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(54) **OPTICAL TRANSMISSION SYSTEM, METHOD OF TESTING OPTICAL TRANSMISSION SYSTEM, AND NON-TRANSITORY COMPUTER-READABLE MEDIUM**

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USPC **398/34**

(57) **ABSTRACT**

An optical transmission system includes: an optical transmission device that has a plurality of optical transmitters configured to output at least one different wavelength and a multiplexer configured to multiplex wavelength lights output by the plurality of optical transmitters and output a multiplexed wavelength light; and a detection unit configured to detect each wavelength light that is branched before being fed into the multiplexer by sweeping an objective wavelength for detection, wherein, in a single sweeping, the detection unit selects and detects two or more wavelength lights with a wavelength interval that is wider than a wavelength interval of an output light of the multiplexer.

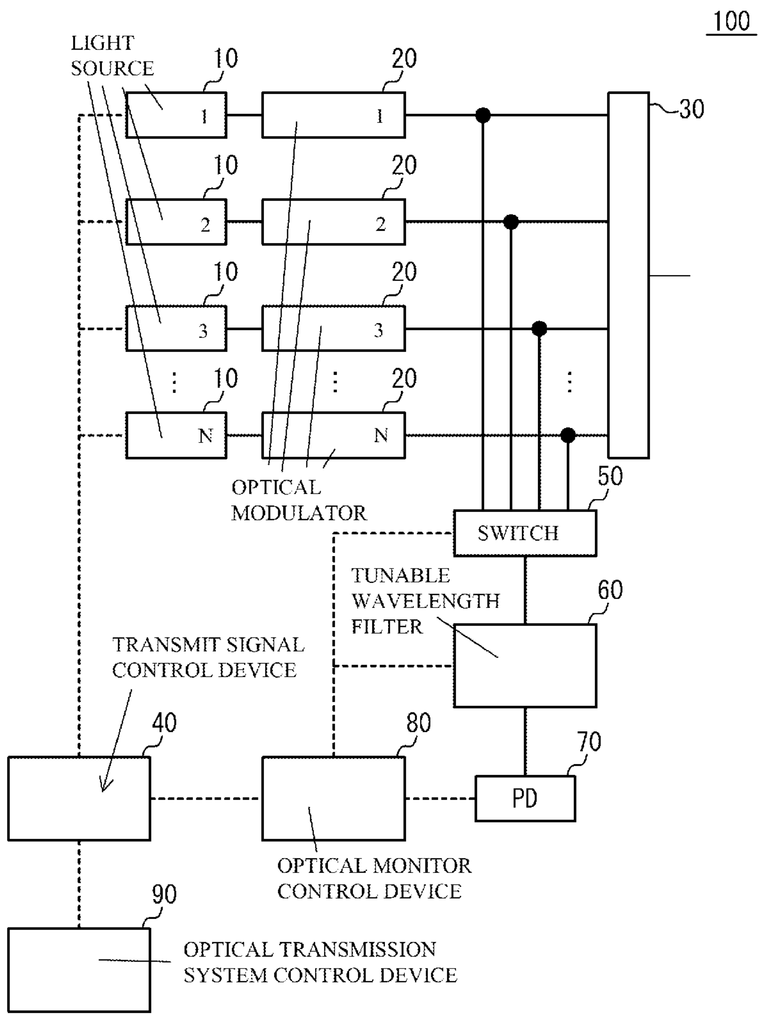
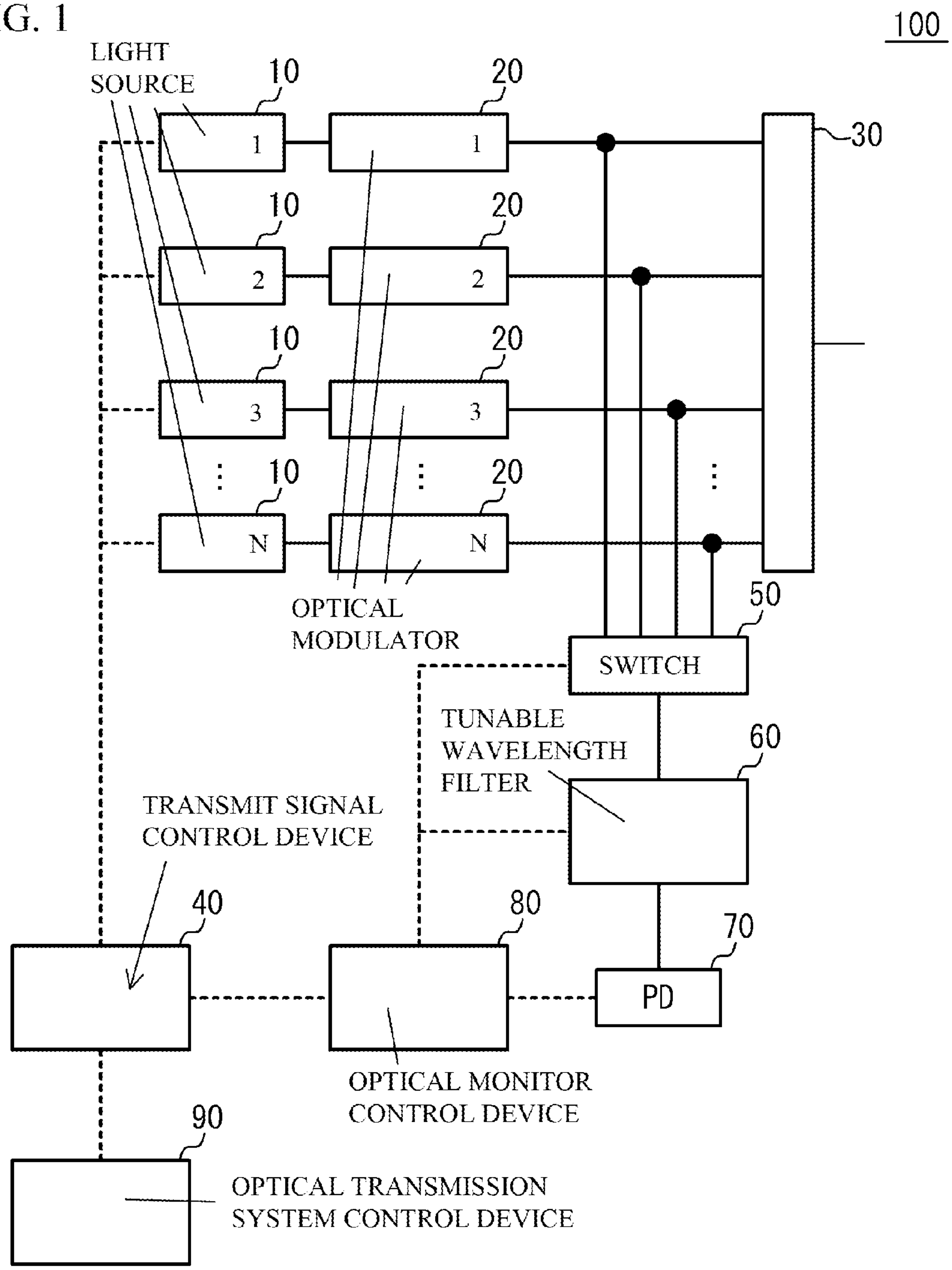


FIG. 1


100
LIGHT SOURCE
10
20
1
2
3
N
30
OPTICAL MODULATOR
50
SWITCH
TUNABLE WAVELENGTH FILTER
60
TRANSMIT SIGNAL CONTROL DEVICE
40
80
70
PD
OPTICAL MONITOR CONTROL DEVICE
90
OPTICAL TRANSMISSION SYSTEM CONTROL DEVICE

