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CA 2294954 C 2006/08/01

(11)(21) 2 294 954

(12) BREVET CANADIEN
CANADIAN PATENT

(13) C

(86) Date de dépôt PCT/PCT Filing Date: 1998/05/16
(87) Date publication PCT/PCT Publication Date: 1998/12/23
(45) Date de délivrance/Issue Date: 2006/08/01
(85) Entrée phase nationale/National Entry: 1999/12/16
(86) N° demande PCT/PCT Application No.: EP 1998/002894
(87) N° publication PCT/PCT Publication No.: 1998/058466
(30) Priorité/Priority: 1997/06/18 (DE197 25 714.3)

(51) Cl.Int./Int.Cl. *H04J 13/00* (2006.01), *H04B 10/08* (2006.01), *H04J 14/00* (2006.01), *H04J 14/02* (2006.01)

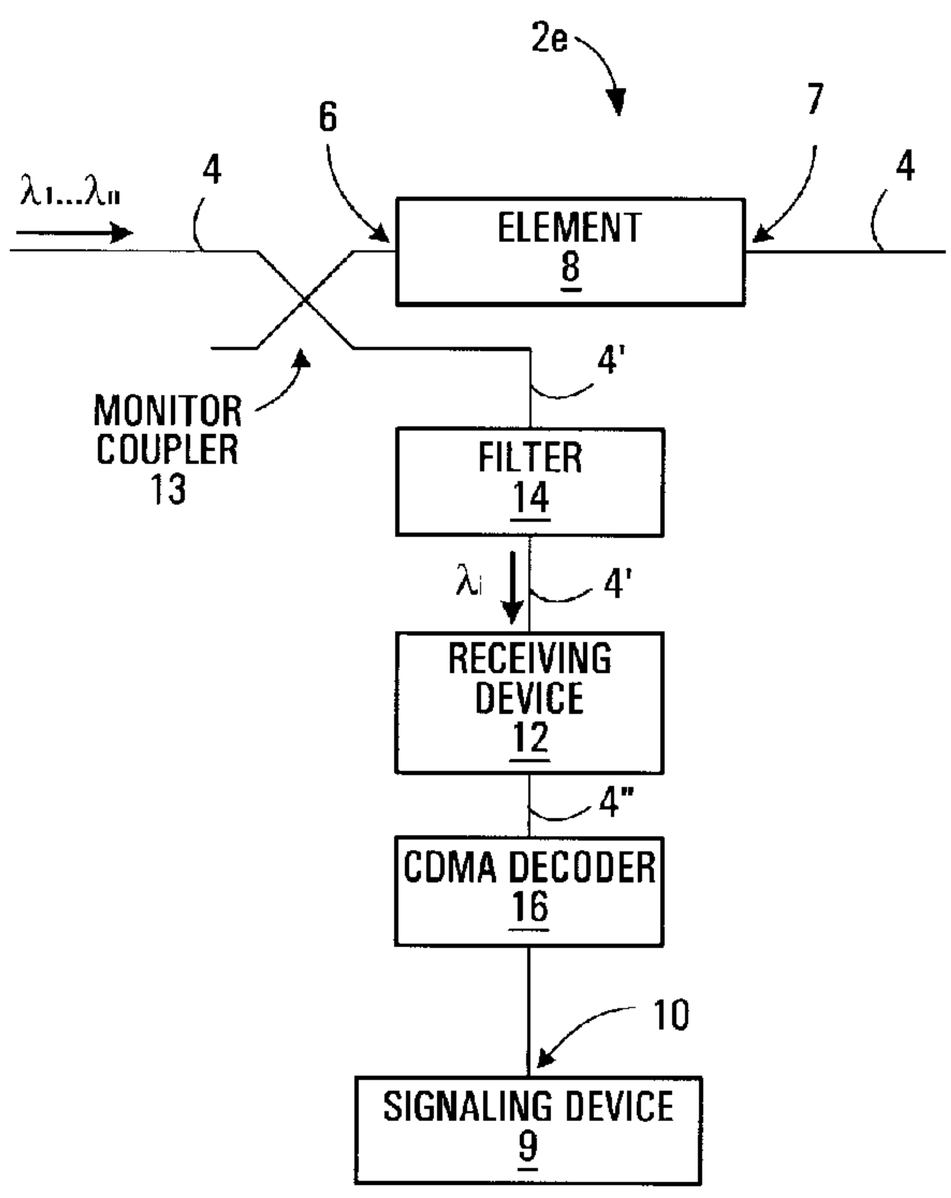
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(54) Titre : PROCEDE POUR LA TRANSMISSION OPTIQUE D'INFORMATIONS DE SIGNALISATION ET DE COMMANDE DANS DES RESEAUX OPTIQUES A MULTIPLEXAGE EN LONGUEUR D'ONDE

(54) Title: METHOD FOR OPTICALLY TRANSMITTING SIGNALLING AND CONTROL INFORMATION IN OPTICAL NETWORKS



(57) Abrégé/Abstract:
The invention relates to a method for optically transmitting signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element. According to the invention, the signalling and control information and the useful information are transmitted in the form of a digital signal. The inventive method is characterised in that the signal for the signalling and control information is transmitted by means of a code division multiple access process. The invention also relates to a device for receiving signalling and control information, said receiving device (12) being characterised in that it is allocated at least a monitor coupler (13), a CDMA decoder (16) and a signalling device (9).

