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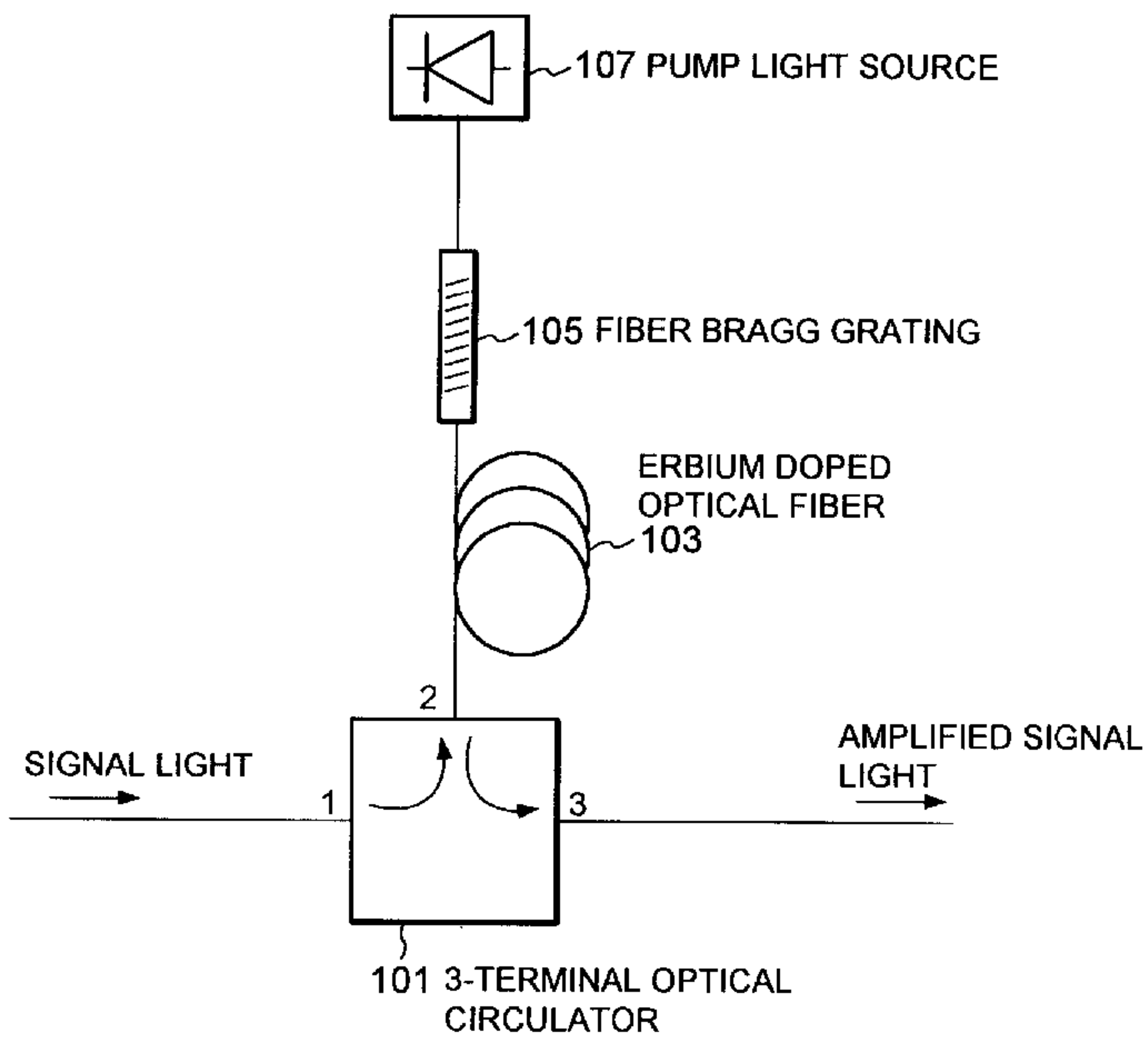
(54) **AMPLIFICATEUR A FIBRE OPTIQUE ET DISPOSITIF D'AMPLIFICATION OPTIQUE POUR TRANSMISSION OPTIQUE BIDIRECTIONNELLE AU MOYEN DE L'AMPLIFICATEUR**

(54) **OPTICAL FIBER AMPLIFIER AND OPTICAL AMPLIFICATION DEVICE FOR BIDIRECTIONAL OPTICAL TRANSMISSION USING THE OPTICAL FIBER AMPLIFIER**



(57) An optical fiber amplifier comprises a pump light source outputting pump light and an optical amplification medium in which signal light is amplified by pump light. The signal light is input to, and output from, one end of the optical amplification medium. Between the other end of the optical amplification medium and the pump light source is provided an optical filter selectively transmitting the pump light and selectively reflecting light with a wavelength bandwidth equal to that of the signal light. Two optical fiber amplifiers, joined by a 4-terminal fully-circulating optical circulator, are provided to amplify up signal light and down signal light. The up signal light is input into, and amplified down signal light is output from, a first optical I/O terminal. The down signal light is input into, and amplified up signal light is output from, a third optical I/O terminal. A second optical I/O terminal and a fourth optical I/O terminal are connected to one end of the first optical amplification medium and the second optical amplification medium, respectively. The signal light and the amplified signal light are thus input into, and output from, the optical fiber amplifier. A fiber bragg grating may be used as the optical filter. Thus, the optical amplification device for bi-directional light transmission may be reduced in size.

ABSTRACT OF THE DISCLOSURE

An optical fiber amplifier comprises a pump light source outputting pump light and an optical amplification medium in which signal light is amplified by pump light. The signal light is input to, and output from, one end of the optical amplification medium. Between the other end of the optical amplification medium and the pump light source is provided an optical filter selectively transmitting the pump light and selectively reflecting light with a wavelength bandwidth equal to that of the signal light. Two optical fiber amplifiers, joined by a 4-terminal fully-circulating optical circulator, are provided to amplify up signal light and down signal light. The up signal light is input into, and amplified down signal light is output from, a first optical I/O terminal. The down signal light is input into, and amplified up signal light is output from, a third optical I/O terminal. A second optical I/O terminal and a fourth optical I/O terminal are connected to one end of the first optical amplification medium and the second optical amplification medium, respectively. The signal light and the amplified signal light are thus input into, and output from, the optical fiber amplifier. A fiber bragg grating may be used as the optical filter. Thus, the optical amplification device for bi-directional light transmission may be reduced in size.

OPTICAL FIBER AMPLIFIER AND OPTICAL AMPLIFICATION DEVICE FOR BIDIRECTIONAL OPTICAL TRANSMISSION USING THE OPTICAL FIBER AMPLIFIER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical fiber amplifier and an optical amplification device for use in bidirectional optical transmission using the optical fiber amplifier and to the configuration of the optical fiber amplifier which amplifies signal light directly in an optical transmission device. More particularly, the present invention relates to an optical fiber amplifier used in a bidirectional light transmission system.

2. Description of the Related Art

In a long-distance optical fiber communication system, optical repeaters are used to amplify signal light attenuated in transmission optical fibers. In many cases, optical fiber amplifiers, which use rare-earth doped optical fibers to amplify light, are used as optical repeaters.

In the optical fiber amplifier, pump light and signal light must be in a rare-earth doped optical fiber. The pump light is used to pump the optical fiber to amplify the signal light. Therefore, the optical fiber amplifier requires a wavelength division multiplexer (WDM) to multiplex the signal light and the pump light.

The conventional optical fiber amplifier has a pump light source which outputs pump light, a rare-earth doped optical fiber which is an optical amplification medium, and a wavelength division multiplexer which multiplexes the pump light and the signal light and sends the multiplexed light to the rare-earth doped optical fiber. A typical wavelength division multiplexer is an optical fiber fusion-spliced coupler or an optical filter composed of multi-layer dielectric films.

On the other hand, the conventional optical fiber amplifier used in a one-directional light transmission device is not so complicated, while the conventional optical fiber amplifier used in a bidirectional light transmission device is complicated and therefore requires many optical parts.

The bi-directional light transmission device using the conventional optical fiber amplifier must have two optical fiber amplifiers to amplify up and down signal light. Each optical fiber amplifier has its own pump light source, rare-earth (for example, erbium) doped optical fiber, and wavelength division multiplexer. The bidirectional light transmission device sends and receives both the up and down signal light via a single optical fiber. Therefore, the device must separate these two types of signal light, up and down, sent or received via the erbium doped optical fibers used by the up and down signal optical fiber amplifiers. To do so, the device has two optical circulators before and after the erbium doped optical fibers.

However, the conventional optical fiber amplifier has two components between the pump light source and the erbium doped optical fiber; one is an optical coupler coupling the pump light source and the erbium doped optical fiber and the other is the wavelength division multiplexer. They attenuate the output from the pump light source and reduce the power of the pump light sent to the rare-earth doped optical fiber, thereby reducing the gain of the signal light achieved by the erbium doped optical fiber.

An attempt to configure the optical amplification device for bidirectional light transmission using the above optical fiber amplifiers requires two optical circulators and two wavelength division multiplexers. This results in more optical parts in the optical amplification device, making the device larger.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an optical fiber amplifier and an optical amplification device for use in bi-directional light transmission using the optical fiber amplifier. In particular, it is an object of the present invention to provide a simply-structured optical fiber amplifier and, especially, an optical amplification device for use in bi-directional light transmission.