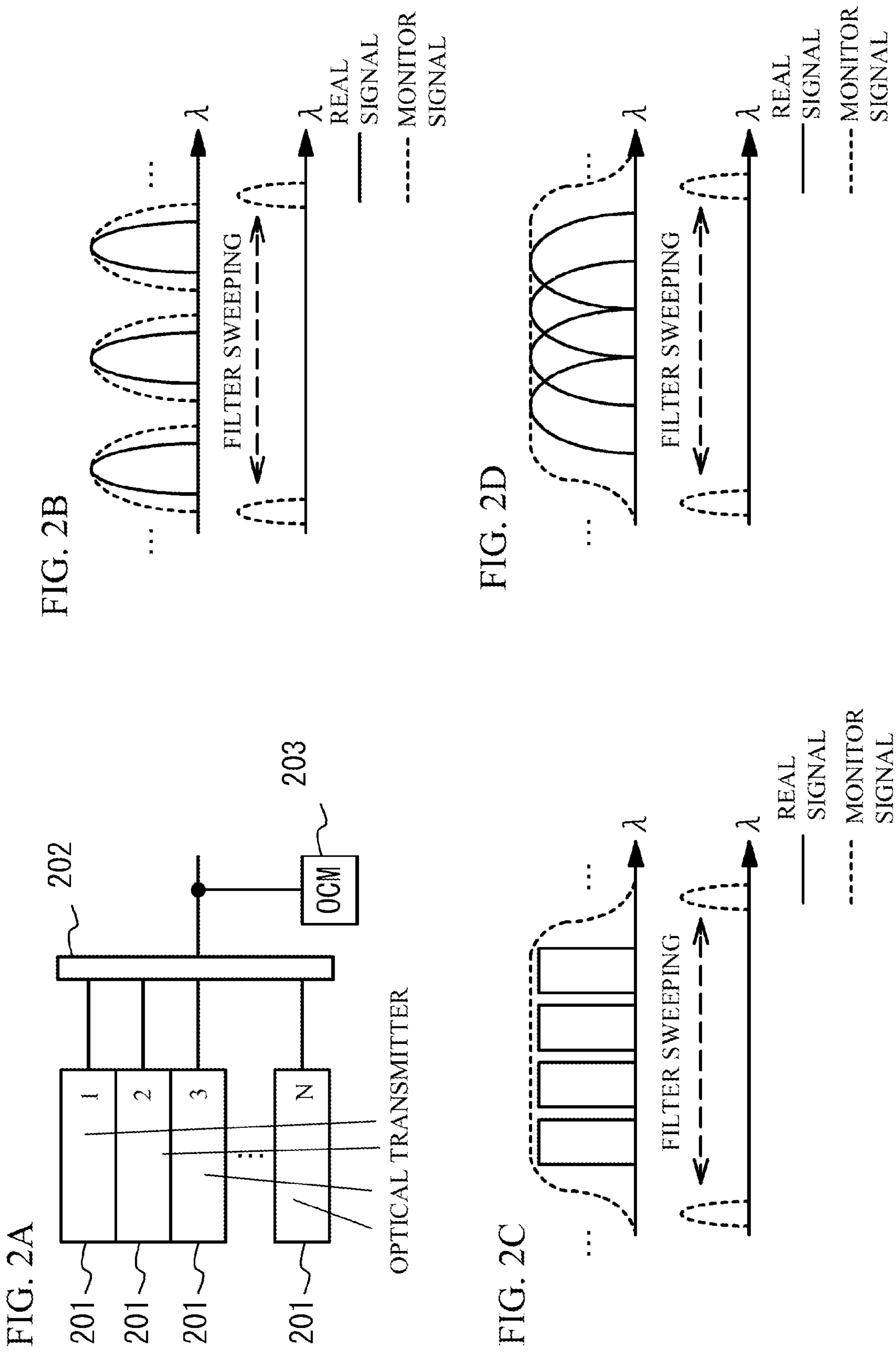


FIG. 2A
201
201
201
201
1
2
3
N
OPTICAL TRANSMITTER
202
OCM
203
FIG. 2B
FILTER SWEEPING
λ
λ
REAL SIGNAL
MONITOR SIGNAL
FIG. 2C
FILTER SWEEPING
λ
λ
REAL SIGNAL
MONITOR SIGNAL
FIG. 2D
FILTER SWEEPING
λ
λ
REAL SIGNAL
MONITOR SIGNAL

FIG. 3D

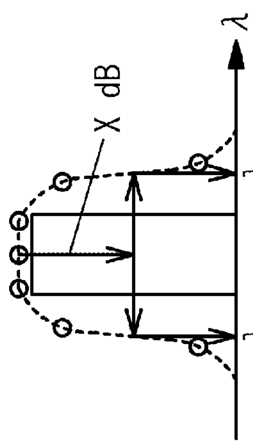


FIG. 3A

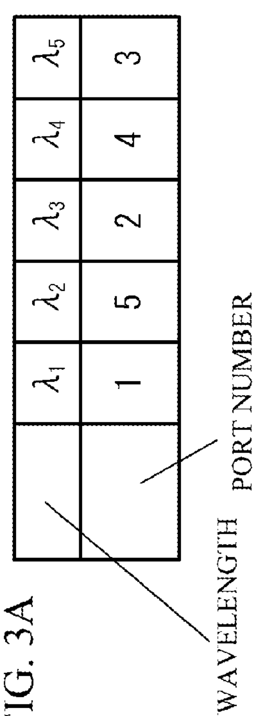


FIG. 3B

FIRST SWEEPING

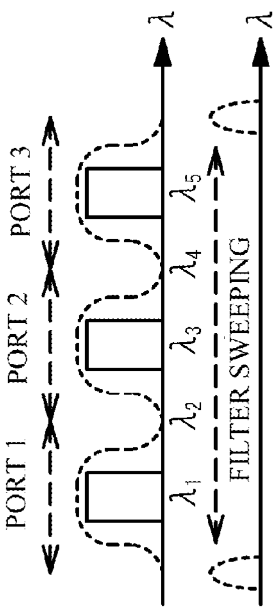


FIG. 3C

SECOND SWEEPING

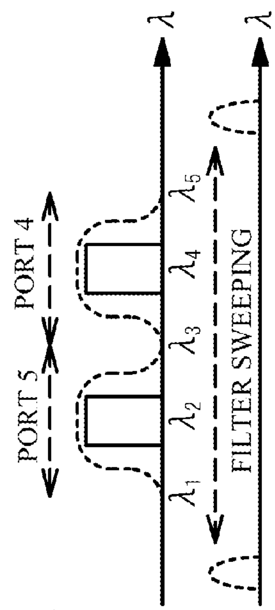


FIG. 4

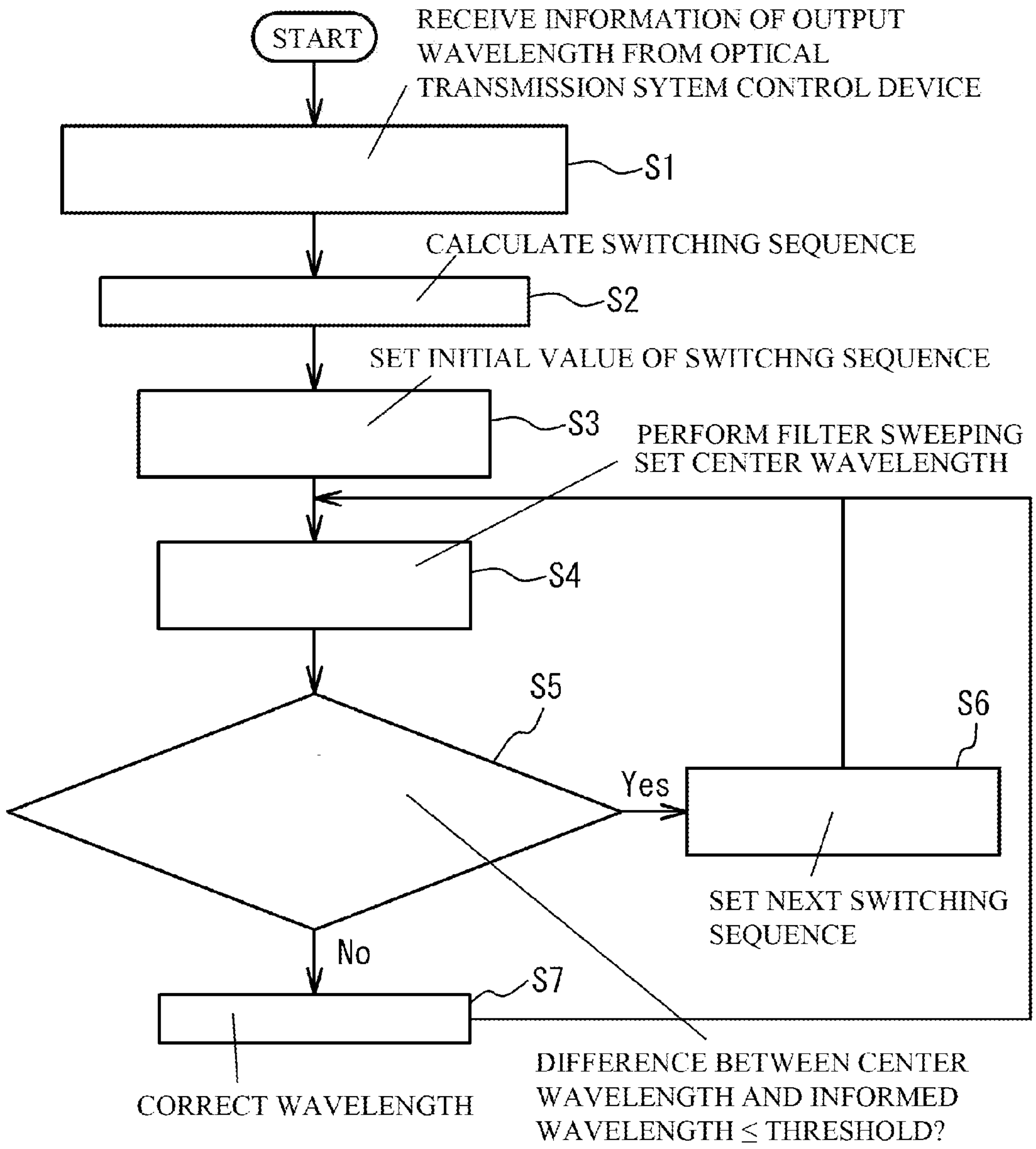

START
RECEIVE INFORMATION OF OUTPUT WAVELENGTH FROM OPTICAL TRANSMISSION SYTEM CONTROL DEVICE
S1
CALCULATE SWITCHING SEQUENCE
S2
SET INITIAL VALUE OF SWITCHNG SEQUENCE
S3
PERFORM FILTER SWEEPING SET CENTER WAVELENGTH
S4
S5
Yes
S6
SET NEXT SWITCHING SEQUENCE
No
S7
CORRECT WAVELENGTH
DIFFERENCE BETWEEN CENTER WAVELENGTH AND INFORMED WAVELENGTH ≤ THRESHOLD?

