Additionally, the controller 212 may measure a second gross calibration electrical signal at the second optical monitor 202B representative of a second reflected beam of light 224B. The following equations may describe the first and the second gross calibration electrical signals:

$$a_1 PL_1 = CS_{PL1_1}$$

$$a_2 PL_1 = CS_{PL1_2}$$

In the above equations, CS_{PL1_1} may represent the first gross calibration electrical signal measured at the first optical monitor 202A. Likewise, CS_{PL1_2} may represent the second gross calibration electrical signal measured at the second optical monitor 202B. PL_1 may represent the known power level of the first channel of light 206A. The variables a_1 and a_2 may represent a first coefficient and a second coefficient, respectively.

Accordingly, the controller 212 may calculate the first coefficient as a ratio of the first gross calibration electrical signal to the first known power level. Additionally, the controller 212 may calculate a second coefficient as a ratio of the second gross calibration electrical signal to the first known power level.

With reference to Figure 2C, the controller 212 may be further configured to generate the set of coefficients by energizing the second optical source 204B such that the second channel of light 206B of a second known power level is transmitted towards the second collimator lens 210B. During this time, the first optical source 204A is not energized, thus the light in the monitoring system 200 is transmitted by the second optical source 204B.

The second channel of light 206B may be reflected from the second collimator lens 210B creating multiple reflected beams of light 226A-226D, some subset of which may be received by the second optical monitor 202B and the first optical monitor 202A. The controller 212 may measure a third gross calibration electrical signal at the first optical monitor 202A. Additionally, the controller 212 may measure a fourth gross calibration electrical signal at the second optical monitor 202B. The third gross calibration electrical

signal may be representative of a third reflected beam of light 226B and the fourth gross calibration electrical signal may be representative of a fourth reflected beam of light 226A. The following equations may describe the third and fourth gross calibration electrical signals:

$$\begin{aligned} b_1 PL_2 &= CS_{PL2_1} \\ b_2 PL_2 &= CS_{PL2_2} \end{aligned}$$

In the immediately above equations, CS_{PL2_1} may represent the third gross calibration electrical signal measured at the first optical monitor 202A. Likewise, CS_{PL2_2} may represent the fourth gross calibration electrical signal measured at the second optical monitor 202B. PL_2 may represent the second known power level of the second channel of light 206B. The variables b_1 and b_2 represent a third coefficient and a fourth coefficient, respectively.

Accordingly, the controller 212 may calculate the third coefficient as a ratio of the third gross calibration electrical signal to the second known power level. Additionally, the controller 212 may calculate the fourth coefficient as a ratio of the fourth gross calibration electrical signal to the second known power level.

Generally, each of the coefficients indicates a quantity of the gross electrical signal measured at a particular optical monitor 202 to attribute to a particular optical source 204. Thus, referring back to Figure 2A, the gross electrical signals measured by the first optical monitor 202A and the second optical monitor 202B may be described by the following equations:

$$\begin{aligned} a_1 L_1 + b_1 L_2 &= GS_1 \\ a_2 L_1 + b_2 L_2 &= GS_2 \end{aligned}$$

In the immediately foregoing equations, the GS_1 , and GS_2 , may represent gross electrical signals communicated from the first optical monitors 202A and the second optical monitor 202B, respectively. The variables L_1 and L_2 may represent a total power the channels of light 206 transmitted by the corresponding optical sources 204. For example, L_1 may represent the total power of the first channel of light 206A transmitted by the first optical source 204A. The variables a_1 - a_2 and b_1 - b_2 may represent the set of coefficients determined above.

The foregoing equation describes each of the gross electrical signals as a sum of contributions from each of the optical sources 204. The contributions from each of the optical sources 204 are equal to some proportion of the total power of the channel of light

206 multiplied by a corresponding coefficient. With reference to Figure 2A, the first gross electrical signal is equal to the first portion of the first reflected channel of light 218A added to the second portion of the second reflected channel of light 216B. The coefficients a_1 and b_1 represent the amount or quantity of the channel of light 206B included in the “first portion” of first portion of the first reflected channel of light 218A and the “second portion” of the second portion of the second reflected channel of light 216B.

To solve the foregoing equation, it may be written in matrix form:

$$\begin{bmatrix} a_1 & b_1 \\ a_2 & b_2 \end{bmatrix} \begin{bmatrix} L_1 \\ L_2 \end{bmatrix} = \begin{bmatrix} GS_1 \\ GS_2 \end{bmatrix}$$

10 In the matrix form of the foregoing equation, a_1 , a_2 , b_1 , and b_2 are the determined (e.g., known) coefficients and GS_1 and GS_2 are measured. Thus, L_1 and L_2 may be solved for through using matrix algebra. Combining the first, second, third, and fourth coefficients may result in the set of coefficients described by the matrix:

$$\begin{bmatrix} a_1 & b_1 \\ a_2 & b_2 \end{bmatrix}$$

15 More generally, the processes described above for generating the set of coefficients may be expanded for applicability in monitoring systems 200 including any number of optical sources 202, optical monitors 204, and focusing assemblies 214. General calibration equations below may describe the generation of a set of coefficients by sequentially energizing one optical source 202 to a known power level:

$$\begin{array}{lll} a_1 PL_1 = CS_{PL1_1} & b_1 PL_2 = CS_{PL2_1} & \lambda_1 PL_n = CS_{PLn_1} \\ a_2 PL_1 = CS_{PL1_2} & b_2 PL_2 = CS_{PL2_2} & \lambda_2 PL_n = CS_{PLn_2} \\ \vdots & \dots & \vdots \\ a_n PL_1 = CS_{PL1_n} & b_n PL_2 = CS_{PL2_n} & \lambda_n PL_n = CS_{PLn_n} \end{array} \dots$$

In the foregoing general calibration equations, a_1 - a_n may represent the coefficients quantifying the amount of light to attribute to a first channel of light having a first power level, PL_1 . Specifically, a_1 represents amount of light to attribute to a first channel of light at a first optical monitor 202A, a_2 represents amount of light to attribute to the first channel of light at a second optical monitor 202B, and a_n represents amount of light to attribute to the first channel of light at an Nth optical monitor (not shown). Likewise, b_1 - b_n may represent the amount of light to attribute to a second channel of light having a second known power level, PL_2 at each of the optical monitor 202 and λ_1 - λ_n may represent

the amount of light to attribute to an Nth channel of light having an Nth known power level PL_n at each of the optical monitor 202. Additionally, in forgoing general calibration equations, the variables PL_I-PL_n in this set of equations are equal to the known power levels of the channels of light and $CSP_{LI_I}-CSP_{Ln_n}$ represent the gross calibration electrical signal measured at one of the optical monitors 202. Accordingly, each of a_I-a_n , b_I-b_n , and $\lambda_I-\lambda_n$ may be calculated as a ratio of the gross calibration electrical signal to the known power level.