The optical fiber amplifier according to the present invention comprises a pump light source outputting pump light; and an optical amplification medium receiving the pump light, amplifying received signal light, and outputting amplified signal light. The signal light is input from, and the amplified signal light is output from, one end of the optical amplification medium. Between the other end of the optical amplification medium and the pump light source is provided an optical filter selectively transmitting the pump light and selectively reflecting light with a wavelength bandwidth equal to that of the signal light.

The optical fiber amplifier according to the present invention comprises a pump light source outputting pump light with a first wavelength; an optical amplification medium receiving the pump light, amplifying signal light with a second wavelength, and outputting amplified signal light; and an optical filter selectively transmitting light with the first wavelength and selectively reflecting the light with the second wavelength, the optical filer being provided between the pump light source and the optical amplification medium. In addition, the optical fiber amplifier has optical coupling means for outputting the signal light received from a first optical I/O terminal to a second optical I/O terminal and for outputting the amplified signal light received from the second optical I/O terminal to a third optical I/O terminal, the second optical I/O terminal being connected to one end of the optical amplification medium.

The optical filter may be a fiber bragg grating or may include a multi-layer dielectric filter. The optical coupler may be an optical circulator or a directional optical coupler. The optical amplification medium is a rare-earth doped optical fiber such as a erbium doped optical fiber or a praseodymium doped optical fiber.

The optical fiber amplifier according to the present invention further comprises a pump light cut filter selectively removing the pump light, the pump light cut filter being provided after the third optical I/O terminal or between the optical amplification medium and the second optical I/O terminal.

In the conventional optical fiber amplifier, a wavelength division multiplexer is provided before the erbium doped optical fiber to multiplex the pump light and the signal light. On the other hand, in the optical fiber amplifier according to the present invention, the signal light is input into, and the amplified signal light is output from, one end of the optical amplification medium. The pump light source is at the other end. The optical filter, provided between the pump light source and the erbium doped optical fiber, transmits only the pump light and reflects the signal light. This configuration eliminates the need for the wavelength division multiplexer which was required in the conventional configuration.

An optical amplification device for bi-directional light transmission using the optical fiber amplifier according to the present invention basically uses the above-described optical fiber amplifier. To amplify the up signal light, the device has a first optical fiber amplifier comprising a first pump light source outputting first pump light with a first wavelength; a first optical amplification medium receiving the first pump light, amplifying up signal light with a second wavelength, and outputting amplified up signal light; and a first optical filter selectively transmitting light with the first wavelength and selectively reflecting the light with the second wavelength, the first optical filer being provided between the first pump light source and the first optical amplification medium. Similarly, a second optical fiber amplifier comprises a second pump light source outputting second pump light with a third wavelength; a second optical amplification medium receiving the second pump light, amplifying down signal light with a fourth wavelength, and outputting amplified down signal light; and a second optical filter selectively transmitting the light with the third wavelength and selectively reflecting the light with the fourth wavelength, the second optical filer being provided between the second pump light source and the second optical amplification medium.

The first optical fiber amplifier and the second optical fiber amplifier are connected by an optical coupler. The optical coupling means comprises a first optical I/O terminal receiving the up signal light and outputting the amplified down signal light; a second optical I/O terminal outputting the up signal light and receiving the amplified up signal light, the second optical I/O terminal being connected to one end of the first optical amplification medium; a third optical I/O terminal outputting the amplified up signal light received from the second optical I/O terminal and receiving down signal light; and a fourth optical I/O terminal outputting the down signal light and receiving the amplified down signal light, the fourth optical I/O terminal being connected to one end of the second optical amplification medium.

The first wavelength equals the third wavelength. That is, the wavelength of the up signal light may be equal to that of the down signal light. In this case, instead of using the first pump light source and the second pump light source, the optical amplification device for bi-directional light transmission using the optical fiber amplifier according to the present invention may use one pump light source outputting the pump light with a first wavelength. The device may use an optical branching circuit to branch this pump light into a first pump light and a second pump light.

In the above configuration, the optical filter may be a fiber grating. The optical coupler may be an optical circulator. The optical amplification medium is a rare-earth doped optical fiber such as an erbium doped optical fiber.

The optical amplification device for bi-directional light transmission using the optical fiber amplifier according to the present invention may further comprises a first pump light cut filter selectively removing the first pump light, the first pump light cut filter being connected to the third optical I/O terminal; and a second pump light cut filter selectively removing the second pump light, the second pump light cut filter being connected to the first optical I/O terminal.

The positions of the first pump light cut filter and the second pump light cut filter described above may be changed. That is, the first pump light cut filter may be provided between the first optical amplification medium and the second optical I/O terminal to selectively remove the first pump light. And, the second pump light cut filter may be provided between the second optical amplification medium and the fourth optical I/O terminal to selectively remove the second pump light.

The optical amplification device for bidirectional light transmission using the optical fiber amplifier according to the present invention is designed basically around the optical fiber amplifier described above. In addition, the device may use a fully-circulating type 4-terminal optical circulator. This configuration requires only one optical circulator instead of two. Combining this configuration with the elimination of the wavelength division multiplexer makes the optical amplification device for bidirectional light transmission smaller than the conventional one.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will be become more apparent from the following detailed description when taken in conjunction with the accompanying drawings wherein:

Fig. 1 is a diagram showing an example of the configuration of a conventional optical fiber amplifier.

Fig. 2 is a diagram showing the configuration of a bidirectional light transmission device having the conventional optical fiber amplifier.

Fig. 3 is a diagram showing the configuration of the first embodiment of the optical fiber amplifier according to the present invention.

Fig. 4 is a diagram showing the configuration of the second embodiment of the optical fiber amplifier according to the present invention.

Fig. 5 is a diagram showing the configuration of the third embodiment of the optical fiber amplifier according to the present invention.

Fig. 6 is a diagram showing the configuration of the first embodiment of the bidirectional light transmission device using the optical fiber amplifier according to the present invention.

Fig. 7 is a diagram showing the configuration of the second embodiment of the bidirectional light transmission device using the optical fiber amplifier according to the present invention.

Fig. 8 is a diagram showing the configuration of the third embodiment of the bidirectional light transmission device using the optical fiber amplifier according to the present invention.

Fig. 9 is a diagram showing the configuration of the fourth embodiment of the bidirectional light transmission device using the optical fiber amplifier according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Before describing an optical amplification device for bidirectional light transmission according to the present invention, a conventional optical amplification device is described to help understand the present invention.

Fig. 1 is a diagram showing an example of the configuration of the conventional optical fiber amplifier.

In a long-distance optical fiber communication system, optical repeaters are used to amplify signal light attenuated in transmission optical fibers. In many cases, optical fiber amplifiers, which use rare-earth doped optical fibers to amplify light, are used as optical repeaters.

In the optical fiber amplifier, pump light and signal light must be in the rare-earth doped optical fiber. The pump light is used to pump the optical fiber to amplify the signal light. Therefore, the optical fiber amplifier requires a wavelength division multiplexer (optical multiplexer) to multiplex the signal light and the pump light.

As shown in Fig. 1, the conventional optical fiber amplifier has a pump light source 407 which outputs pump light, a rare-earth doped optical fiber 405 which is an optical amplification medium, and a wavelength division multiplexer 404 which multiplexes the pump light and the signal light and sends the multiplexed light to the rare-earth doped optical fiber. A typical wavelength division multiplexer is an optical fiber fusion-spliced coupler or an optical filter composed of multi-layer dielectric films.

The conventional optical fiber amplifier used in a one-directional light transmission device is not so complicated, while the conventional optical fiber amplifier used in a bidirectional light transmission device is complicated and therefore requires many optical parts.

Fig. 2 is a diagram showing the configuration of a bidirectional light transmission device having the conventional optical fiber amplifiers. The optical fiber amplifier amplifying the up signal light comprises the pump light source 407, erbium doped optical fiber 405, and wavelength division multiplexer 403. Likewise, the optical fiber amplifier amplifying the down signal light comprises the pump light source 408, erbium doped optical fiber 406, and wavelength division multiplexer 404. An optical filter 410 and an optical filter 409 are provided for the up signal and the down signal, respectively, to cut the pump light.

The bidirectional light transmission device sends and receives both the up and down signal light via a single optical fiber. Therefore, the device must separate these two types of signal light, up and down, sent or received via the erbium doped optical fibers used by the up and down signal optical fiber amplifiers. To do so, the device has two optical circulators, 401 and 402, before and after the erbium doped optical fibers 405 and 406.

The conventional optical fiber amplifier has two components between the pump light source and the erbium doped optical fiber; one is an optical coupler coupling the pump light source and the erbium doped optical fiber and the other is the wavelength division multiplexer. They attenuate the output from the pump light source and reduce the power of the pump light sent to the rare-earth doped optical fiber, thereby reducing the gain of the signal light achieved by the erbium doped optical fiber.

An attempt to configure the optical amplification device for bidirectional light transmission using the above optical fiber amplifiers requires two optical circulators and two wavelength division multiplexers. This results in more optical parts in the optical amplification device, making the device larger.

Next, the optical fiber amplifier and the optical amplification device using the optical fiber amplifier according to the present invention will be described more in detail.