FIG. 5

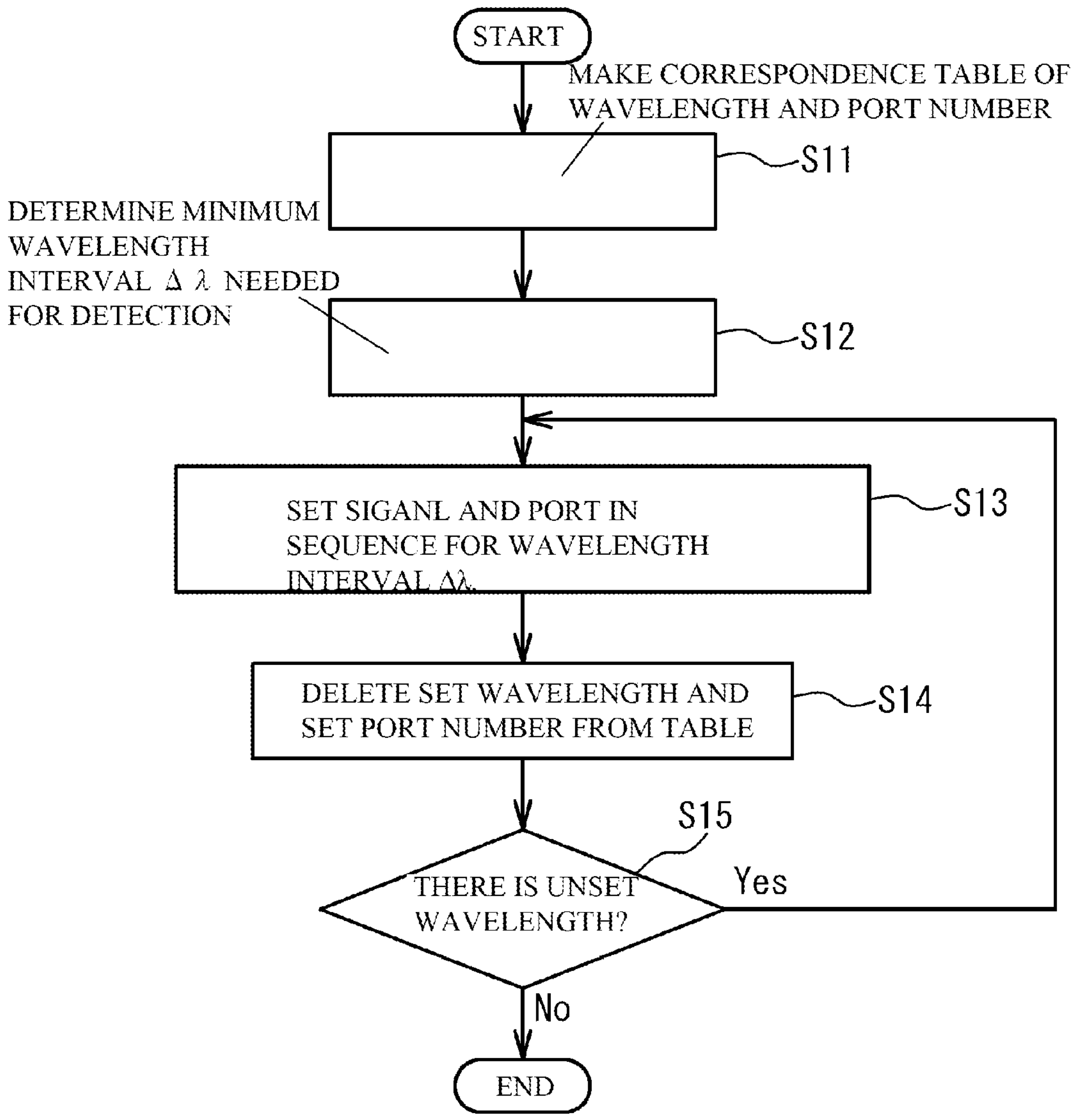

START
MAKE CORRESPONDENCE TABLE OF WAVELENGTH AND PORT NUMBER
S11
DETERMINE MINIMUM WAVELENGTH INTERVAL Δ λ NEEDED FOR DETECTION
S12
SET SIGANL AND PORT IN SEQUENCE FOR WAVELENGTH INTERVAL Δλ.
S13
DELETE SET WAVELENGTH AND SET PORT NUMBER FROM TABLE
S14
S15
THERE IS UNSET WAVELENGTH?
Yes
No
END

FIG. 6A

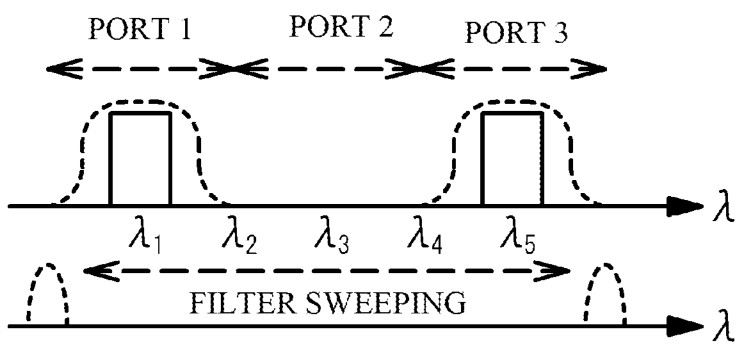
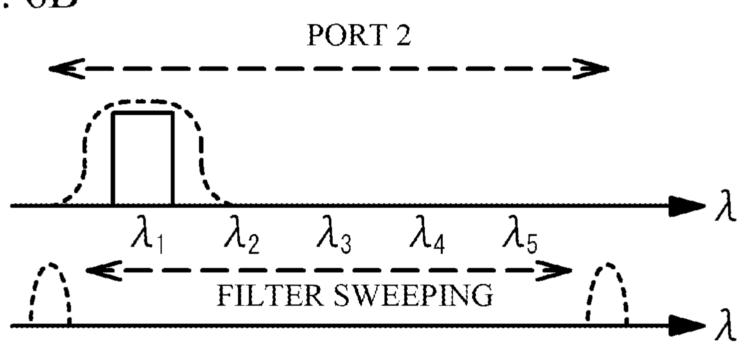