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WELTORGANISATION FÜR GEISTIGES EIGENTUM
Internationales Büro

INTERNATIONALE ANMELDUNG VERÖFFENTLICHT NACH DEM VERTRAG ÜBER DIE INTERNATIONALE ZUSAMMENARBEIT AUF DEM GEBIET DES PATENTWESENS (PCT)

(51) Internationale Patentklassifikation 6 :
H04J 13/00, 14/02, H04B 10/08

A1

(11) Internationale Veröffentlichungsnummer: WO 98/58466

(43) Internationales Veröffentlichungsdatum: 23. Dezember 1998 (23.12.98)

(21) Internationales Aktenzeichen: PCT/EP98/02894

(22) Internationales Anmeldedatum: 16. Mai 1998 (16.05.98)

(30) Prioritätsdaten:
197 25 714.3 18. Juni 1997 (18.06.97) DE

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(81) Bestimmungsstaaten: AU, CA, JP, NO, US, europäisches Patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Veröffentlicht
Mit internationalem Recherchenbericht.
Vor Ablauf der für Änderungen der Ansprüche zugelassenen Frist; Veröffentlichung wird wiederholt falls Änderungen eintreffen.

(54) Title: METHOD FOR OPTICALLY TRANSMITTING SIGNALLING AND CONTROL INFORMATION IN OPTICAL WAVELENGTH MULTIPLEX NETWORKS

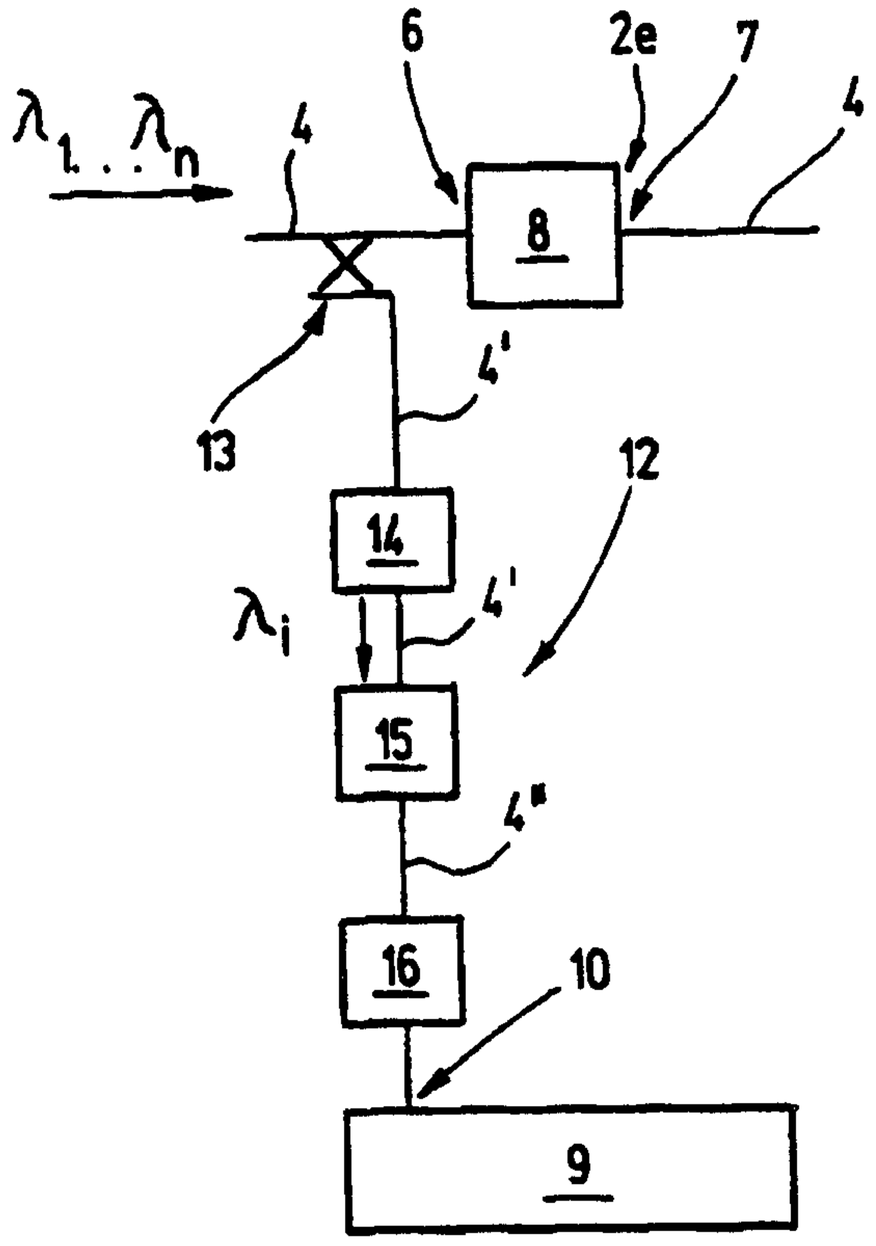
(54) Bezeichnung: VERFAHREN ZUR OPTISCHEN ÜBERTRAGUNG VON SIGNALISIERUNGS– UND STEUERINFORMATIONEN IN OPTISCHEN WELLENLÄNGENMULTIPLEXNETZEN