Fig. 3 is a diagram showing the configuration of the first embodiment of the optical fiber amplifier according to the present invention. The optical fiber amplifier according to the present invention comprises a pump light source 107 which outputs pump light, a fiber bragg grating 105 which functions as an optical fiber selectively transmitting the pump light and selectively reflecting the signal light, an erbium doped optical fiber 103 which is an optical amplification medium, and a 3-terminal optical circulator 101.

The signal light enters the optical fiber amplifier through an optical I/O terminal 1 of the 3-terminal optical circulator 101. The signal light is then output from an optical I/O terminal 2 of the 3-terminal optical circulator 101 for transmission to the erbium doped optical fiber 103.

On the other hand, the pump light output from the pump light source 107 is sent to the erbium doped optical fiber 103 through the fiber bragg grating 105. This pump light amplifies the signal light in the erbium doped optical fiber 103. The signal light, reflected in the fiber bragg grating 105, is sent back through to an optical I/O terminal 2 of the 3-terminal optical circulator 101. The amplified signal light entered from the optical I/O terminal 2 is output from the optical I/O terminal 3.

The optical fiber amplifier according to the present invention does not have the wavelength division multiplexer for multiplexing the signal light and the pump light, as with the conventional optical fiber amplifier; instead, it has the optical circulator and the optical filter, such as the fiber bragg grating, which reflect and transmit only the selected wavelength light. This configuration allows the signal light to be entered, and the amplified signal light to be output, from the same end of the erbium doped optical fiber.

In this embodiment, the fiber bragg grating is used to selectively transmit the pump light and selectively reflect the signal light. Instead of the fiber brag grating, an optical filter such as the one using a multi-layer dielectric filer may be used. The erbium doped optical fiber is also used in this embodiment as a rare-earth doped optical fiber which functions as the light amplification medium. Instead of the erbium doped optical fiber, some other rare-earth doped optical fiber such as a praseodymium doped optical fiber may be used. In addition, instead of the optical circulator, an optical directional coupler may be used.

Figs. 4 and 5 are diagrams showing the configuration of the second and the third embodiments of the optical fiber amplifier according to the present invention. The optical fiber amplifiers shown in those figures differ from that shown in Fig. 3 in that a pump light cut filter 110 is installed after the erbium doped optical fiber 103 to cut the pump light included in the amplified signal light.

In the second embodiment shown in Fig. 4, the pump light cut filter 110 is connected to the optical I/O terminal 3 of the 3-terminal optical circulator 101. In the third embodiment shown in Fig. 5, the pump light cut filter 110 is provided between the optical I/O terminal 2 of the 3-terminal optical circulator 101 and the erbium doped optical fiber 103. Providing the pump light cut filter 110 after the erbium doped optical fiber 103 reduces noises included in the amplified signal light.

Next, the bidirectional light transmission device using the optical fiber amplifier according to the present invention will be described.

Fig. 6 is a diagram showing the configuration of the first embodiment of the bidirectional light transmission device using the optical fiber amplifier according to the present invention. The optical fiber amplifier for the up signal light comprises the pump light source 107, fiber bragg grating 105, and erbium doped optical fiber 103. Likewise, the optical fiber amplifier for the down signal light comprises a pump light source 108, fiber bragg grating 106, and erbium doped optical fiber 104.

The above-described optical fiber amplifiers use a fully-circulating type 4-terminal optical circulator 102. The optical circulator used in the bidirectional light transmission device using the optical fiber amplifier according to the present invention is a fully-circulating type 4-terminal optical circulator. It has optical I/O terminals 1 to 4. Light entered through one terminal is output to the next terminal. That is, light entered through optical I/O terminal 1 is output to the optical I/O terminal 2, light entered through optical I/O terminal 2 is output to the optical I/O terminal 3, light entered through optical I/O terminal 3 is output to the optical I/O terminal 4, and light entered through optical I/O terminal 4 is output to the optical I/O terminal 1.

The erbium doped optical fiber 103 of the optical fiber amplifier for the up signal is connected to the optical I/O terminal 2 of the fully-circulating type 4-terminal optical circulator 102. The erbium doped optical fiber 104 of the optical fiber amplifier for the down signal is connected to the optical I/O terminal 4 of the fully-circulating type 4-terminal optical circulator 102. The up signal light entered through the optical I/O terminal 1 is amplified as in the one-directional operation shown in Fig. 3 and is output from the optical I/O terminal 3. On the other hand, the down signal light entered through the optical I/O terminal 3 is amplified similarly and is output from the optical I/O terminal 4.

The optical fiber amplifier according to the present invention allows the signal light to be entered, and the amplified signal light to be output, from the same end of the erbium doped optical fiber. This enables one optical circulator to connect both optical fiber amplifiers, thus allowing one optical circulator to build a bidirectional light transmission device. As compared with the conventional optical fiber amplifier requiring two optical circulators, the optical fiber amplifier according to the present invention is simpler in configuration.

Fig. 7 is a diagram showing the configuration of the second embodiment of the bidirectional light transmission device using the optical fiber amplifier according to the present invention.

Basically, the bidirectional light transmission device of the second embodiment shown in Fig. 7 is similar to the one in the first embodiment shown in Fig. 6 except that only one pump light source 107 is provided. This pump light source is used for both the up signal light and the down signal light. The pump light output from the pump light source 107 is branched into two by an optical branching circuit 109 and is sent to each erbium doped optical fiber through the fiber bragg grating 105 and the fiber bragg grating 106. This configuration is possible when the wavelength bandwidth of the up signal light is the same as that of the down signal light and when the pump light has the same wavelength.

Next, other embodiments of the bidirectional light transmission device using the optical fiber amplifier according to the present invention will be described.

Figs. 8 and 9 are diagrams showing the configuration of the third and fourth embodiments of the bidirectional light transmission device using the optical fiber amplifier according to the present invention. As with the optical fiber amplifier according to the present invention shown in

Fig. 4 or Fig. 5, a pump light cut filter 111 or 112 is provided after the erbium doped optical fiber.

In the third embodiment shown in Fig. 8, the pump light cut filters 111 and 112 are connected to the optical I/O terminal 3 and the optical I/O terminal 1 of the optical circulator, respectively. On the other hand, in the fourth embodiment shown in Fig. 9, the pump light cut filters 111 and 112 are provided between the optical I/O terminal 2 of the optical circulator and the erbium doped optical fiber 103 and between the optical I/O terminal 4 of the optical circulator and the erbium doped optical fiber 104, respectively. These pump light cut filters may be replaced by band pass filters provided that they cut light with different wavelengths and transmit only light with a wavelength approximately equal to that of the signal light. That is, they are required to cut not only the pump light but also spontaneous emission light introduced by the light amplification medium during light amplification. As a result, they reduce noises in the output signal light.

Referring now to Fig. 6 again, the following describes how light is transmitted in the first embodiment of the bidirectional light transmission device using the optical fiber amplifier according to the present invention.

In this embodiment, light with a wavelength of 1550nm is used for the up signal light and light with a wavelength of 1560nm for the down signal light. The fiber bragg grating 105 reflects 99% or more of light with a wavelength of

1550±2nm and transmits 99% or more of light with a wavelength of 1470±20nm. The fiber bragg grating 106 reflects 99% or more of light with a wavelength of 1560±2nm and transmits 99% or more of light with a wavelength of 1470±20nm. Light with the center wavelength of 1470nm and with the output of 80mW is used for the pump light sources 107 and 108. The fully-circulating type 4-terminal optical circulator 102 has the insertion loss of 1dB and the isolation of 40dB.

Under the above condition, when the light output of the up signal light entered through the optical I/O terminal 1 of the fully-circulating type 4-terminal optical circulator 102 was -10dBm, the amplified signal light of +15dBm was output from the optical I/O terminal 3 of the fully-circulating type 4-terminal optical circulator 102. The same result was obtained for the down signal light.

As described above, the optical fiber amplifier according to the present invention has means for receiving the signal light and outputting the amplified signal light at one end and, at the other end, the pump light source. The optical filter transmits only the pump light and reflects the signal light back to the optical amplification medium. This configuration eliminates the need for the wavelength division multiplexer required for the conventional configuration.

The optical amplification device for bidirectional light transmission designed around the optical fiber amplifier according to the present invention, with the fully-circulating type 4-terminal optical circulator, requires only one optical circulator instead of two. Combining this configuration with the elimination of the wavelength division multiplexer makes the optical amplification device for bidirectional light transmission smaller than the conventional one.

While this invention has been described in connection with certain preferred embodiments, it is to be understood that the subject matter encompassed by way of this invention is not to be limited to those specific embodiments. On the contrary, it is intended for the subject matter of the invention to include all alternative, modification, and equivalents as can be included within the spirit and scope of the following claims.

WHAT IS CLAIMED IS:

1. An optical fiber amplifier comprising:

a pump light source outputting pump light;

an optical amplification medium receiving said pump light, amplifying received signal light, and outputting amplified signal light;

means for receiving said signal light, and outputting said amplified signal light, from one end of said optical amplification medium; and

optical filter means for selectively transmitting light with a wavelength bandwidth of said pump light and for selectively reflecting the light with the wavelength bandwidth of said signal light, said optical filer means being provided between another end of said optical amplification medium and said pump light source.