A set of general gross electrical signals may be described by the equations:

$$\begin{aligned} a_1 L_1 + b_1 L_2 \dots + \lambda_1 L_n &= GS_1 \\ a_2 L_1 + b_2 L_2 \dots + \lambda_2 L_n &= GS_2 \\ \dots & \\ a_n L_1 + b_n L_2 \dots + \lambda_n L_n &= GS_n \end{aligned}$$

In foregoing equation for general gross electrical signals, GS_I , GS_2 , and GS_n may represent gross electrical signals communicated from one of the optical monitors 202. Specifically, GS_I may represent a first gross electrical signal communicated from the first optical monitor 202A, GS_2 represents a second gross electrical signal communicated from the second optical monitor 202B, etc. The variables L_I-L_n may represent a total power of one of the channels of light 206 transmitted by a corresponding optical source 204. For example, L_I represent the total power of the first channel of light 206A transmitted by the first optical source 204A. The variables a_I-a_n , b_I-b_n , and $\lambda_I-\lambda_n$ may represent coefficients determined above.

For example, in the top equation $a_I L_I + b_I L_2 \dots \lambda_I L_n = GS_I$, the first gross electrical signal GS_I may be equal to a sum of first coefficient multiplied by the total power of the first channel of light $a_I L_I$, a second coefficient multiplied by the total power of the second channel of light $b_I L_2$, and an Nth coefficient of an Nth channel of light $\lambda_I L_n$. To calculate the discrete signal representative of the first optical source 204A (e.g., L_I), the second coefficient multiplied by the total power of the second channel of light ($b_I L_2$) and the Nth coefficient of the Nth channel of light ($\lambda_I L_n$) may be subtracted from the first gross electrical (GS_I). The difference may be divided by a_I as determined above during the calibration.

In some embodiments, the coefficients may be approximately equal. For example:

$$b_1 \approx a_1 \approx \lambda_1$$

However, by including the protrusions 222, one of the coefficients may be increased in relation to the coefficients related to the other optical coefficients. For example, the

coefficient corresponding to the primary optical source may be increased with respect to the other coefficients. A resulting relationship may be described by the equation:

$$b_1 << a_1 >> \lambda_1$$

The set of general gross electrical signals may be represented in matrix form by the equation below:

$$\begin{bmatrix} a_1 & b_1 & \dots & \lambda_1 \\ a_2 & b_2 & \dots & \lambda_2 \\ \vdots & \vdots & \dots & \vdots \\ a_n & b_n & \dots & \lambda_n \end{bmatrix} \begin{bmatrix} L_1 \\ L_2 \\ \vdots \\ L_n \end{bmatrix} = \begin{bmatrix} GS_1 \\ GS_2 \\ \vdots \\ GS_n \end{bmatrix}$$

The variables in the matrix form of the general gross electrical signals represent the similar to values discussed above with respect to the general gross electrical signals. In matrix form, a first matrix (starting from the left side) including a_1 - a_n , b_1 - b_n , and λ_1 - λ_n represents the set of coefficients. Additionally, a second matrix including the variables L_1 - L_n that may represent total powers of each of the channels of light. Additionally or alternatively, in some embodiments, the variables L_1 - L_n may include discrete signals and/or the second matrix including the variables L_1 - L_n may be a basis from which the discrete signals are derived.

In some embodiments, during the generation of the coefficients the power level of the channel of light 206 may not be known. With reference to Figure 2B, the first optical source 204A may be energized such that the first channel of light 206B is transmitted against the collimator lens 210A. However, rather than the controller 212 knowing the power level of the first channel of light 206A, the controller 212 measures the total received light in the monitoring system 200. Based on total received light, the controller 212 may generate the set of coefficients. Specifically, the set of coefficients, may be equal a proportion of light received at each optical monitor 202 to the total received light at all the optical monitors 202. For example, the following equations may describe the first and the second coefficients calculated without a known power level of the channel of light 206:

$$a_1 RL_1 = CS_{RL1_1}$$

$$a_2 RL_1 = CS_{RL1_2}$$

$$a_1 + a_2 = 1$$

In the above equations, CS_{RL_1} may represent a first gross calibration electrical signal measured at the first optical monitor 202A. Likewise, CS_{RL_2} may represent the second gross calibration electrical signal measured at the second optical monitor 202B. RL_1 may represent the total received light of the first channel of light 206A. The variables a_1 and a_2 may represent a first coefficient and a second coefficient, respectively.

Accordingly, the controller 212 may calculate the first coefficient as a ratio of the first gross calibration electrical signal to the total received light. The total received light may be equal to the sum of the first gross calibration electrical signal and the second gross calibration electrical signal. Additionally, the controller 212 may calculate a second coefficient as a ratio of the second gross calibration electrical signal to the first known power level. Any number of remaining coefficients may be generated in a fashion similar to that discussed above.

A second set of general gross electrical signals may be described by the equations:

$$\begin{aligned} a_1 RL_1 + b_1 RL_2 \dots + \lambda_1 RL_n &= GS_1 \\ a_2 RL_1 + b_2 RL_2 \dots + \lambda_2 RL_n &= GS_2 \\ \dots & \\ a_n RL_1 + b_n RL_2 \dots + \lambda_n RL_n &= GS_n \end{aligned}$$

In foregoing equation for general gross electrical signals, GS_1 , GS_2 , and GS_n may represent gross electrical signals communicated from one of the optical monitors 202. Specifically, GS_1 may represent a first gross electrical signal communicated from the first optical monitor 202A, GS_2 represents a second gross electrical signal communicated from the second optical monitor 202B, etc. The variables RL_1 – RL_n represent a total received power of one of the channels of light 206 transmitted by a corresponding optical source 204. For example, RL_1 may represent the total received power of the first channel of light 206A transmitted by the first optical source 204A. The variables a_1 – a_n , b_1 – b_n , and λ_1 – λ_n may represent the coefficients determined above.