PORT 1
PORT 2
PORT 3
λ
λ1
λ2
λ3
λ4
λ5
FILTER SWEEPING
λ

FIG. 6B


PORT 2
λ
λ1
λ2
λ3
λ4
λ5
FILTER SWEEPING
λ

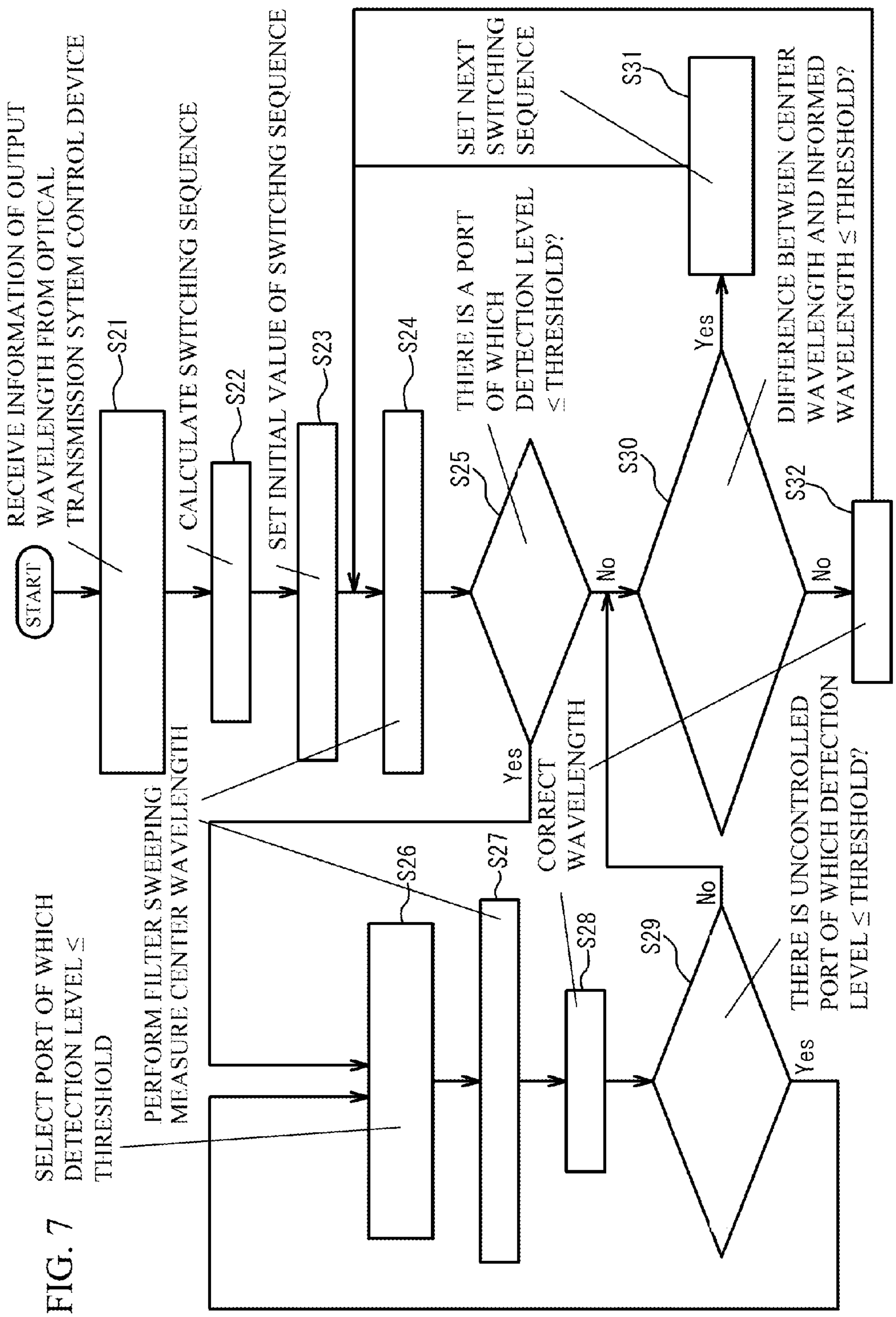

START
RECEIVE INFORMATION OF OUTPUT WAVELENGTH FROM OPTICAL TRANSMISSION SYTEM CONTROL DEVICE
S21
CALCULATE SWITCHING SEQUENCE
S22
SET INITIAL VALUE OF SWITCHING SEQUENCE
S23
PERFORM FILTER SWEEPING
S24
THERE IS A PORT OF WHICH DETECTION LEVEL ≤ THRESHOLD?
S25
Yes
No
SELECT PORT OF WHICH DETECTION LEVEL ≤ THRESHOLD
S26
MEASURE CENTER WAVELENGTH
S27
CORRECT WAVELENGTH
S28
THERE IS UNCONTROLLED PORT OF WHICH DETECTION LEVEL ≤ THRESHOLD?
S29
Yes
No
DIFFERENCE BETWEEN CENTER WAVELENGTH AND INFORMED WAVELENGTH ≤ THRESHOLD?
S30
Yes
No
SET NEXT SWITCHING SEQUENCE
S31
S32

FIG. 7

FIG. 8

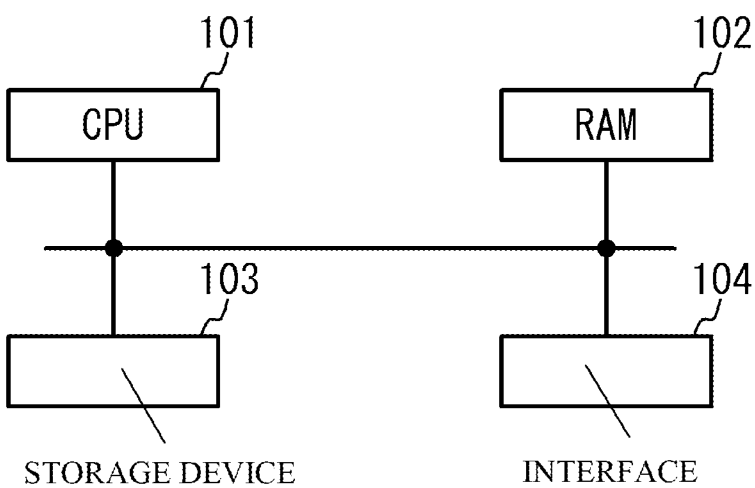


FIG. 9

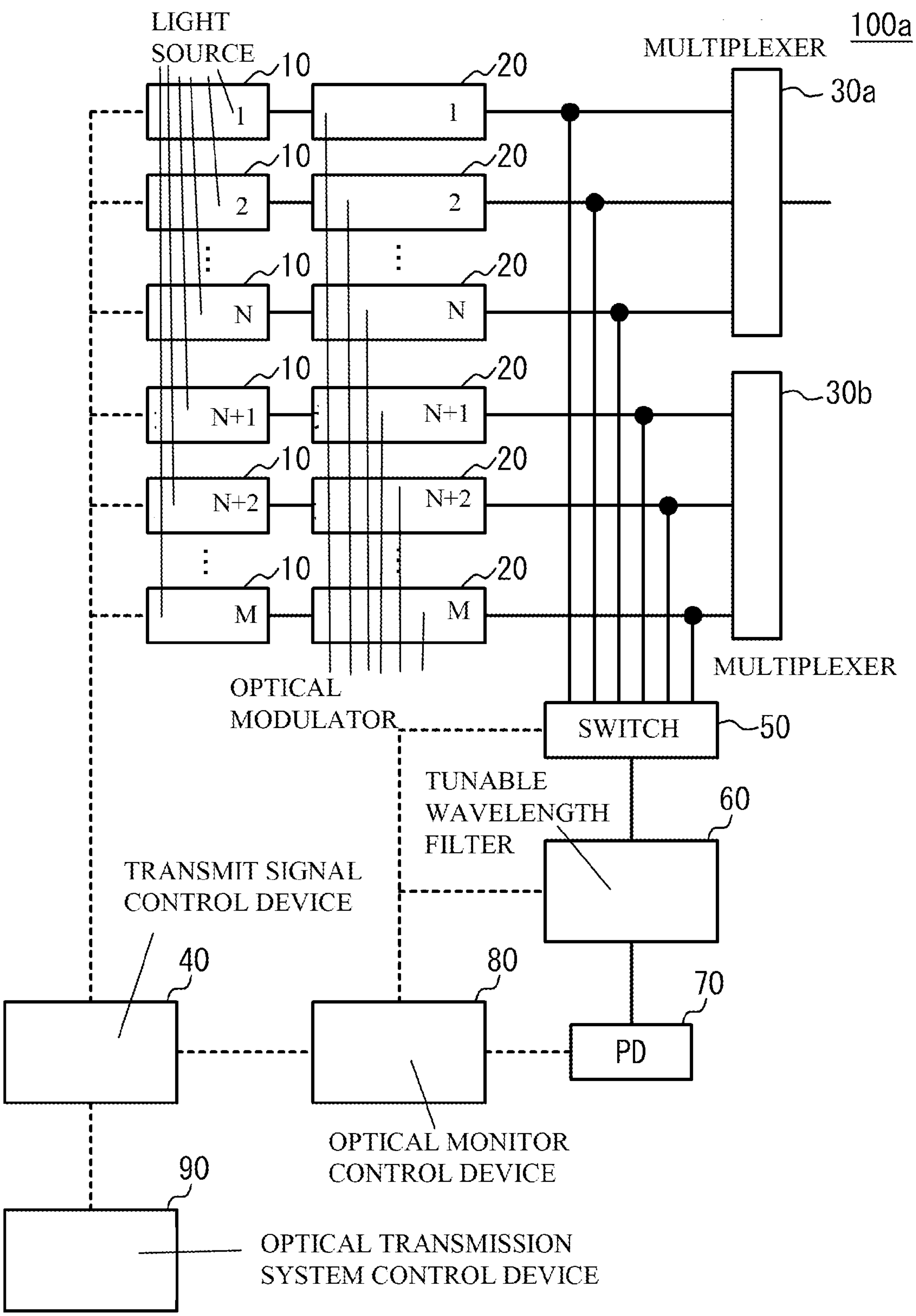

100a
LIGHT SOURCE
10
20
1
2
N
N+1
N+2
M
MULTIPLEXER
30a
30b
MULTIPLEXER
OPTICAL MODULATOR
SWITCH
50
TUNABLE WAVELENGTH FILTER
60
TRANSMIT SIGNAL CONTROL DEVICE
40
80
70
PD
OPTICAL MONITOR CONTROL DEVICE
90
OPTICAL TRANSMISSION SYSTEM CONTROL DEVICE