2. An optical fiber amplifier comprising:

a pump light source outputting pump light with a first wavelength;

an optical amplification medium receiving said pump light, amplifying signal light with a second wavelength, and outputting amplified signal light;

an optical filter selectively transmitting light with said first wavelength and selectively reflecting the light with said second wavelength, said optical filer being provided between said pump light source and said optical amplification medium; and optical coupling means for outputting said signal light received from a first optical I/O terminal to a second optical I/O terminal and for outputting said amplified signal light received from said second optical I/O terminal to a third optical I/O terminal, said second optical I/O terminal being connected to one end of said optical amplification medium.

3. The optical fiber amplifier according to claim 2, wherein said optical filter optical filter is a fiber bragg grating.

4. The optical fiber amplifier according to claim 2, wherein said optical filter includes a multi-layer dielectric filter.

5. The optical fiber amplifier according to claim 2, wherein said optical coupling means is an optical circulator.

6. The optical fiber amplifier according to claim 2, wherein said optical coupling means is a directional optical coupler.

7. The optical fiber amplifier according to claim 2, wherein said optical amplification medium is a rare-earth doped optical fiber.

8. The optical fiber amplifier according to claim 7, wherein said rare-earth doped optical fiber is an erbium doped optical fiber.

9. The optical fiber amplifier according to claim 2, further comprising a pump light cut filter selectively removing said pump light, said pump light cut filter being provided after said third optical I/O terminal.

10. The optical fiber amplifier according to claim 2, further comprising a pump light cut filter selectively

removing said pump light, said pump light cut filter being provided between said optical amplification medium and said second optical I/O terminal.

11. The optical fiber amplifier according to claim 10, wherein said pump light cut filter has means for removing spontaneous emission light output from said optical amplification medium.

12. An optical amplification device for bi-directional light transmission using an optical fiber amplifier, said optical fiber amplifier comprising:

a first optical fiber amplifier comprising:

a first pump light source outputting first pump light with a first wavelength;

a first optical amplification medium receiving said first pump light, amplifying up signal light with a second wavelength, and outputting amplified up signal light; and

a first optical filter selectively transmitting light with said first wavelength and selectively reflecting the light with said second wavelength, said first optical filer being provided between said first pump light source and said first optical amplification medium;

a second optical fiber amplifier comprising:

a second pump light source outputting second pump light with a third wavelength;

a second optical amplification medium receiving said second pump light, amplifying down signal light with a fourth wavelength, and outputting amplified down signal light; and

a second optical filter selectively transmitting the light with said third wavelength and selectively reflecting the light with said fourth wavelength, said second optical filer being provided between said second pump light source and said second optical amplification medium; and

optical coupling means comprising:

a first optical I/O terminal receiving said up signal light and outputting said amplified down signal light;

a second optical I/O terminal outputting said up signal light and receiving said amplified up signal light, said second optical I/O terminal being connected to one end of said first optical amplification medium;

a third optical I/O terminal outputting said amplified up signal light received from said second optical I/O terminal and receiving down signal light; and

a fourth optical I/O terminal outputting said down signal light and receiving said amplified down signal light, said fourth optical I/O terminal being connected to one end of said second optical amplification medium.

13. The optical amplification device for bi-directional light transmission according to claim 12, wherein said first wavelength equals said third wavelength.

14. An optical amplification device for bi-directional light transmission using an optical fiber amplifier, said optical fiber amplifier comprising:

a pump light source outputting pump light;

an optical branching circuit branching said pump light and outputting a first pump light with a first wavelength and a second pump light with a third wavelength;

a first optical fiber amplifier comprising:

a first optical amplification medium receiving said first pump light, amplifying up signal light with a second wavelength, and outputting amplified up signal light; and

a first optical filter selectively transmitting light with said first wavelength and selectively reflecting the light with said second wavelength, said first optical filer being provided between said optical branching circuit and said first optical amplification medium;

a second optical fiber amplifier comprising:

a second optical amplification medium receiving said second pump light, amplifying down signal light with a fourth wavelength, and outputting amplified down signal light; and

a second optical filter selectively transmitting light with said third wavelength and selectively reflecting the light with said fourth wavelength, said second optical filer being provided between said optical branching circuit and said second optical amplification medium; and

optical coupling means comprising:

a first optical I/O terminal receiving said up signal light and outputting said amplified down signal light;

a second optical I/O terminal outputting said up signal light and receiving said amplified up signal light, said second optical I/O terminal being connected to one end of said first optical amplification medium;

a third optical I/O terminal outputting said amplified up signal light received from said second optical I/O terminal and receiving down signal light; and

a fourth optical I/O terminal outputting said down signal light and receiving said amplified down signal light, said fourth optical I/O terminal being connected to one end of said second optical amplification medium.

15. The optical amplification device for bi-directional light transmission according to claim 12, wherein said optical filter is a fiber bragg grating.

16. The optical amplification device for bi-directional light transmission according to claim 14, wherein said optical filter is a fiber bragg grating.

17. The optical amplification device for bi-directional light transmission according to claim 12, wherein said optical coupling means is an optical circulator.

18. The optical amplification device for bi-directional light transmission according to claim 14, wherein said optical coupling means is an optical circulator.

19. The optical amplification device for bi-directional light transmission according to claim 12, wherein said optical amplification medium is a rare-earth doped optical fiber.

20. The optical amplification device for bi-directional light transmission according to claim 14, wherein said optical amplification medium is a rare-earth doped optical fiber.

21. The optical amplification device for bi-directional light transmission according to claim 19, wherein said rare-earth doped optical fiber is an erbium doped optical fiber.

22. The optical amplification device for bi-directional light transmission according to claim 20, wherein said rare-earth doped optical fiber is an erbium doped optical fiber.

23. The optical amplification device for bi-directional light transmission using the optical fiber amplifier according to claim 12, said optical fiber amplifier further comprising:

a first pump light cut filter selectively removing said first pump light, said first pump light cut filter being connected to said third optical I/O terminal; and

a second pump light cut filter selectively removing said second pump light, said second pump light cut filter being connected to said first optical I/O terminal.

24. The optical amplification device for bi-directional light transmission using the optical fiber amplifier according to claim 14, said optical fiber amplifier further comprising:

a first pump light cut filter selectively removing said first pump light, said first pump light cut filter being connected to said third optical I/O terminal; and a second pump light cut filter selectively removing said second pump light, said second pump light cut filter being connected to said first optical I/O terminal.

25. The optical amplification device for bi-directional light transmission using the optical fiber amplifier according to claim 23, wherein said first pump light cut filter comprises first spontaneous emission light removing means for removing spontaneous emission light output from said first optical amplification medium and wherein said second pump light cut filter comprises second spontaneous emission light removing means for removing the spontaneous emission light output from said second optical amplification medium.

26. The optical amplification device for bi-directional light transmission using the optical fiber amplifier according to claim 24, wherein said first pump light cut filter comprises first spontaneous emission light removing means for removing spontaneous emission light output from said first optical amplification medium and wherein said second pump light cut filter comprises second spontaneous emission light removing means for removing the spontaneous emission light output from said second optical amplification medium.

27. The optical amplification device for bi-directional light transmission using the optical fiber amplifier according to claim 12, said optical fiber amplifier further comprising:

a first pump light cut filter selectively removing said first pump light, said first pump light cut filter being provided between said first optical amplification medium and said second optical I/O terminal; and

a second pump light cut filter selectively removing said second pump light, said second pump light cut filter being provided between said second optical amplification medium and said fourth optical I/O terminal.

28. The optical amplification device for bi-directional light transmission using the optical fiber amplifier according to claim 14, said optical fiber amplifier further comprising:

a first pump light cut filter selectively removing said first pump light, said first pump light cut filter being provided between said first optical amplification medium and said second optical I/O terminal; and

a second pump light cut filter selectively removing said second pump light, said second pump light cut filter being provided between said second optical amplification medium and said fourth optical I/O terminal.

29. The optical amplification device for bi-directional light transmission using the optical fiber amplifier according to claim 27, wherein said first pump light cut filter comprises first spontaneous emission light removing means for removing spontaneous emission light output from said first optical amplification medium and wherein said second pump light cut filter comprises second spontaneous

emission light removing means for removing the spontaneous emission light output from said second optical amplification medium.

30. The optical amplification device for bi-directional light transmission using the optical fiber amplifier according to claim 28, wherein said first pump light cut filter comprises first spontaneous emission light removing means for removing spontaneous emission light output from said first optical amplification medium and wherein said second pump light cut filter comprises second spontaneous emission light removing means for removing the spontaneous emission light output from said second optical amplification medium.