Solving the foregoing equation is described above through matrix algebra. However, the variables RL_1 – RL_n represent a total received power of one of the channels of light 206. Thus, in embodiments in which the power level may not be known when generating the coefficients, the controller 212 may include different processing to relate the total received light (e.g., variables RL_1 – RL_n) to one of the channels of light 206 and/or one or more characteristics of the corresponding optical source 204.

Calculation of the discrete signals may include multiplying a gross electrical signal received during operation at one of the optical monitors 202 by a corresponding coefficient. For example, to calculate a first discrete signal for the first optical source 204A, a first coefficient a_1 by a first gross electrical signal received during operation at the first optical monitor 202A and a second discrete signal for the second optical source 204B, a second coefficient b_2 by a second gross electrical signal received during operation at the second optical monitor 202B.

The steps described herein from which the set of coefficients are determined are not meant to be limiting. The set of coefficients may be determined in multiple other ways.

For example, in some embodiments, both (or all) the of the optical sources 204A and 204B may be simultaneously operated, then individually turned off to measure contributions of each of the optical sources 204A and 204B. Additionally or alternatively, sets of secondary optical sources 204 may be operated simultaneously to measure contributions from combinations of secondary optical sources 204. Additionally or alternatively, one or more of the optical sources 204 may be operated at different power levels to measure individual contribution variations which can be factored into the set of coefficients.

Figure 3 is a flow diagram of an example method 300 of monitoring an optical system, which may include multiple optical sources, multiple optical monitors, and multiple focusing assemblies with collimator lenses such as those described with respect to Figures 2A-2C. The method 300 may be implemented in the optical network 100 or in the monitoring system 200 of Figures 2A-2C, in some embodiments. For example, the method 300 (including the operations in the various blocks described below) may be performed in some embodiments by the controller 120 that may include or may be communicatively coupled to a non-transitory computer-readable medium having thereon computer-readable instructions, which in response to execution by a processor, cause the processor to perform or control performance of the method 300. The controller 120 in some embodiments may be implemented by such computer-readable instructions stored on a non-transitory computer-readable medium (such as a memory) and executable by one or more processors. Although illustrated as discrete blocks, various blocks may be divided into additional blocks, supplemented with additional blocks, combined into fewer blocks, or eliminated, depending on the particular implementation.

The method 300 may begin at 302 by generating a set of coefficients which is configured to indicate quantities of received light to attribute to each of multiple optical sources. In

some embodiments, generating the set of coefficients may include a first optical source being energized such that the first optical source transmits a channel of light of a known power level. While the first optical source is transmitting the channel of light, a set of gross calibration electrical signals may be received at the plurality of optical monitors.

5 From the set of gross calibration electrical signals, a first subset of coefficients for the first optical source may be calculated. For example, the first subset of coefficients may be calculated by dividing each of the set of gross calibration electrical signals by the known power level.

10 In some embodiments, generating the set of coefficients may include energizing a first optical source. While the first optical source is transmitting a channel of light, a set of gross calibration electrical signals may be received at multiple optical monitors. From the set of gross calibration electrical signals, a first subset of coefficients for the first optical source may be calculated by dividing each of the set of gross calibration electrical signals by a sum of each of the set of gross calibration electrical signals.

15 At 304, the method 300 may include receiving a gross electrical signal representative of the received light that includes multiple reflected channels of light directly from the collimator lenses. At 306, based on the set of coefficients and the gross electrical signal, the method 300 may include determining a distinct signal representative of a first channel of light transmitted by a first optical source. Additionally, in some embodiments, the
20 method 300 may include interrupting a portion of the plurality of channels of light reflected directly from the collimator lenses.

For this and other procedures and methods disclosed herein, the functions performed in the processes and methods may be implemented in differing order. Furthermore, the outlined operations are only provided as examples, and some of the operations may be
25 optional, combined into fewer operations, supplemented with other operations, or expanded into additional operations without detracting from the disclosed embodiments.

Figure 4 is a flow diagram of an example method 400 of monitoring multiple optical sources. The method 400 may be implemented in the optical network 100 or in the monitoring system 200 of Figures 2A-2C, in some embodiments. For example, the
30 method 400 (including the operations in the various blocks described below) may be performed in some embodiments by the controller 120 that may include or may be communicatively coupled to a non-transitory computer-readable medium having thereon computer-readable instructions, which in response to execution by a processor, cause the processor to perform or control performance of the method 400. The controller 120 in

some embodiments may be implemented by such computer-readable instructions stored on a non-transitory computer-readable medium (such as a memory) and executable by one or more processors. Although illustrated as discrete blocks, various blocks may be divided into additional blocks, supplemented with additional blocks, combined into fewer blocks, or eliminated, depending on the particular implementation.

The method 400 may begin at 402 by receiving a first portion of a reflected first channel of light directly from a first collimator lens. By directly from the first collimator lens, the first portion does not enter, pass through, refract from, or further reflect off any other object, structure, surface, etc. At 404, the method 400 may include simultaneously receiving a second portion of second reflected channel of light directly from a second collimator lens.

At 406, the method 400 may include generating a gross electrical signal representative of the first portion of the first reflected channel of light and the second portion of the second reflected channel of light. In some embodiments, the generating a gross electrical signal may be a result of the first portion of the first reflected channel of light and the received second portion of the second reflected channel of light entering an optical monitor.

At 408, the method 400 may include determining a first discrete signal representative of a first channel of light from the gross electrical signal. In some embodiments, determining the first discrete signal may include generating a set of coefficients. The set of coefficients may indicate the quantity of the gross electrical signal attributed to the received first portion of the first reflected channel and the received second portion of the second reflected channel of light.

Additionally, generating the set of coefficients may include a first optical source being energized such that a channel of light of a first known power level is transmitted towards the first collimator lens. A set of gross calibration electrical signals may then be measured. From the gross calibration electrical signals, the set of coefficients may be calculated. For example, the set of coefficients may be calculated as a ratio set of gross calibration electrical signals to the first known power level.

The embodiments described herein may include the use of a special purpose or general-purpose computer including various computer hardware or software modules, as discussed in greater detail below.