FIG. 10

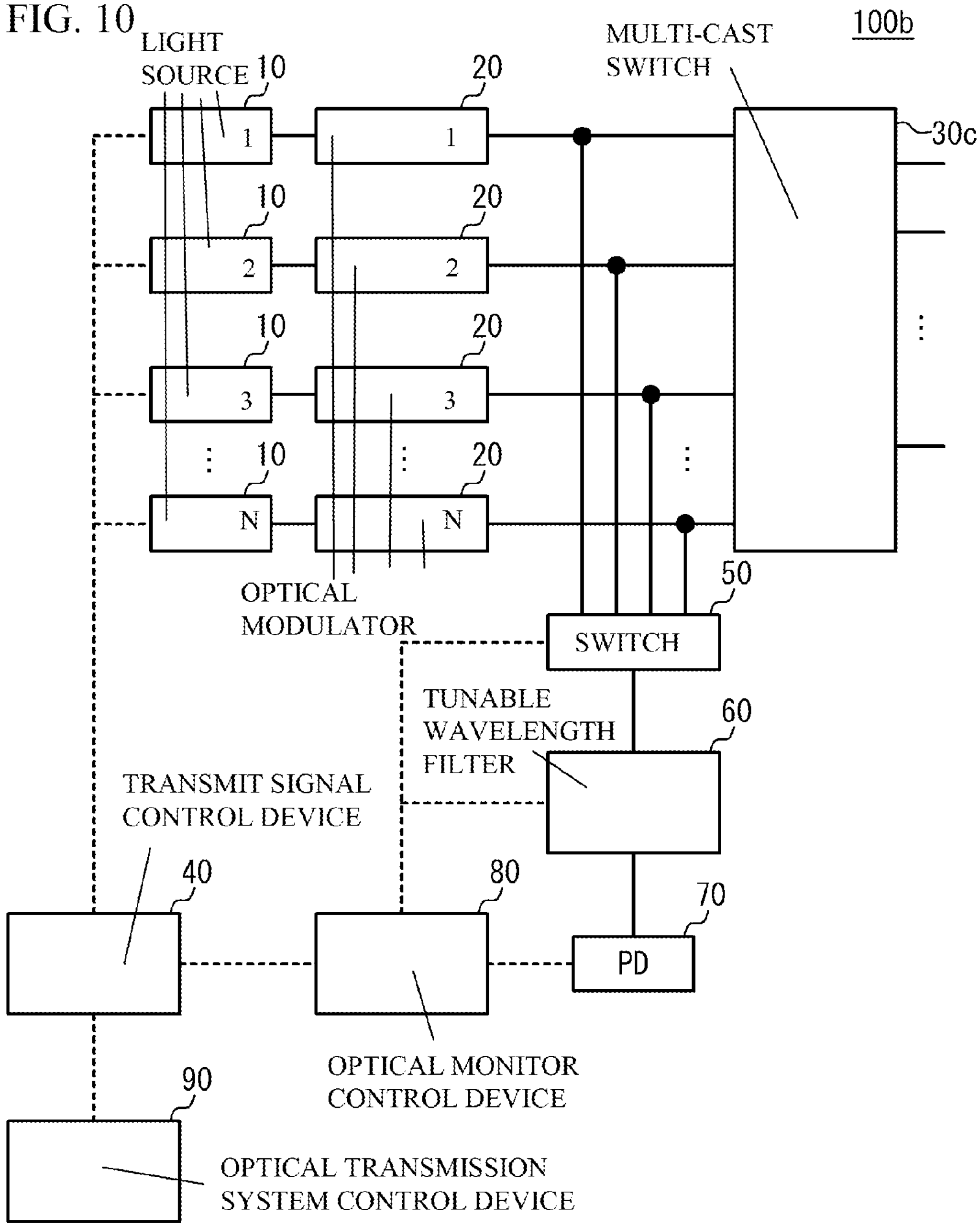

100b
LIGHT SOURCE
10
1
2
3
N
20
OPTICAL MODULATOR
MULTI-CAST SWITCH
30c
50
SWITCH
TUNABLE WAVELENGTH FILTER
60
70
PD
TRANSMIT SIGNAL CONTROL DEVICE
40
80
OPTICAL MONITOR CONTROL DEVICE
90
OPTICAL TRANSMISSION SYSTEM CONTROL DEVICE

FIG. 11A

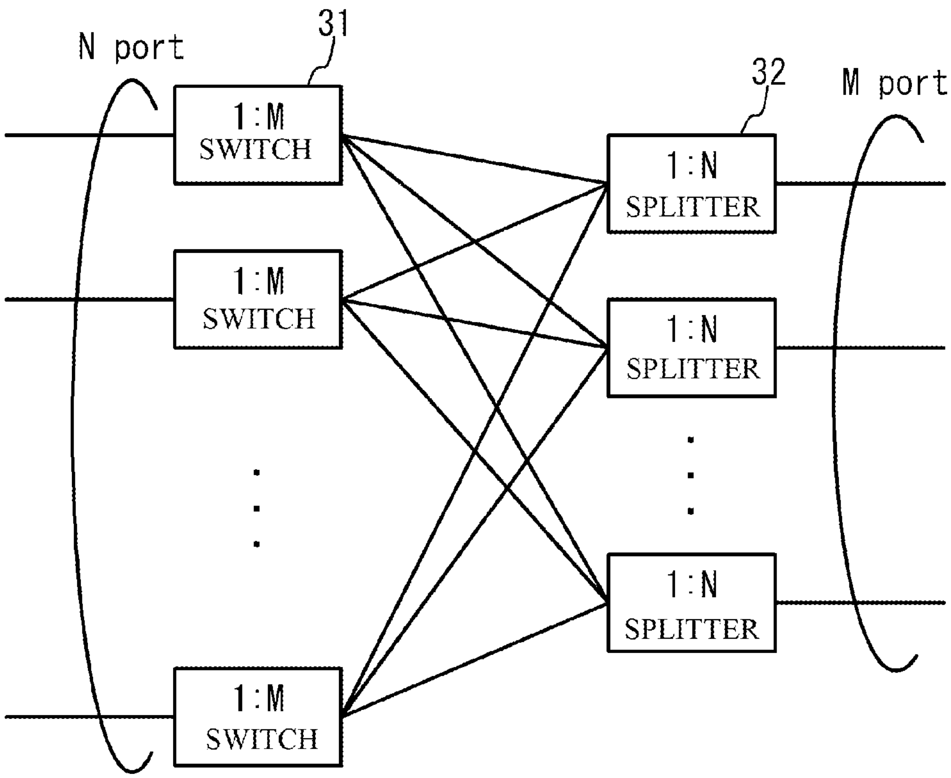


FIG. 11B

WAVALENGTH

	λ_1	λ_2	λ_3	λ_4	λ_5	λ_5
	1	5	2	4	3	6

PORT NUMBER

OPTICAL TRANSMISSION SYSTEM, METHOD OF TESTING OPTICAL TRANSMISSION SYSTEM, AND NON-TRANSITORY COMPUTER-READABLE MEDIUM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2012-226920, filed on Oct. 12, 2012, the entire contents of which are incorporated herein by reference.

FIELD

[0002] A certain aspect of embodiments described herein relates to an optical transmission system, a method of testing an optical transmission system, and a program of testing an optical transmission system.

BACKGROUND

[0003] Japanese Patent Application Publication No. 2008-84923 discloses a technology in which an OCM (Optical Channel Monitor) monitors each signal wavelength obtained when a WDM (Wavelength Division Multiplexing) light passes through a tunable wavelength filter.

SUMMARY

[0004] According to an aspect of the present invention, there is provided an optical transmission system including: an optical transmission device that has a plurality of optical transmitters configured to output at least one different wavelength and a multiplexer configured to multiplex wavelength lights output by the plurality of optical transmitters and output a multiplexed wavelength light; and a detection unit configured to detect each wavelength light that is branched before being fed into the multiplexer by sweeping an objective wavelength for detection, wherein, in a single sweeping, the detection unit selects and detects two or more wavelength lights with a wavelength interval that is wider than a wavelength interval of an output light of the multiplexer.