Fig.1 PRIOR ART

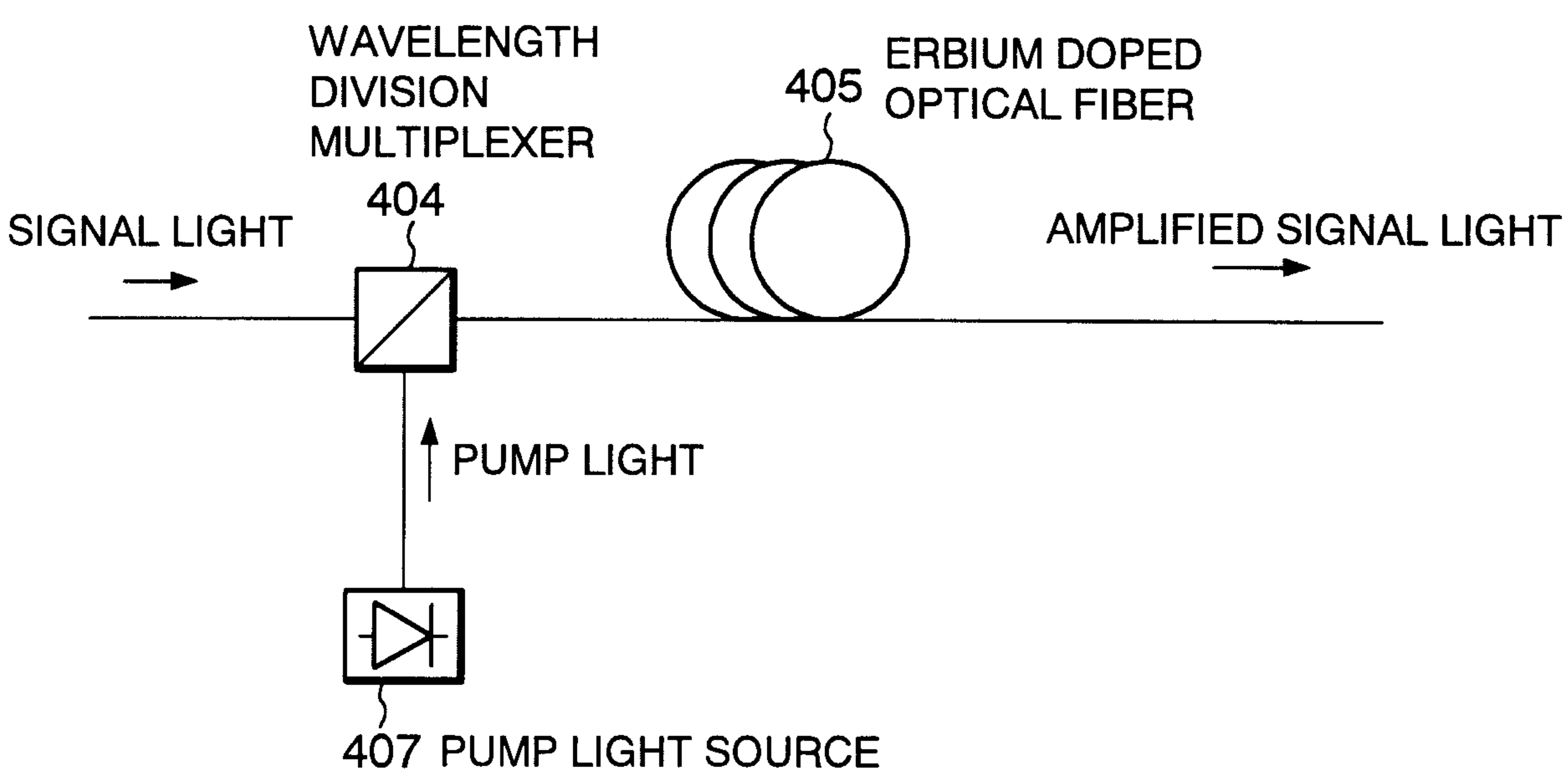


Fig.2 PRIOR ART

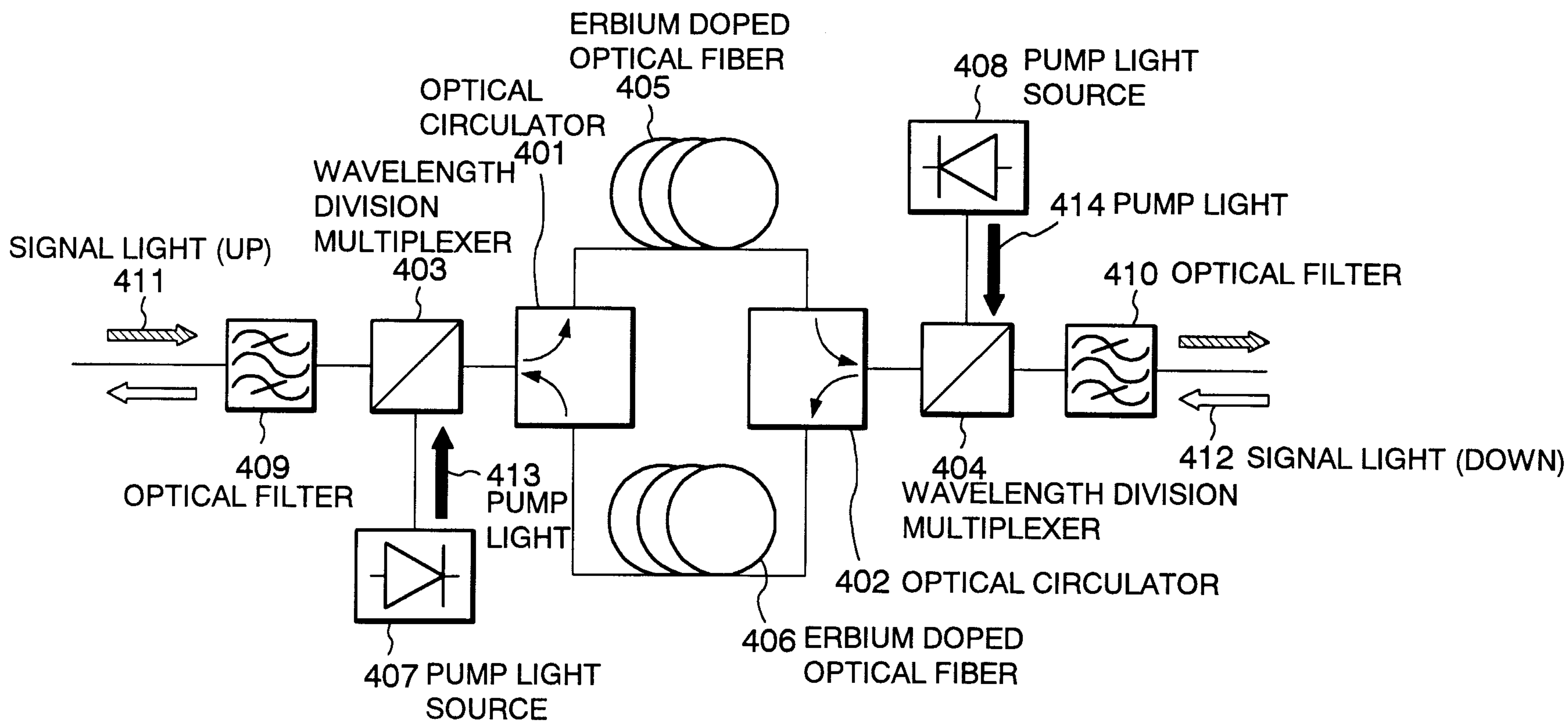


Fig.3

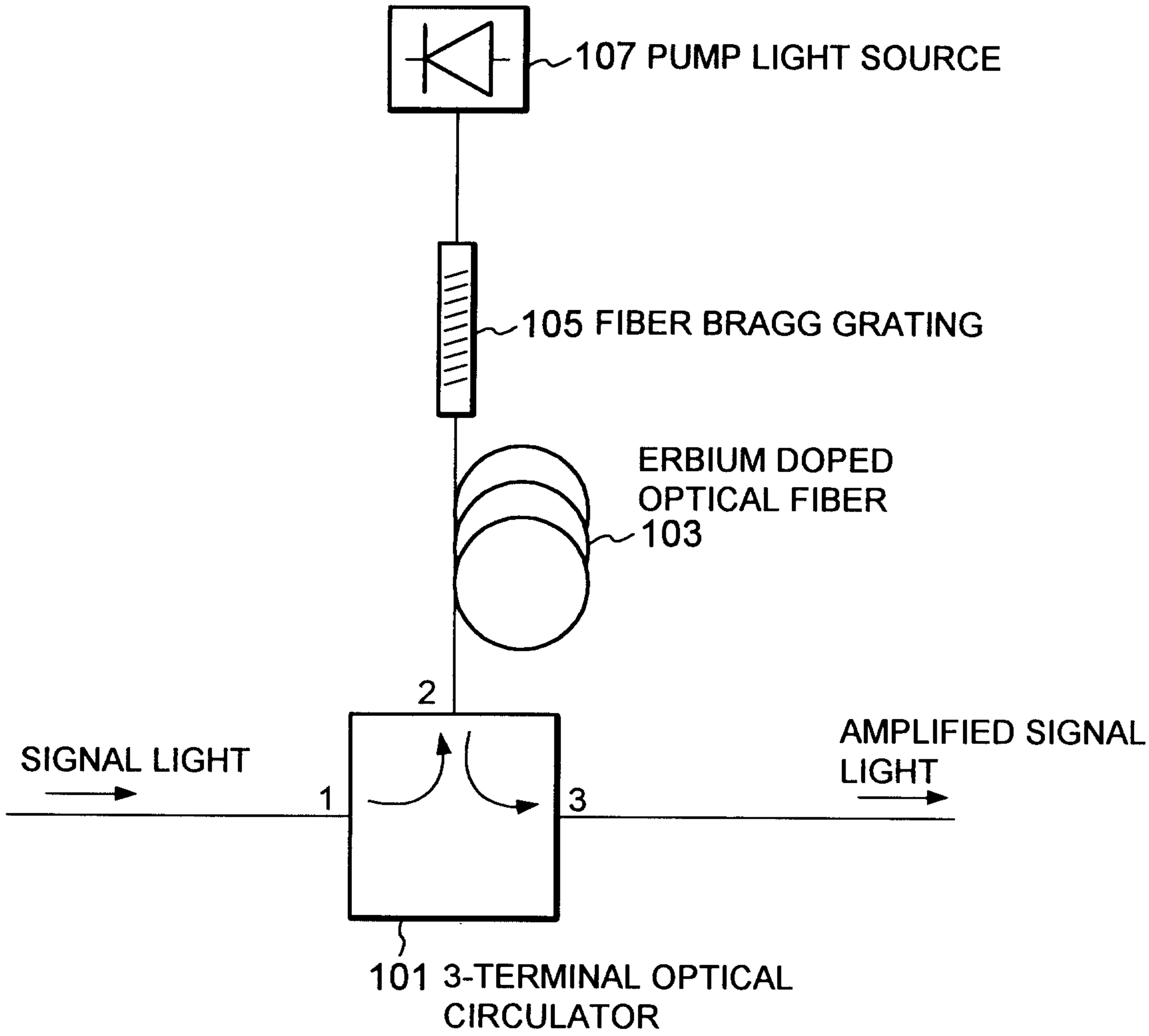

107 PUMP LIGHT SOURCE
105 FIBER BRAGG GRATING
ERBIUM DOPED OPTICAL FIBER 103
2
SIGNAL LIGHT
1
3
AMPLIFIED SIGNAL LIGHT
101 3-TERMINAL OPTICAL CIRCULATOR

Fig.4

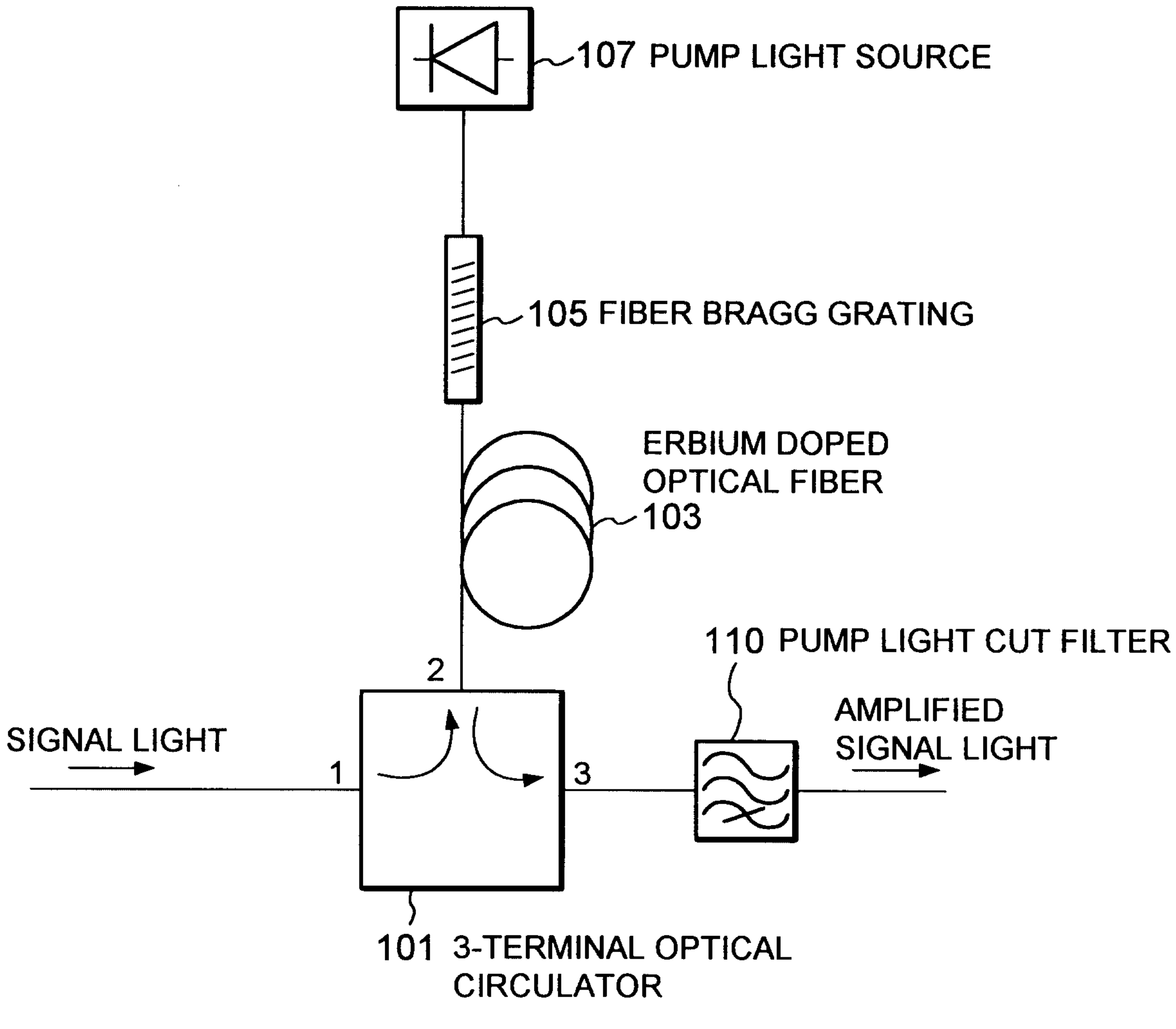

107 PUMP LIGHT SOURCE