Embodiments within the scope of the present invention also include computer-readable media for carrying or having computer-executable instructions or data structures stored thereon. Such computer-readable media can be any available media that can be accessed

by a general purpose or special purpose computer. By way of example, and not limitation, such computer-readable media can comprise RAM, ROM, EEPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other medium which can be used to carry or store desired program code means in the form of computer-executable instructions or data structures and which can be accessed by a general purpose or special purpose computer. When information is transferred or provided over a network or another communications connection (either hardwired, wireless, or a combination of hardwired or wireless) to a computer, the computer properly views the connection as a computer-readable medium. Thus, any such connection is properly termed a computer-readable medium. Combinations of the above should also be included within the scope of computer-readable media.

Computer-executable instructions comprise, for example, instructions and data which cause a general purpose computer, special purpose computer, or special purpose processing device to perform a certain function or group of functions. Although the subject matter has been described in language specific to structural features and/or methodological acts, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features or acts described above. Rather, the specific features and acts described above are disclosed as example forms of implementing the claims.

As used herein, the term "module" or "component" can refer to software objects or routines that execute on the computing system. The different components, modules, engines, and services described herein may be implemented as objects or processes that execute on the computing system (e.g., as separate threads). While the system and methods described herein are preferably implemented in software, implementations in hardware or a combination of software and hardware are also possible and contemplated. In this description, a "computing entity" may be any computing system as previously defined herein, or any module or combination of modules running on a computing system.

Some embodiments may take other specific forms without departing from the scope of the present description. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes which come within the meaning and range of equivalency of the claims are to be embraced within their scope.

CLAIMS

What is claimed is:

1. An optical transmission device comprising:
an optical source configured to transmit a channel of light;
5 a collimator lens configured to collimate the channel of light and to reflect a portion of the channel of light; and
an optical monitor arranged to receive at least a first portion of a reflected channel of light directly from the collimator lens, and configured to communicate a gross electrical signal representative of received light including the first portion of the reflected
10 channel of light.
2. The optical transmission device of claim 1, further comprising:
a second optical source configured to transmit a second channel of light;
a second collimator lens configured to collimate the second channel of light and to
15 reflect a portion of the second channel of light;
a second optical monitor arranged to receive a second portion of the reflected channel of light and a first portion of the second reflected channel of light directly from the collimator lens and the second collimator lens, respectively, and configured to communicate a second gross electrical signal representative of received light including
20 the second portion of the reflected channel of light and the first portion of the second reflected channel of light; and
a controller configured to determine a second discrete signal representative of the second channel of light from the second gross electrical signal.
- 25 3. The optical transmission device of claim 2, wherein:
the optical monitor includes a protrusion configured to interrupt a third portion of the second reflected channel of light; and
the second optical monitor includes a second protrusion configured to interrupt a third portion of the reflected channel of light.
30
4. The optical transmission device of claim 2, wherein:
the optical monitor is arranged to receive a second portion of the second reflected channel of light; and

the controller is further configured to determine a first discrete signal representative of the channel of light from the gross electrical signal.

5 5. The optical transmission device of claim 4, wherein the controller is configured to determine the second discrete signal based on a set of coefficients that indicate a first quantity of the second gross electrical signal to attribute to the second portion of the reflected channel of light.

10 6. The optical transmission device of claim 5, wherein the set of coefficients further indicates a second quantity of the gross electrical signal to attribute to the first portion of the second reflected channel of light.

7. The optical transmission device of claim 6, wherein to generate the set of coefficients, the controller is configured to:

15 energize the optical source such that the channel of light of a first known power is transmitted;

measure a gross calibration electrical signal at the optical monitor and a second gross calibration electrical signal at the second optical monitor;

20 calculate a first coefficient as a ratio of the gross calibration electrical signal to the first known power level and a second coefficient as a ratio of the second gross calibration electrical signal to the first known power level;

energize the second optical source such that the second channel of light of a second known power is transmitted;

25 measure a third gross calibration electrical signal at the optical monitor and a fourth gross calibration electrical signal at the second optical monitor; and

calculate a third coefficient as a ratio of the third gross calibration electrical signal to the second known power level and a fourth coefficient as a ratio of the fourth gross calibration electrical signal to the second known power level.

30 8. The optical transmission device of claim 1, wherein the collimator lens is shaped to direct the reflected channel of light towards the optical monitor.

9. An optical transmission device comprising:

a plurality of optical sources, each of the optical sources configured to transmit a channel of light;

a plurality of collimator lenses, each of the collimator lenses positioned in relation to a primary optical source of the plurality of optical sources such that the channel of light
5 transmitted by the primary optical source is reflected from the collimator lens;

a plurality of optical monitors, each of the optical monitors positioned in relation to the one of the collimator lenses such that the optical monitor receives a first portion of a first reflected channel of light transmitted by the primary optical source and a second portion of a second reflected channel of light transmitted by a secondary optical source
10 directly from the collimator lenses, and is configured to communicate one of a plurality of gross electrical signals representative of received light including the first portion of the first reflected channel of light and the second portion of the second reflected channel of light; and

a controller configured to determine a plurality of discrete signals representative
15 of the channels of light transmitted by the primary optical sources based on the plurality of the gross electrical signals.

10. The optical transmission device of claim 9, wherein the controller determines the plurality of discrete signals based on a set of coefficients indicating
20 quantities of the received light to attribute to each of the channels of light.

11. The optical transmission device of claim 10, wherein each of the plurality of optical monitors comprises a protrusion configured to interrupt a third portion of at least one reflected channel of light of a secondary optical source.
25

12. The optical transmission device of claim 11, wherein the protrusions is configured to increase a first coefficient corresponding to the primary optical source in relation to the coefficients related to other coefficients.

13. The optical transmission device of claim 9, wherein the collimator lenses are laterally symmetric and rotationally asymmetric.
30

14. A method of monitoring an optical system including a plurality of optical sources, a plurality of optical monitors, and a plurality of collimator lenses, the method comprising:

generating a set of coefficients which is configured to indicate quantities of
5 received light to attribute to each of the plurality of optical sources;

receiving a gross electrical signal representative of the received light that includes a plurality of reflected channels of light directly from the collimator lenses; and

based on the set of coefficients and the gross electrical signal, determining a distinct signal representative of a first channel of light transmitted by a first optical source
10 of the plurality of optical sources.