BRIEF DESCRIPTION OF DRAWINGS

[0005] FIG. **1** illustrates a block diagram of a main structure of an optical transmission device in accordance with a first embodiment;

[0006] FIG. **2**A illustrates a general WDM transmission device;

[0007] FIG. **2**B illustrates a monitor signal obtained by a filter sweeping;

[0008] FIG. **2**C illustrates a filter sweeping with respect to a sub-channel signal obtained by Nyquist-WDM technology;

[0009] FIG. **2**D illustrates a filer sweeping with respect to a sub-channel signal obtained by OFDM technology;

[0010] FIG. **3**A illustrates a correspondence table for describing a relation between a port number and each channel of a switch;

[0011] FIG. **3**B and FIG. **3**C illustrate a filter sweeping;

[0012] FIG. **3**D illustrates a concrete example of wavelength detection of each wavelength light;

[0013] FIG. **4** illustrates a flowchart for describing an operation of an optical monitor control device;

[0014] FIG. **5** illustrates a flowchart for describing a calculation of a sequence;

[0015] FIG. **6**A illustrates a case where a light source for outputting a wavelength light to a port **2** wrongly outputs a wavelength light of a wavelength Xl;

[0016] FIG. **6**B illustrates a filter sweeping;

[0017] FIG. **7** illustrates another example of a flowchart describing an operation of an optical monitor control device;

[0018] FIG. **8** illustrates a block diagram of a hardware structure of an optical monitor control device;

[0019] FIG. **9** illustrates a block diagram of a main structure of another optical transmission system;

[0020] FIG. **10** illustrates a block diagram of a main structure of another optical transmission system;

[0021] FIG. **11**A illustrates a block diagram for describing details of a multi-cast switch; and

[0022] FIG. **11**B illustrates a correspondence table for describing a relation between a port number of a switch and each channel.

DESCRIPTION OF EMBODIMENTS

[0023] It is difficult for a conventional OCM to perform a sufficient resolution capability with respect to a wavelength-multiplexed light of an OFDM (Orthogonal Frequency Division Multiplexing) technology, a Nyquist WDM technology or the like because of a filter width.

[0024] The following is a description of embodiments, with reference to the accompanying drawings.

[0025] FIG. **1** illustrates a block diagram of a main structure of an optical transmission system **100** in accordance with an embodiment. The optical transmission system **100** multiplexes wavelength lights of N channels and transmits the multiplexed wavelength lights. As illustrated in FIG. **1**, the optical transmission system **100** has a light source **10**, an optical modulator **20**, a multiplexer **30**, a transmit-signal control device **40**, a switch **50**, a tunable wavelength filter **60**, a light-receiving element **70**, an optical monitor control device **80** and an optical transmission system control device **90**.

[0026] In the optical transmission system **100**, the light source **10** and the optical modulator **20** are provided according to each channel. That is, the optical transmission system **100** has N sets of the light sources **10** and the optical modulators **20**. The light source **10** and the optical modulator **20** act as an optical transmitter. The light source **10** is a device for outputting a wavelength light of a single wavelength such as a semiconductor laser. The light source **10** outputs a different wavelength light in accordance with the channel. The optical modulator **20** is a device for modulating a wavelength light output by the light source **10** and outputting the modulation signal. The multiplexer **30** multiplexes modulation signals output by the optical modulators **20** and transmits the wavelength-multiplexed signal to a light-receiver. The light source **10**, the optical modulator **20** and the multiplexer **30** act as an optical transmission device.

[0027] The transmit-signal control device **40** is a device for controlling an optical signal transmitted from each of the light sources **10**. For example, the transmit-signal control device **40** controls on/off of each of the light sources **10**.

[0028] The transmit-signal control device **40** controls a wavelength, an optical intensity and so on of the optical signal transmitted from each of the light sources **10**.

[0029] A part of the modulation signal fed into the multiplexer **30** from the optical modulator **20** is branched into the switch **50**. A beam splitter or the like is used for branching the modulation signal. The switch **50** is capable of an N:1switching, selects a channel from the N channels and inputs a modulation signal of the selected channel into the tunable wavelength filter **60**. That is, the switch **50** switches a wavelength by a wavelength light and input the selected wavelength light into the tunable wavelength filter **60**. The switch **50** switches the channel in accordance with an instruction of the optical monitor control device **80**.

[0030] The tunable wavelength filter **60** is a wavelength filter of which transparent wavelength fluctuates in accordance with an electrical signal input thereinto, and has a band width for selectively transmitting each wavelength signal branched before being input into the multiplexer **30**. The tunable wavelength filter **60** changes the transparent wavelength in accordance with an instruction of the optical monitor control device **80**. The light-receiving element **70** converts an optical intensity of a light having passes through the tunable wavelength filter **60** into an electrical signal and inputs the electrical signal into the optical monitor control device **80**.

[0031] The optical monitor control device **80** is a device for detecting a wavelength characteristic of the wavelength light of each channel. The optical transmission system control device **90** is a device for performing an overall control of the optical transmission system **100**. For example, the optical monitor control device **80** detects a wavelength of the wavelength light of each channel and tests whether a desired wavelength instructed by the optical transmission system control device **90** is output. The optical monitor control device **80** detects an optical intensity of the wavelength light of each channel, and tests whether a desired optical intensity instructed by the optical transmission system control device **90** is achieved.

[0032] The optical monitor control device **80** controls a switching of the switch **50**, controls the transparent wavelength of the tunable wavelength filter **60**, and detects the wavelength light of each channel by receiving an electrical signal from the light-receiving element **70**. In concrete, the optical monitor control device **80** controls the switch **50** so that a modulation signal of a predetermined channel is input into the tunable wavelength filter **60**, controls the transparent wavelength of the tunable wavelength filter **60** to the wavelength of the predetermined channel in synchronization with the switching of the switch **50**, and receives an electrical signal from the light-receiving element **70**. It is therefore possible to detect the wavelength light of the predetermined channel separately. For example, the optical monitor control device **80** detects the wavelength light of each channel (filter sweeping) by sweeping a wavelength for detection from a shorter wavelength side to a longer wavelength side or from a longer wavelength side to a shorter wavelength side so that the wavelength range of each channel is covered. In the embodiment, the switch **50**, the tunable wavelength filter **60**, the light-receiving element **70** and the optical monitor control device **80** act as an OCM (Optical Channel Monitor) that detects each wavelength light branched before being fed into the multiplexer **30**.

[0033] A description will be given of the filter sweeping. FIG. **2**A illustrates an ordinal WDM transmission device **200**. An optical transmitter **201** is a light source and an optical modulator. A multiplexer **202** multiplexes modulation lights output by each of the optical transmitters **201**. An OCM **203** is a tunable wavelength filter, a light-receiving element and a monitor device.

[0034] FIG. **2**B illustrates a monitor signal obtained by the filter sweeping. In FIG. **2**B, a horizontal axis indicates a wavelength, and a vertical axis indicates an optical intensity. As illustrated in FIG. **2**B, a spectrum of each wavelength light can be detected as a monitor signal, when the OCM **203** sweeps a transparent wavelength of the tunable wavelength filter from a shorter wavelength side to a longer wavelength side or from a longer wavelength side to a shorter wavelength side.

[0035] There is a limitation to a wavelength resolution capability of the OCM **203**. Therefore, a spectrum width of a monitor signal detected with use of the light-receiving element tends to be wider than a spectrum width of a real signal.

[0036] However, in an ordinal WDM, a wavelength interval of each wavelength light is set to be wide. Therefore, an overlapping between spectrums of monitor signals detected with respect to each wavelength light is suppressed. It is therefore possible to detect each wavelength light with high accuracy.

[0037] FIG. **2**C illustrates a filter sweeping with respect to a sub channel signal (wavelength light) obtained by using Nyquist-WDM technology. In FIG. **2**C, a horizontal axis indicates a wavelength, and a vertical axis indicates an optical intensity. As illustrated in FIG. **2**C, in the Nyquist-WDM technology, a wavelength interval of each wavelength light is narrow. When a cross talk occurs between adjacent channels, a single spectrum is detected as a monitor signal with respect to a plurality of wavelength lights. In this case, a spectrum width of the monitor signal gets larger. Thus, detection accuracy of a wavelength (for example, a center wavelength) of each wavelength light is degraded. That is, it may be difficult to detect each wavelength light with high accuracy.

[0038] FIG. **2**D illustrates a filter sweeping with respect to a sub channel signal (wavelength light) obtained by using OFDM technology. In FIG. **2**D, a horizontal axis indicates a wavelength, and a vertical axis indicates an optical intensity. As illustrated in FIG. **2**D, in the OFDM technology, a wavelength interval of each wavelength light is narrow. And each spectrum of a real signal is partially overlapped with each other. When a cross talk occurs between adjacent channels, a single spectrum is detected as a monitor signal with respect to a plurality of wavelength lights. In this case, a spectrum width of the monitor signal gets larger. Thus, detection accuracy of a wavelength (for example, a center wavelength) of each wavelength light is degraded. That is, it may be difficult to detect each wavelength light with high accuracy.