105 FIBER BRAGG GRATING
ERBIUM DOPED
OPTICAL FIBER
103
110 PUMP LIGHT CUT FILTER
2
SIGNAL LIGHT
1
3
AMPLIFIED
SIGNAL LIGHT
101 3-TERMINAL OPTICAL
CIRCULATOR

Fig.5

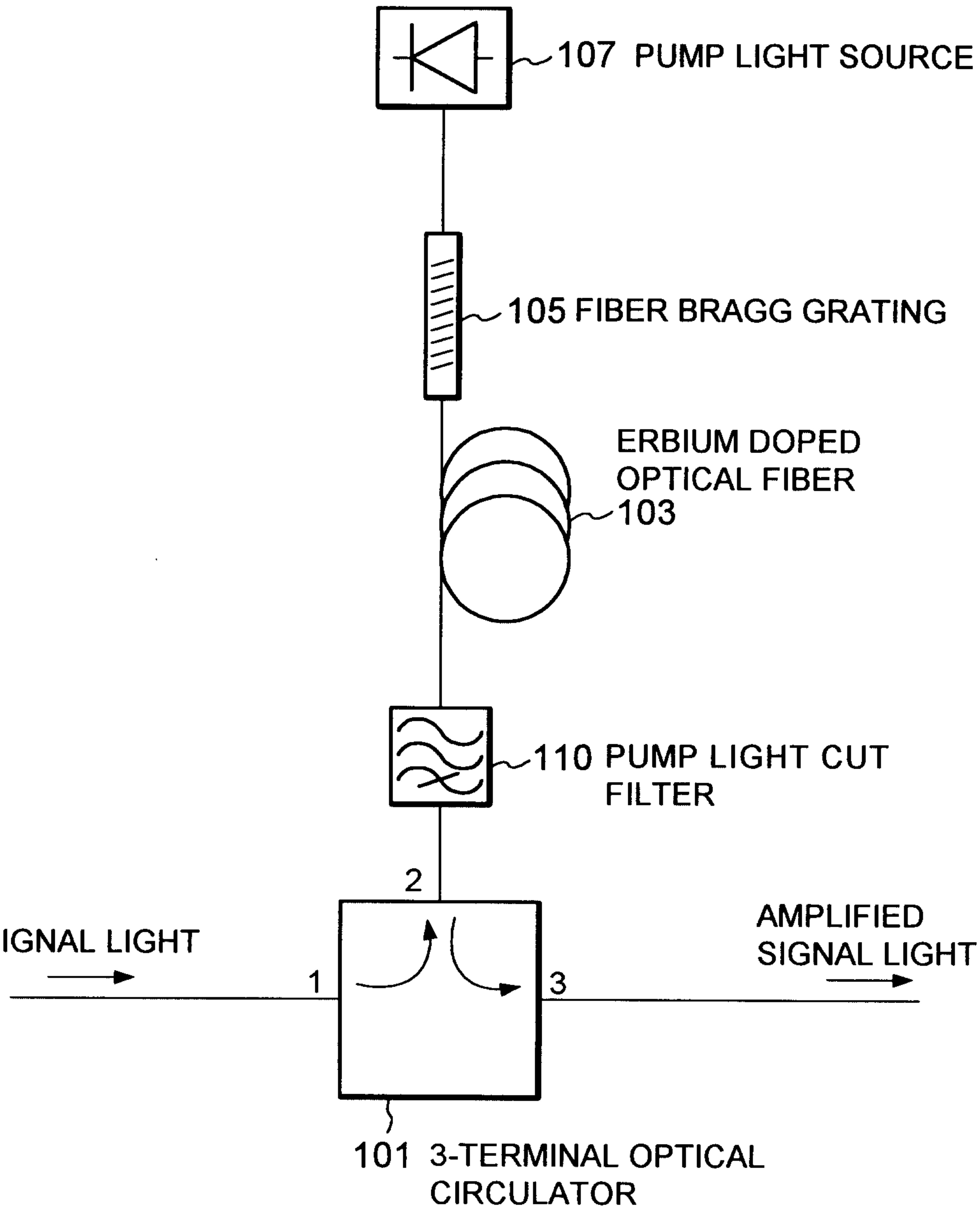

107 PUMP LIGHT SOURCE
105 FIBER BRAGG GRATING
ERBIUM DOPED OPTICAL FIBER 103
110 PUMP LIGHT CUT FILTER
2
SIGNAL LIGHT
1
3
AMPLIFIED SIGNAL LIGHT
101 3-TERMINAL OPTICAL CIRCULATOR