15. The method of claim 14, wherein the generating the set of coefficients includes:

energizing the first optical source such that the first optical source transmits a
15 channel of light of a known power level;

while the first optical sources is transmitting the channel of light, receiving at the plurality of optical monitors a set of gross calibration electrical signals; and

from the set of gross calibration electrical signals, calculating a first subset of coefficients by dividing each of the set of gross calibration electrical signals by the know
20 power level.

16. The method of claim 15, wherein the generating the set of coefficients includes:

energizing the first optical source;

25 while the first optical sources is transmitting the channel of light, receiving at the plurality of optical monitors a set of gross calibration electrical signals; and

from the set of gross calibration electrical signals, calculating a first subset of coefficients by dividing each of the set of gross calibration electrical signals by a sum of each of the set of gross calibration electrical signals.

30

17. The method of claim 14, further comprising interrupting a portion of the plurality of channels of light reflected directly from the collimator lenses.

18. The method of claim 14, further comprising:

receiving a first portion of a first reflected channel of light directly from a first collimator lens;

receiving a second portion of a second reflected channel of light directly from a second collimator lens;

5 generating the gross electrical signal representative of the first portion of the first reflected channel of light and the second portion of the second reflected channel of light.

19. The method of claim 18, wherein the determining the discrete signal includes:

10 determining a quantity of the gross electrical signal to attribute to the first portion of the first reflected channel of light; and

determining another quantity of the gross electrical signal a second quantity of the gross electrical signal to attribute to the second portion of the second reflected channel of light.

15

20. The method of claim 14, wherein the generating the set of coefficients comprises:

energizing the first optical source such that the first optical source transmits a channel of light;

20 while the first optical sources is transmitting the channel of light, receiving at the plurality of optical monitors a set of gross calibration electrical signals, a sum of the set of gross calibration electrical signals representing a total received light of the plurality of optical monitors; and

25 from the set of gross calibration electrical signals, calculating a first subset of coefficients by dividing each of the set of gross calibration electrical signals by the sum of the set of the gross calibration electrical signals.