[0039] In contrast, the optical transmission system **100** in accordance with the embodiment secures a resolution capability by detecting a wavelength light of each channel with a wavelength interval that is wider than a wavelength interval of a wavelength-multiplexed light obtained in the multiplexer **30** in a single filter sweeping. A description will be given of the details.

[0040] FIG. **3**A illustrates a correspondence table for describing a relation between a port number of the switch **50** and each channel. An example of FIG. **3**A includes a relation between the port number of the switch **50** and a wavelength of a wavelength light fed into each port. In order to simplify an explanation, a description will be given of a relation between port numbers 1 to 5 and wavelengths λ1 to λ5. The wavelengths λ1 to λ5 correspond to channels that are adjacent to each other. The larger the wavelength number is, the longer the wavelength is.

[0041] The optical monitor control device **80** selects at least two channels with a wavelength interval that is wider than a wavelength interval of a wavelength-multiplexed light in a first filter sweeping. In other words, the optical monitor control device **80** selects at least two channels so that selected wavelengths are not next to each other. For example, the optical monitor control device **80** selects the wavelength λ1, the wavelength λ3 and the wavelength λ5. The optical monitor control device **80** sets port numbers corresponding to the selected channels in a first sequence. The sequence corresponds to a switching order and a switching time of the switch **50**. Next, the optical monitor control device **80** selects at least two channels with a wavelength interval that is wider than the wavelength interval of the wavelength-multiplexed light in a second filter sweeping. For example, the optical monitor control device **80** selects the wavelength λ2 and the wavelength λ4. The optical monitor control device **80** sets port numbers corresponding to the selected channels in a second sequence. Similarly, the optical monitor control device **80** selects channels in accordance with a third sweeping or later and sets port numbers corresponding to the selected channels in a third sequence or later until all channels are selected.

[0042] Next, the optical monitor control device **80** controls the switch **50** in accordance with an obtained sequence. In concrete, as illustrated in FIG. 3B, in the first filter sweeping, the switch **50** selects a port 1 when the transparent wavelength of the tunable wavelength filter **60** is the wavelength λ1, the switch **50** selects a port 2 when the transparent wavelength of the tunable wavelength filter **60** is the wavelength λ3, and the switch **50** selects a port 3 when the transparent wavelength of the tunable wavelength filter **60** is the wavelength λ5. Thus, in the first filter sweeping, the wavelength lights of the wavelengths λ1, λ3, and λ5 can be detected.

[0043] Next, as illustrated in FIG. 3C, in the second filter sweeping, the switch **50** selects a port 5 when the transparent wavelength of the tunable wavelength filter **60** is the wavelength λ2, and the switch **50** selects a port 4 when the transparent wavelength of the tunable wavelength filter **60** is the wavelength λ4. Thus, in the second filter sweeping, the wavelength lights of the wavelengths λ2 and λ4 can be detected. In this way, the wavelength interval of detected wavelengths gets larger, compared to a case where the wavelengths λ1 to λ5 are detected in a single filter sweeping. Thus, the resolution capability during detecting each wavelength light can be secured.

[0044] FIG. 3D illustrates a concrete example of a wavelength detection of each wavelength light. As illustrated in FIG. 3D, the optical monitor control device **80** uses a maximum level value of the detected optical intensity and two points before and after the optical intensity and calculates a peak level of the wavelength lights with use of a quadratic function fitting or the like. Next, the optical monitor control device **80** obtains a longer side wavelength (λ2 in FIG. 3D) and a shorter side wavelength (λ1 in FIG. 3D) of which levels are reduced by a predetermined value (X dB in FIG. 3D) from the calculated peak level. The optical monitor control device **80** calculates a center wavelength $\lambda c=0.5(\lambda 1+\lambda 2)$ that is a center between the wavelength λ1 and the wavelength λ2. The optical monitor control device **80** detects the center wavelength λc as a wavelength of a wavelength light. The wavelength detection is not limited to the example of FIG. 3D. For example, a wavelength of a maximum level value may be detected as the wavelength of the wavelength light.

[0045] The optical monitor control device **80** instructs the transmit-signal control device **40** to correct an output wavelength of the light source **10** of the channel, when there is a difference between the detected wavelength and a wavelength received from the optical transmission system control device **90**. The optical monitor control device **80** instructs the transmit-signal control device **40** to correct an output optical intensity of the light source **10** of the channel, when there is a difference between an optical intensity at the detected wavelength and an optical intensity received from the optical transmission system control device **90**. The optical monitor control device **80** may instruct correcting of another parameter. The optical monitor control device **80** and the transmit-signal control device **40** act as a correct unit.

[0046] FIG. **4** illustrates a flowchart for describing an example of an operation of the optical monitor control device **80**. As illustrated in FIG. **4**, the optical monitor control device **80** receives information of an output wavelength of each channel from the optical transmission system control device **90** (Step S**1**). Next, the optical monitor control device **80** calculates a sequence for switching (Step S**2**). The optical monitor control device **80** calculates a sequence in accordance with a flowchart of FIG. **5**, as an example.

[0047] As illustrated in FIG. **5**, the optical monitor control device **80** makes a correspondence table of a wavelength of a wavelength light of each channel and a port number of the switch **50** (Step S**11**). Next, the optical monitor control device **80** determines a minimum wavelength interval Δλ that is necessary for detection of a wavelength light (Step S**12**). The minimum wavelength interval Δλ may be determined in accordance with a band width of the tunable wavelength filter **60**, a spectrum width of each wavelength light and so on.

[0048] Next, the optical monitor control device **80** selects two or more channels from a shorter wavelength side (or longer wavelength side) so that a wavelength interval is Δλ or more and sets the selected channels in a sequence (Step S**13**). Next, the optical monitor control device **80** deletes the set wavelength the set port number from the correspondence table (Step S**14**). Next, the optical monitor control device **80** determines whether there is a wavelength that is not set (Step S**15**). When it is determined as "Yes" in the Step S**15**, the Step S**13** is executed again. When it is determined as "No" in the Step S**15**, the flowchart of FIG. **5** is terminated.

[0049] With reference to FIG. **4** again, after termination of the flowchart of FIG. **5**, the optical monitor control device **80** sets an initial value of the sequence (Step S**3**). Next, the optical monitor control device **80** performs the sequence in which the initial value is set in synchronization with the filter sweeping, and measures a center wavelength of each detected wavelength light (Step S**4**). Next, the optical monitor control device **80** determines whether a difference between the measured center wavelength and a wavelength received from the optical transmission system control device **90** is equal to a threshold or less (Step S**5**). When it is determined as "Yes" in the Step S**5**, the optical monitor control device **80** sets a next sequence (Step S**6**). After that, the Step S**4** is executed again. When it is determined as "No" in the Step S**5**, the transmit-signal control device **40** corrects a center wavelength of the light source **10** of the channel where it is determined that the difference is equal to the threshold or more to the wavelength received from the optical transmission system control device **90** (Step S**7**). After that, the Step S**4** is executed again. The flowchart of FIG. **4** is terminated when all sequences are executed.

[0050] In accordance with the embodiment, in a single filter sweeping, it is possible to select and detect a wavelength light with a wavelength interval that is wider than a wavelength interval of the wavelength-multiplexed light obtained in the multiplexer **30**. It is therefore possible to secure a resolution capability with respect to a wavelength light of the optical monitor control device **80**. Accordingly, each wavelength light can be detected with high accuracy. It is thought that only one wavelength light is detected in a single filter sweeping. However, in this case, it is necessary to perform N filter sweepings in an optical transmission device of N channels. In contrast, in the embodiment, wavelength lights of at least two channels are an objective in a single filter sweeping. Therefore, increasing of a number of the filter sweeping can be suppressed. In accordance with the embodiment, the increasing of the number of the filter sweeping can be suppressed, and each wavelength light can be detected with high accuracy.

[0051] It is not necessary that wavelength lights of two or more channels are an objective in all filter sweepings. Two or more wavelength lights have only to be an objective in at least one filter sweeping. For example, the wavelength λ1 and the wavelength λ3 may be an objective in the first filter sweeping, the wavelength λ2 and the wavelength λ4 may be an objective in the second filter sweeping and the wavelength λ5 may be an objective in the third filter sweeping. In this case, the number of the filter sweeping can be reduced, compared to a case where only a single wavelength light is detected in each filter sweeping.