Fig.6

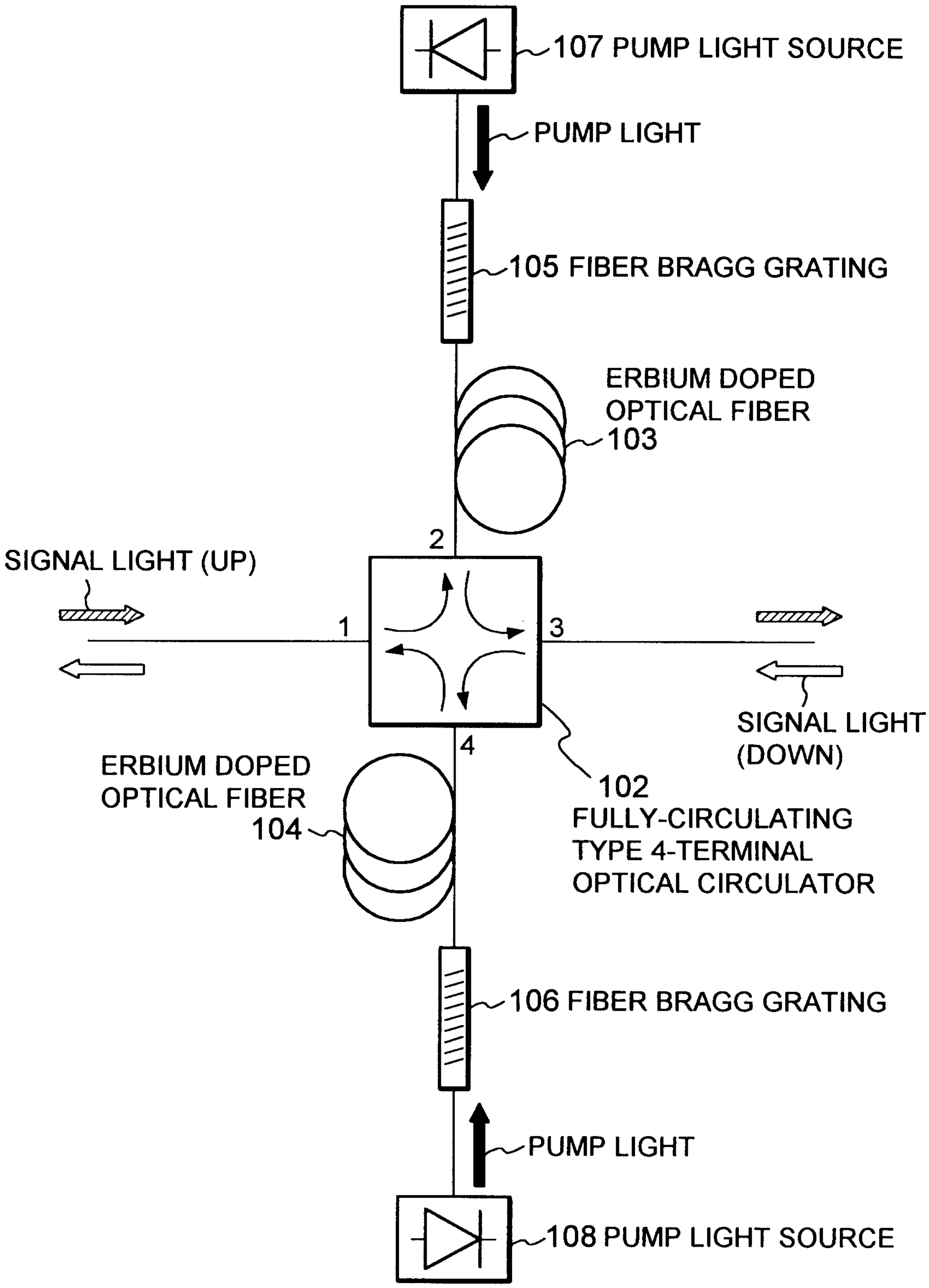

107 PUMP LIGHT SOURCE
PUMP LIGHT
105 FIBER BRAGG GRATING
ERBIUM DOPED
OPTICAL FIBER
103
2
SIGNAL LIGHT (UP)
1
3
SIGNAL LIGHT
(DOWN)
4
ERBIUM DOPED
OPTICAL FIBER
104
102
FULLY-CIRCULATING
TYPE 4-TERMINAL
OPTICAL CIRCULATOR
106 FIBER BRAGG GRATING
PUMP LIGHT
108 PUMP LIGHT SOURCE