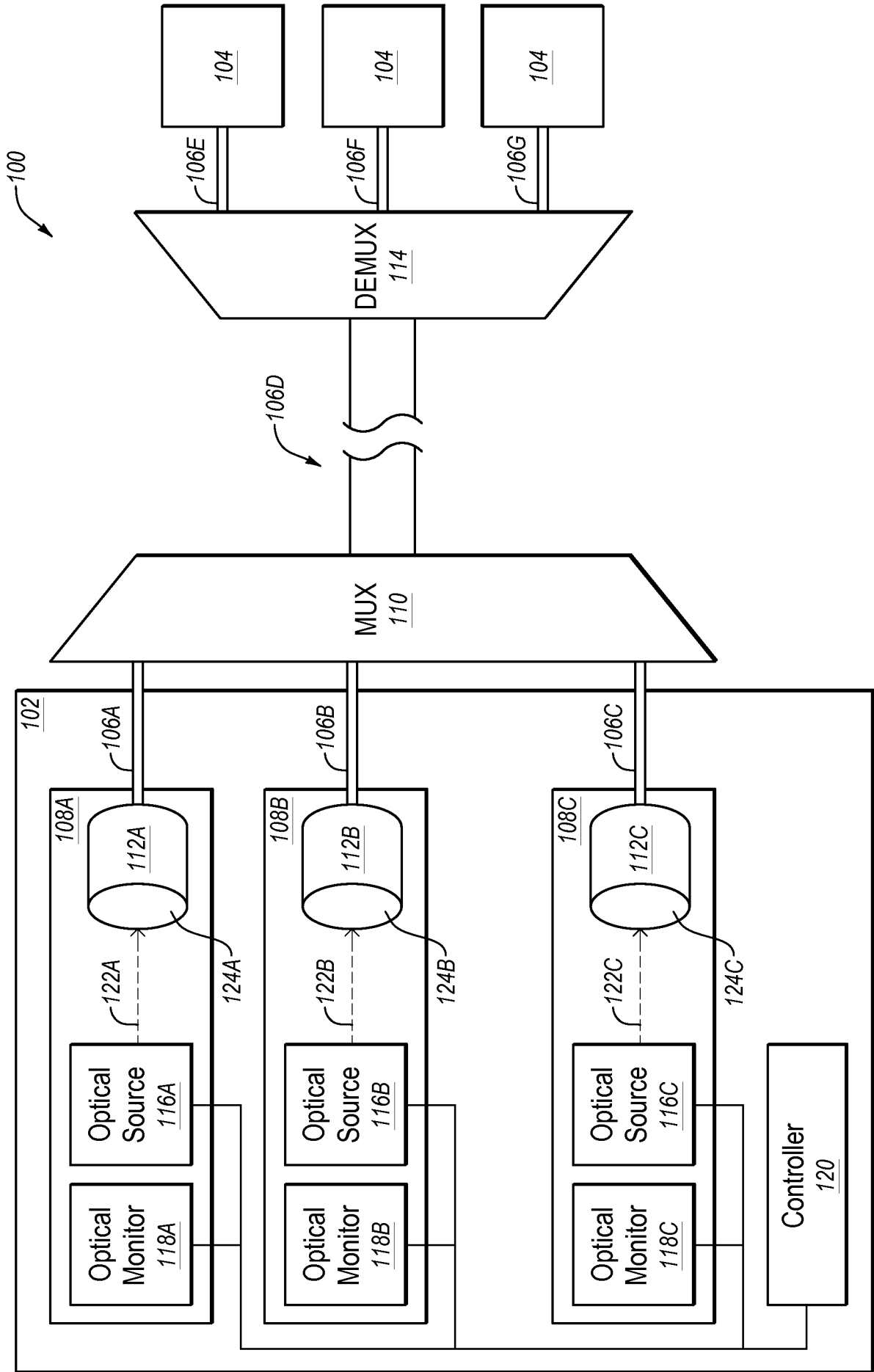


Fig. 1

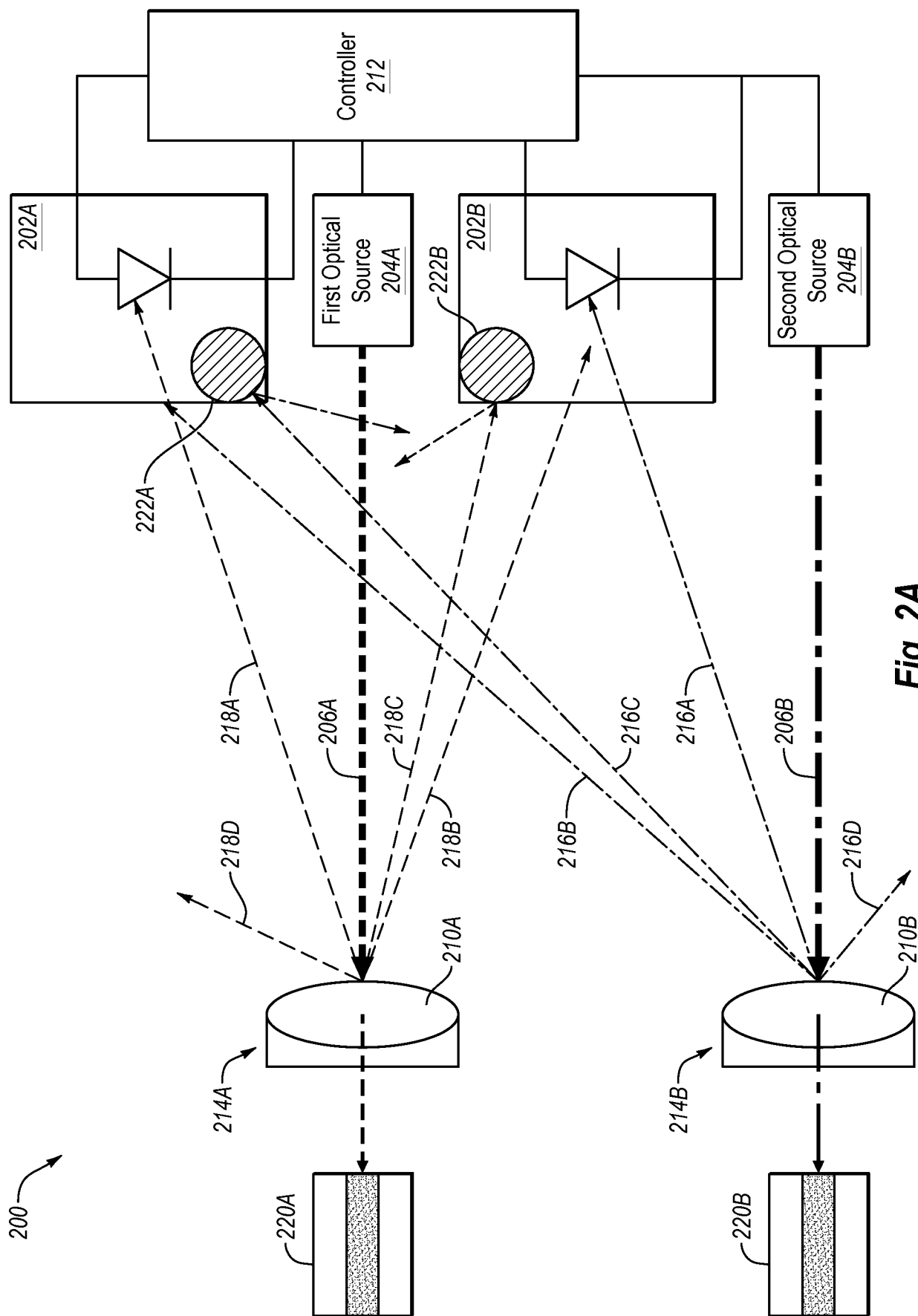


Fig. 2A

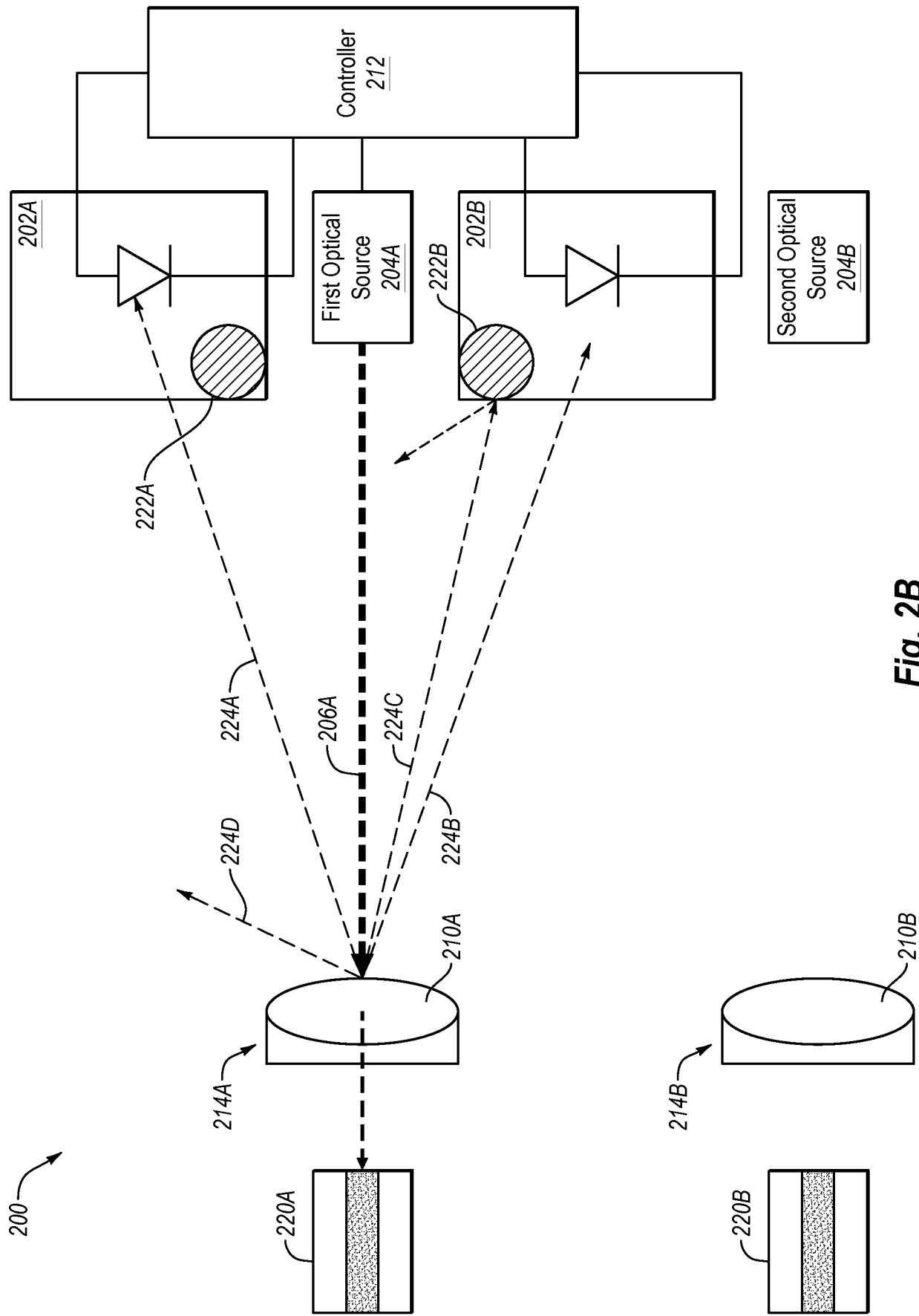


Fig. 2B

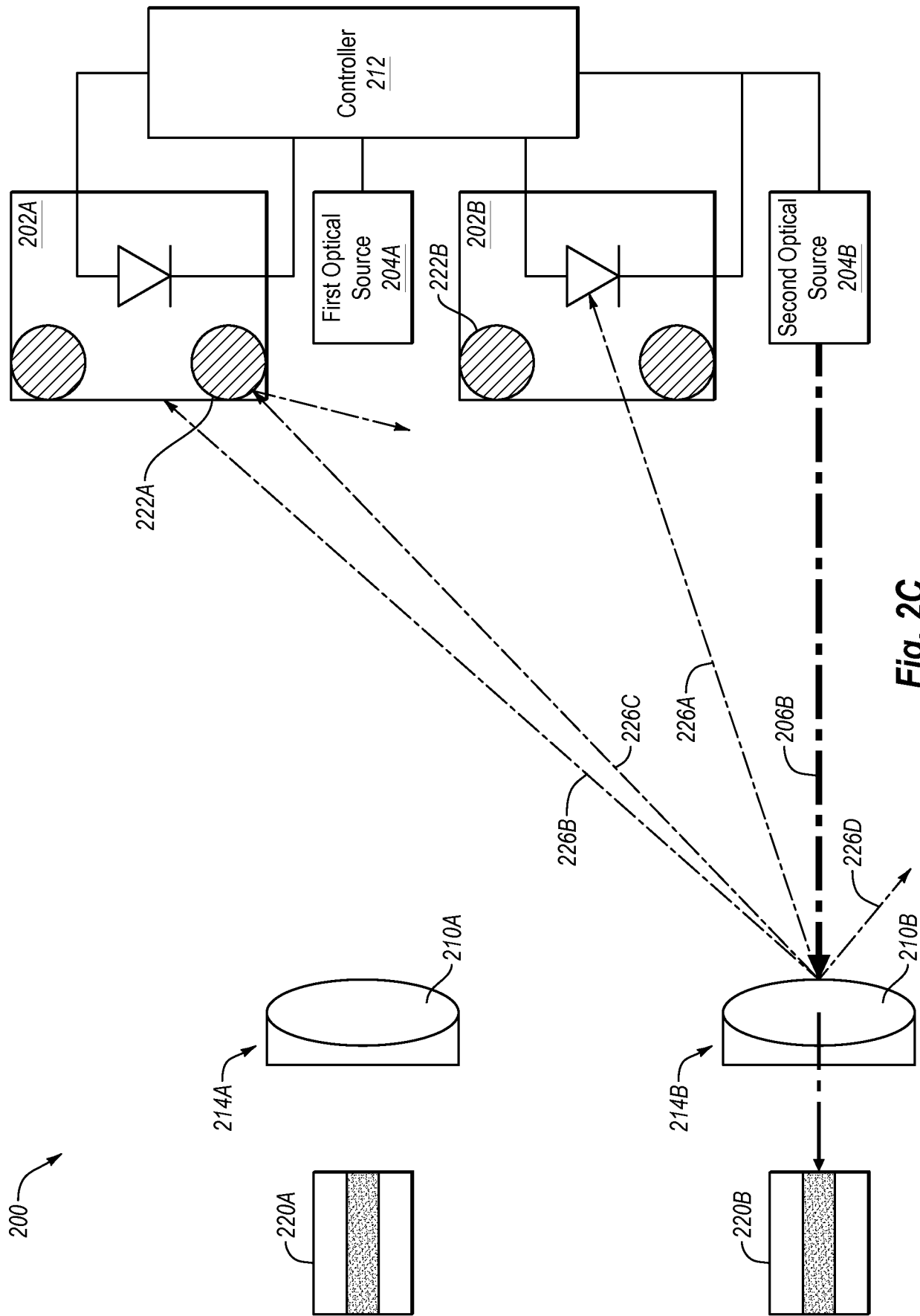
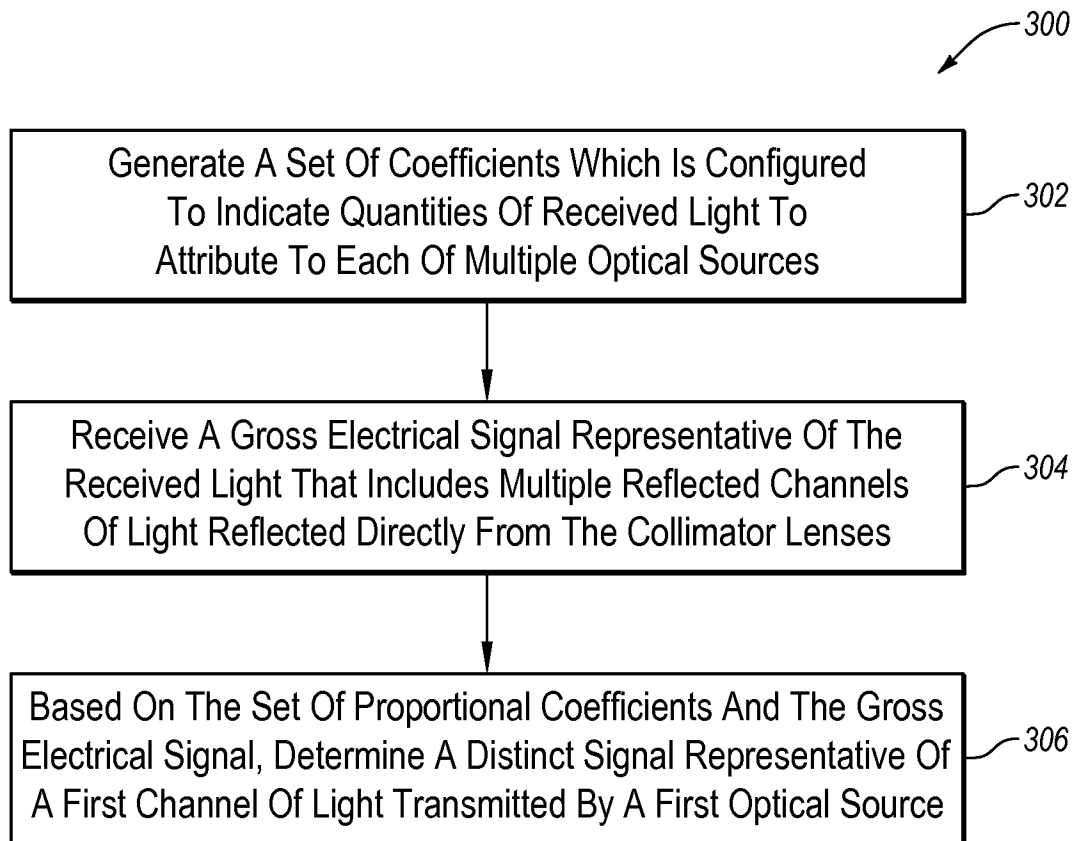
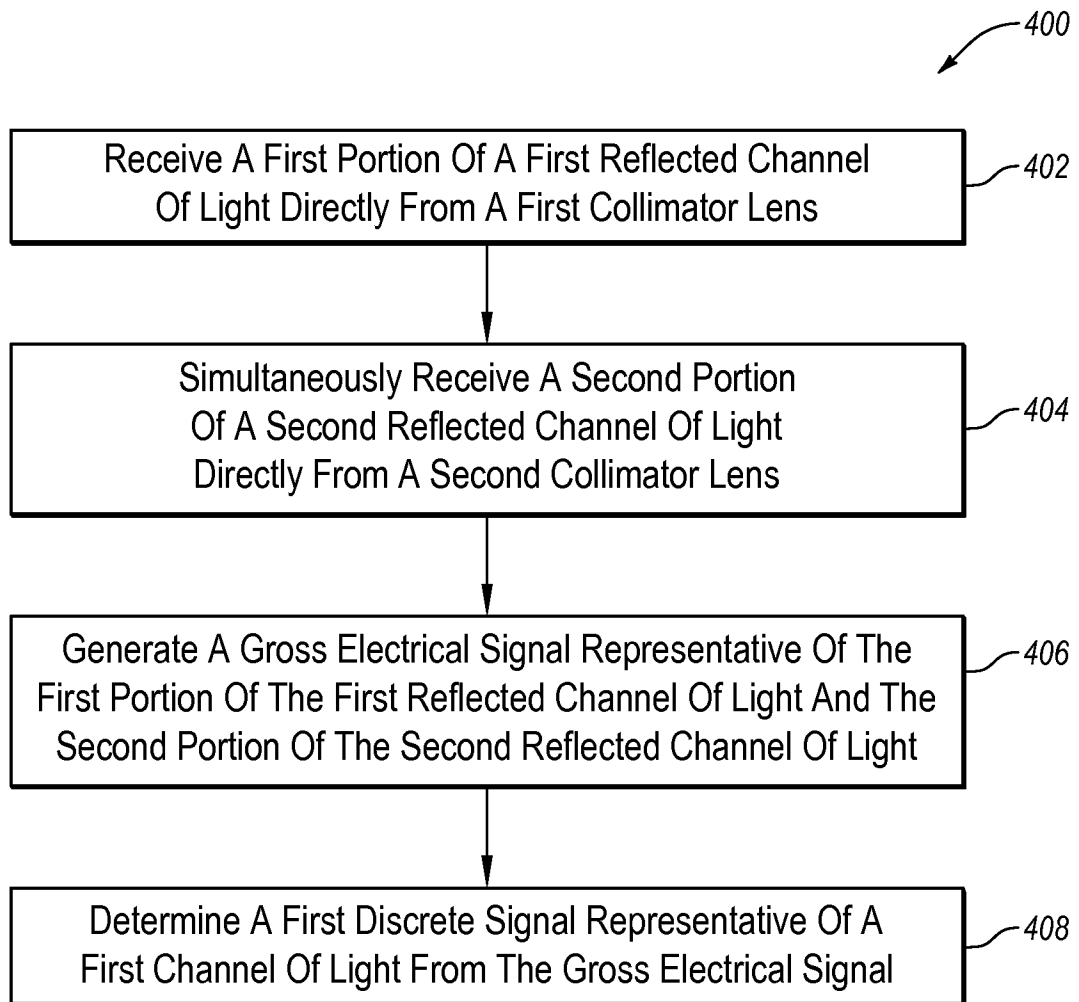


Fig. 2C

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**Fig. 3**

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**Fig. 4**

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/026666

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04B10/079
ADD.

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)
H04B 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 practicable, search terms used)

EPO-Internal, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 7 099 536 B1 (CHANDRA HARYANTO [US]) 29 August 2006 (2006-08-29) figures 1A, 1B, 2, 3 column 1, lines 16-33 column 2, lines 4-10 column 2, line 64 - column 3, line 16 column 3, lines 42-54 column 4, lines 16-24 -----	1-20
A	US 2004/052463 A1 (CHEN YE CHRISTINE [US]) 18 March 2004 (2004-03-18) figures 1,2 paragraphs [0020], [0026] -----	1-20
A	US 2010/295063 A1 (MORIOKA SHIMPEI [JP]) 25 November 2010 (2010-11-25) paragraphs [0002], [0016], [0017] -----	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

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Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
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Authorized officer

Petitit, Nicolas

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Information on patent family members

International application No

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