(57) Abstract

The invention relates to a method for optically transmitting signalling and control information for monitoring and controlling single or multi–channel useful information in optical networks with at least one network element. According to the invention, the signalling and control information and the useful information are transmitted in the form of a digital signal. The inventive method is characterised in that the signal for the signalling and control information is transmitted by means of a code division multiple access process. The invention also relates to a device for receiving signalling and control information, said receiving device (12) being characterised in that it is allocated at least a monitor coupler (13), a CDMA decoder (16) and a signalling device (9).

(57) Zusammenfassung

Die Erfindung betrifft ein Verfahren zur optischen Übertragung von Signalisierungs– und Steuerinformationen, die der Überwachung und Steuerung von ein– oder mehrkanaligen Nutzinformationen in optischen Netzen mit mindestens einem Netzelement dienen, wobei die Signalisierungs– und Steuerinformationen und die Nutzinformationen in Form eines digitalen Signals übertragen werden, das sich dadurch auszeichnet, daß das Signal der Signalisierungs– und Steuerinformationen mittels eines Kodemultiplex–Verfahrens (CDMA) übertragen wird, sowie eine Vorrichtung zum Empfangen von Signalisierungs– und Steuerinformationen, die sich dadurch auszeichnet, daß der Empfangseinrichtung (12) der Signalisierungs– und Steuerinformationen zumindest ein Monitorkoppler (13), ein CDMA–Dekodierer (16) und eine Signalisierungseinrichtung (9) zugeordnet sind.



Method for Optically Transmitting Signalling and Control Information in Optical Networks

The present invention relates to a method for optically transmitting signaling and the control information, and to a receiving device for signaling and control information.

One or a plurality of optical frequencies (wavelengths) are used for transmitting a signal that carries useful information. If a plurality of optical frequencies is used, these frequencies can be regarded as separate channels. This method is referred to as wavelength multiplex (WDM), access to the individual channels being possible for at least two network elements. This is referred to as multiple access.

It is known that signaling and control information must be transmitted in order to operate optical networks. This signaling and control information serves, on the one hand, to control and monitor network elements and, on the other hand, network statuses can be represented and changed thereby. Known in the prior art is a reference (Chawki, M.J., Tholey, V.Le., Gac, I.: Management protocol of a reconfigurable WDM ring network using SDH overhead bytes; OFC 96 Technical Digest FD3), in which the signaling and control information is transmitted within the useful-information signal (In-Channel-Signaling). Also known in the prior art is a reference (Draft Recommendation ITU-T G.MCS Geneva, June, 1996),

in which the signaling and control information is transmitted on an additional control channel, either using the same or another medium. Finally, the prior art refers to S. Johansson: "Transport Network Involving a Reconfigurable WDM Layer, *Journal of Lightwave Technology*, 14 (1996) 6, pp. 1341-1349, in which the signaling and control information is transmitted with the aid of so called pilot tones. The pilot tones are transmitted in an electrical frequency range that is not used by the useful information.

A disadvantage in the prior art is the fact that when In-Channel-Signaling is used, the signaling and control information must be separated from the useful information signal by using additional electrical demultiplexers and electrical multiplexers, when, first of all, the optical signal with its total bandwidth must be reconverted into an electrical signal. Then, in addition, a transceiver (transmitter/receiver) is needed at each network element to process the signaling and control information.

When additional control channels are used for the signaling and control information, it will be necessary to use the appropriate means to separate/add the control channels from/to the channels of useful information. It will, in addition, be necessary to use a transceiver to process the signaling and control information.

Because of multiple access, it will be essential to use a protocol that controls use of the receiver, i.e., which

establishes at which time the transceiver is to transmit or receive and/or which subscribers can use the transceiver.