[0052] It is not necessary that a wavelength interval between all wavelength lights is widened. The detection accuracy of a wavelength light can be improved when a wavelength interval of at least two wavelength lights is widened. For example, with respect to the wavelengths λ1 to λ5, when a wavelength interval between the wavelength λ4 and the wavelength λ5 is equal to the above-mentioned minimum wavelength interval Δλ or more, the wavelength λ4 and the wavelength λ5 may be an objective in a single filter sweeping. For example, the wavelength λ1 and the wavelength λ3 may be an objective in the first filter sweeping, the wavelength λ2, the wavelength λ4 and the wavelength λ5 may be an objective in the second filter sweeping.

[0053] Next, a description will be given of a case where wavelength lights of an identical wavelength are output in a plurality of channels. FIG. **6**A illustrates an example where the light source **10** outputting a wavelength light to the port 2 wrongly outputs a wavelength light of the wavelength λ1. As illustrated in FIG. **6**A, when the wavelength λ1, the wavelength λ3 and the wavelength λ5 are an objective in a filter sweeping, the wavelength λ3 is not detected or a detected optical intensity of the wavelength λ3 gets smaller. In this case, the optical monitor control device **80** controls the switch **50** to keep selecting the port 2, and performs a filter sweeping, as illustrated in FIG. **6**B. Thus, the wavelength of the wavelength light fed into the port 2 can be detected. In the example of FIG. **6**B, the wavelength light of the wavelength λ1 is detected.

[0054] FIG. **7** illustrates another example of a flowchart describing the operation of the optical monitor control device **80**. As illustrated in FIG. **7**, Steps S**21** to S**24** are the same as the Steps S**1** to S**4** of FIG. **4**. After executing the Step S**24**, the optical monitor control device **80** determines whether there is a port of which detected level is equal to a threshold or less (Step S**25**). When it is determined as "Yes" in the Step S**25**, the optical monitor control device **80** switches a port of the switch **50** to another port of which detected level is equal to the threshold or less (Step S**26**).

[0055] Next, the optical monitor control device **80** performs a filter sweeping and measures a center wavelength of the detected wavelength light (Step S**27**). Next, the optical monitor control device **80** corrects a center wavelength of the light source **10** of the channel of which detected level is equal to the threshold or less to the wavelength received from the optical transmission system control device **90** (Step S**28**). Next, the optical monitor control device **80** determines whether there is an uncontrolled port of which detected level is equal to the threshold or less (Step S**29**). The uncontrolled port is a port where the Steps S**26** to S**28** are not executed. When it is determined as "Yes" in the Step S**29**, the Step S**26** is executed again. When it is determined as "No" in the Step S**29**, the optical monitor control device **80** executes Steps S**30** to S**32** that are the same as the Steps S**5** to S**7** of FIG. **4**. The flowchart of FIG. **7** is terminated when all sequences are executed.

[0056] When ports of which detected level is equal to a threshold or less is selected and a filter sweeping is performed, an output wavelength of the port can be detected. It is therefore possible to correct the output wavelength to a desired wavelength.

[0057] FIG. **8** illustrates a block diagram for describing a hardware structure of the optical monitor control device **80**. As illustrated in FIG. **8**, the optical monitor control device **80** has a CPU **101**, a RAM **102**, a storage device **103**, an interface **104** and so on. These components are connected via a bus or the like. The CPU **101** is a Central Processing Unit. The CPU **101** includes one or more core. The RAM (Random Access Memory) **102** is a volatile memory for temporarily storing a program executed by the CPU **101**, a data processed by the CPU **101** and so on. The storage device **103** is non-volatile storage device. A ROM (Read Only Memory), a solid state drive (SSD) such as a flash memory, a hard disk driven by a hard disk drive or the like can be used as the storage device **103**. When the CPU **101** executes a predetermined program, the optical monitor control device **80** is realized in the optical transmission system **100**. The transmit-signal control device **40** and the optical transmission system control device **90** may be realized when the CPU **101** executes the program. The transmit-signal control device **40**, the optical monitor control device **80** and the optical transmission system control device **90** may be a hardware such as a dedicated circuit or the like.

[0058] FIG. **9** illustrates a block diagram of a main structure of another optical transmission system (an optical transmission system **100*a***). As illustrated in FIG. **9**, the optical transmission system **100*a*** has a plurality of multiplexers **30*a*** and **30*b***. The multiplexer **30*a*** multiplexes wavelength lights from the light sources **10** and the optical modulators **20** of channels 1 to N and transmits the wavelength-multiplexed light. The multiplexer **30*b*** multiplexes wavelength lights from the light sources **10** and the optical modulators **20** of channels N+1 to M and transmits the wavelength-multiplexed light. In this way, a plurality of multiplexers may be provided. In a single filter sweeping, the optical transmission system **100*a*** can detect a wavelength light of each channel with a wavelength interval that is wider than a wavelength interval of the wavelength-multiplexed light obtained in the multiplexers **30*a*** and **30*b***.

[0059] FIG. **10** illustrates a block diagram of a main structure of another optical transmission system (an optical transmission system **100*b***). As illustrated in FIG. **10**, the optical transmission system **100***b* is different from the optical transmission system **100** in a point that a multi-cast switch **30***c* is provided instead of the multiplexer **30**.

[0060] FIG. **11**A illustrates a block diagram for describing details of the multi-cast switch **30***c*. As illustrated in FIG. **11**A, the multi-cast switch **30***c* has M output ports with respect to the N channels. The multi-cast switch **30***c* has N switches **31** of 1:M and M splitters **32** of 1:N. Each of the 1:M switches **31** are connected to each of the 1:N splitters **32**. Thus, each 1:N splitter **32** is capable of multiplexing wavelength lights of a desired combination and outputting the multiplexed lights. That is, the 1:N splitter **32** acts as a multiplexer. In this structure, it is not necessary that all of the light sources **10** of the N channels output a different wavelength. At least one of the light sources **10** has only to output a different wavelength.

[0061] FIG. **11**B illustrates a correspondence table for describing a relation between a port number of the switch **50** and each channel. In FIG. **11**B, a wavelength of the port 3 is the same as a wavelength of the port 6. In this example, port numbers 1, 2 and 3 have only to be selected in a first filter sweeping, port numbers 4 and 5 have only to be selected in a second filter sweeping, and a port number 6 has only to be selected in a third filter sweeping.

[0062] In the above-mentioned embodiment, the light source **10** is controlled when a wavelength of a wavelength light is corrected. However, the structure is not limited. For example, the wavelength may be corrected by controlling a carrier frequency of an optical signal output by the optical modulator **20**.

[0063] All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although the embodiments of the present invention have been described in detail, it should be understood that the various change, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. An optical transmission system comprising:

an optical transmission device that has a plurality of optical transmitters configured to output at least one different wavelength and a multiplexer configured to multiplex wavelength lights output by the plurality of optical transmitters and output a multiplexed wavelength light; and

a detection unit configured to detect each wavelength light that is branched before being fed into the multiplexer by sweeping an objective wavelength for detection,

wherein, in a single sweeping, the detection unit selects and detects two or more wavelength lights with a wavelength interval that is wider than a wavelength interval of an output light of the multiplexer.

2. The optical transmission system as claimed in claim **1**, wherein the detection unit comprises:

a switch configured to output each wavelength light branched before being fed into the multiplexer by a wavelength light;

a tunable wavelength filter configured to transmit each wavelength light output by the switch by tuning a transparent wavelength in synchronization with a switching of the switch; and

a light-receiving element configured to detect an optical intensity of each wavelength light having passed through the tunable wavelength filter.

3. The optical transmission system as claimed in claim **2**, wherein the detection unit sweeps an objective wavelength again with the switch selecting the wavelength light, when an optical intensity of the wavelength light selected in the sweeping is equal to a threshold or less.

4. The optical transmission system as claimed in claim **1** further comprising a correct unit configured to correct an output wavelength of the optical transmitter in accordance with a detection result of the detection unit.

5. A method of testing an optical transmission device that has a plurality of optical transmitters that output at least one different wavelength and a multiplexer configured to multiplex wavelength lights output by the plurality of optical transmitters and output a multiplexed wavelength light comprising

detecting each wavelength light that is branched before being fed into the multiplexer by sweeping an objective wavelength for detection,

wherein, in a single sweeping, two or more wavelength lights are selected and detected with a wavelength interval that is wider than a wavelength interval of an output light of the multiplexer.

6. A computer readable, non-transitory medium storing a program that causes a computer to execute a process in an optical transmission device that has a plurality of optical transmitters that output at least one different wavelength and a multiplexer configured to multiplex wavelength lights output by the plurality of optical transmitters and output a multiplexed wavelength light, the process comprising

detecting each wavelength light that is branched before being fed into the multiplexer by sweeping an objective wavelength for detection,

wherein, in a single sweeping, two or more wavelength lights are selected and detected with a wavelength interval that is wider than a wavelength interval of an output light of the multiplexer.

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