Fig.7

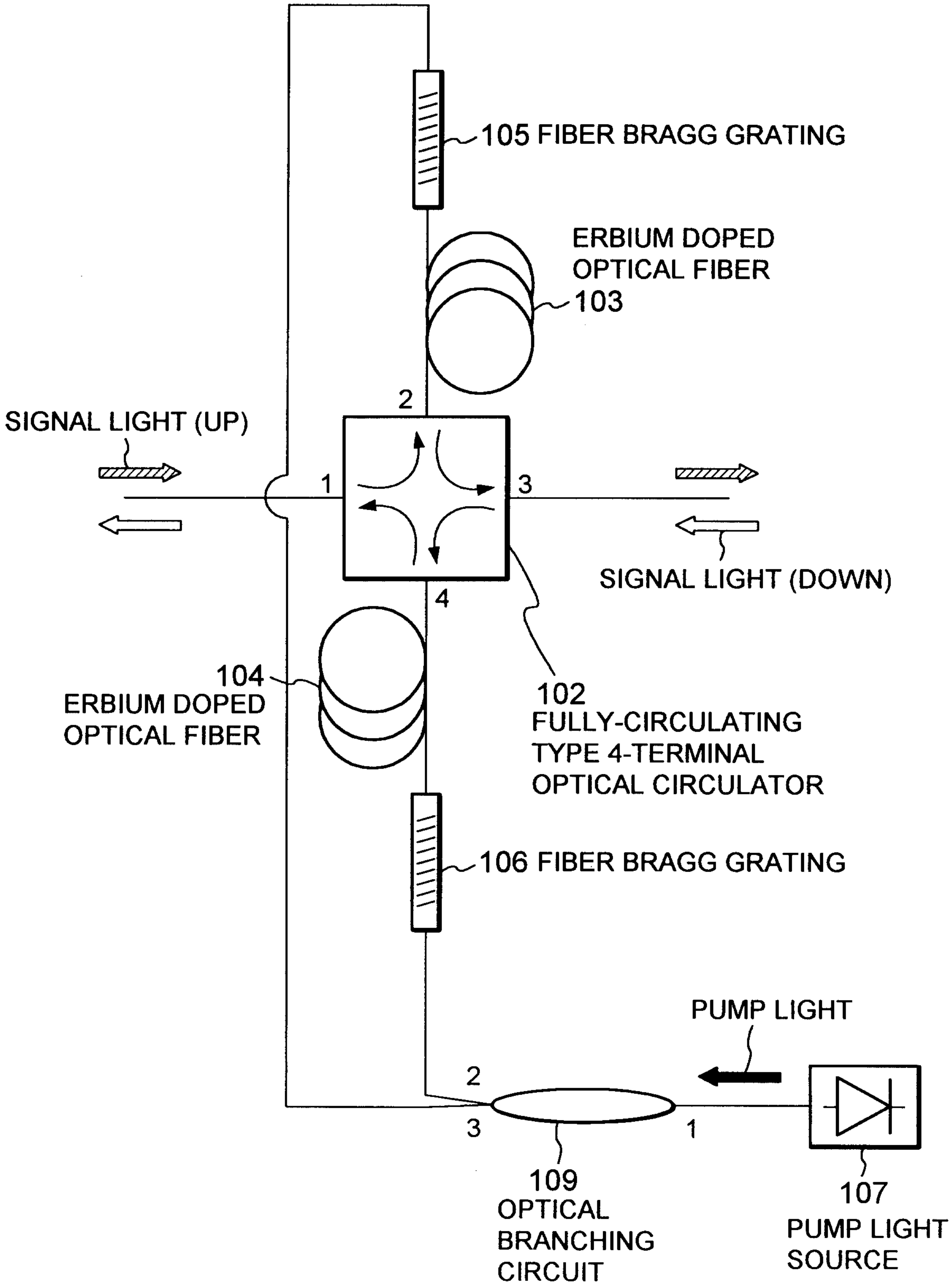
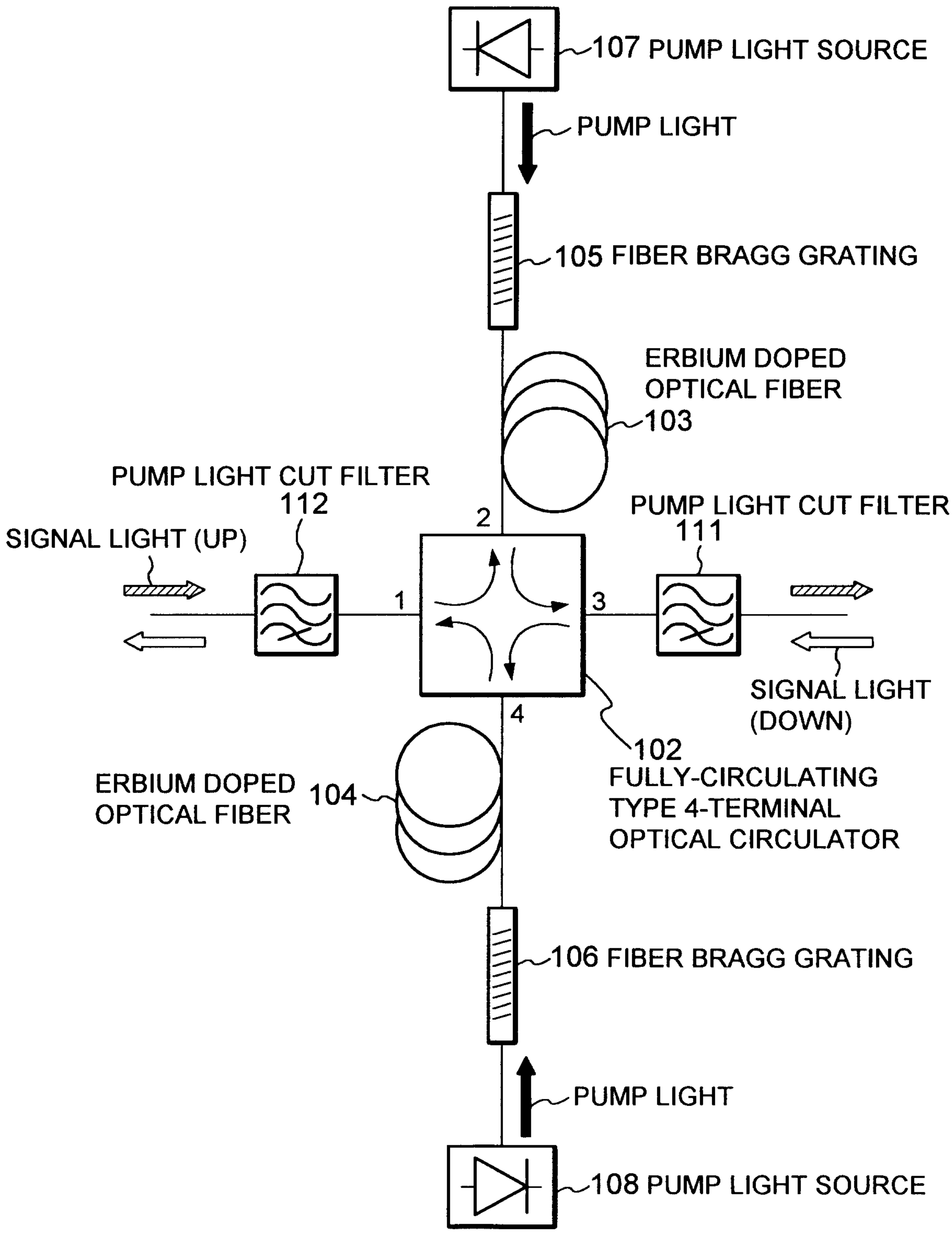
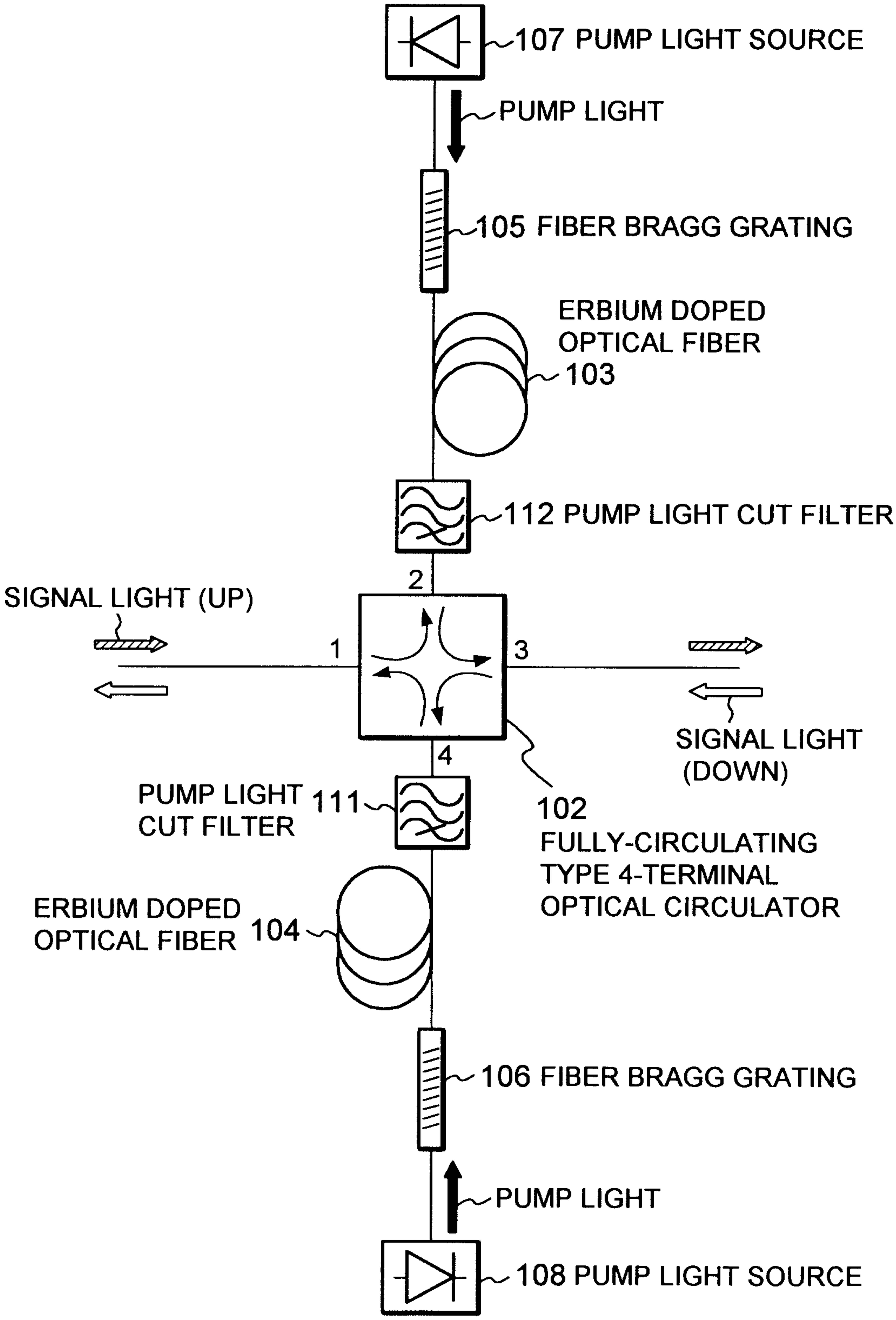

105 FIBER BRAGG GRATING
ERBIUM DOPED OPTICAL FIBER 103
SIGNAL LIGHT (UP)
2
1
3
4
SIGNAL LIGHT (DOWN)
104 ERBIUM DOPED OPTICAL FIBER
102 FULLY-CIRCULATING TYPE 4-TERMINAL OPTICAL CIRCULATOR
106 FIBER BRAGG GRATING
PUMP LIGHT
2
3
1
109 OPTICAL BRANCHING CIRCUIT
107 PUMP LIGHT SOURCE

Fig.8



107 PUMP LIGHT SOURCE
PUMP LIGHT
105 FIBER BRAGG GRATING
ERBIUM DOPED
OPTICAL FIBER
103
PUMP LIGHT CUT FILTER
112
SIGNAL LIGHT (UP)
2
1
3
PUMP LIGHT CUT FILTER
111
SIGNAL LIGHT
(DOWN)
4
102
FULLY-CIRCULATING
TYPE 4-TERMINAL
OPTICAL CIRCULATOR
ERBIUM DOPED
OPTICAL FIBER
104
106 FIBER BRAGG GRATING
PUMP LIGHT
108 PUMP LIGHT SOURCE

Fig.9


107 PUMP LIGHT SOURCE
PUMP LIGHT
105 FIBER BRAGG GRATING
ERBIUM DOPED OPTICAL FIBER 103
112 PUMP LIGHT CUT FILTER
2
SIGNAL LIGHT (UP)
1
3
4
SIGNAL LIGHT (DOWN)
PUMP LIGHT CUT FILTER 111
102 FULLY-CIRCULATING TYPE 4-TERMINAL OPTICAL CIRCULATOR
ERBIUM DOPED OPTICAL FIBER 104
106 FIBER BRAGG GRATING
PUMP LIGHT
108 PUMP LIGHT SOURCE