The use of pilot tones in optical networks with different hierarchical stages is difficult, since information can be transmitted at different data rates in optical networks. Because of this, considering the overall network structure, there are no uniformly free frequency ranges for transmitting the pilot tones.

U.S. Patent No. 5,619,492 that issued April 8, 1997, describes an optical local area network (LAN) in which control information together with useful information is transmitted together in a data packet. The complete data packet, comprising control information and useful information, is CDMA (Code Division Multiple Access) coded. The complete data packet is CDMA decoded again in a receiver section.

EP Patent No. 0 367 452 A2 that issued August 16, 1995, describes an optical network in which information is transmitted by the CDMA method and by the wavelength multiplex method.

Nguyen, L., et al.: "All-optical CDMA with bipolar codes"; *Electronic Letters*; Vol. 31, No. 6, 16 March 1995, pp. 469-470, describes a CDMA method in optical networks, wherein bipolar codes are used.

The paper published subsequently (Giehmann, L. et al.: "The application of code division multiple access for transport overhead information in transparent optical networks," Optical Fiber Communication Conference and Exhibition, Vol. 2, 22 - 27 February 1998, pp. 228 to 229) describes the CDMA coding of the signaling and control information in optical networks, the CDMA coded signaling and control information being impressed on the useful information signal.

Thus, it is the objective of the present invention to describe a method for optically transmitting signaling and control information in optical networks, which requires no free optical or electrical frequency range and, at the same time, does not interfere with a useful information signal that is to be transmitted.

According to the present invention, the underlying objective of the present invention has been achieved in that the CDMA signal of the signaling and control information is impressed additively on the useful information signal, the percentage modulation of the CDMA signal being less than the percentage modulation of the useful information signal. At the same time, signaling and control information can be impressed on a multiplex signal existing on an optical fibre, or on individual channels. By using the code multiplex method, it is possible to transmit to individual network elements or to all network elements within an

optical network on a selective basis, using the signaling and control information. Because of the fact that the percentage modulation of the CDMA signal is less than that of the useful information signal, the useful information signal remains essentially unchanged. Furthermore, it is an advantage that the control signal is independent of synchronization relative to the useful information signal, which is to say that the CDMA signal can be transmitted at a transmission rate other than that used for the useful information.

For a detailed description of the CDMA method, see R.C. Dixon: *Spread Spectrum Systems*, John Wiley and Sons, 1996; and A.J. Viterbi, *CDMA Principals of Spread Spectrum Communications*, Addison-Wesley, 1995.

It is also advantageous that a network element can be identified (addressed) by way of a predetermined code. This code can be unipolar or bipolar or, if desired, multistage. When the CDMA method is used, a bit of the signaling and control information that is to be transmitted is linked to a code word, so that a code sequence made up of a plurality of chips results. The individual bits of the code sequence are referred to as "chips" in order to avoid confusion with the bits of the signaling and control information. These can be addressed by associating the code words with individual network elements. Thus, it is possible to address individual network elements. To this end, a

corresponding codeword is uniquely associated by way of software to the network element that is to be addressed. A number of such codewords will be required in order to be able to address a plurality of network elements of an optical network, with at least one codeword being uniquely associated with a network element. However, for example, it is also possible to assign two codewords to one network element, and these will then represent the information "0" or "1." It is preferred that the individual code words of the corresponding network elements be orthogonal to each other, several code words then forming a so-called code family. By using an appropriate chip number (code-word length) it is possible to address nearly any number of network elements.

If a CDMA coded bit of the signaling and control information is to be transmitted to a network element that has the corresponding codeword in its software, the bit can be identified in that initially both codewords are multiplied chip-by-chip and then the individual results of this multiplication are added. Thus, for example, in the case of a 4-chip codeword, the total of 4 is possible as the maximal sum. It is possible that individual chips will not be clearly identified or will even be lost because of transmission errors, or as a result of noise. The loss of a chip means that only the sum of three will be computed as the sum. However here, too, the result will be unambiguous since, for example, a chip-by-chip multiplication and subsequent addition with a false codeword that is orthogonal to the correct

one results in a 0. Because of this, unambiguous association of a bit of the signaling and control information to a network element is possible. Furthermore, the chip-by-chip multiplication and subsequent addition results in a so-called coding gain, for the bit that originally had the value 1 is assigned the value 4 because of CDMA coding and subsequent decoding. This improves the signal-to-noise ratio, which is to say that a coding gain is achieved. In addition, it is also possible, in an advantageous way, to transmit particularly important signaling and coding information on a priority basis by selecting a preselectable code.

In a further development of the present invention, a smaller modulation index is selected when the signal of the signaling and control information is impressed on the envelope of the useful symbol by intensity modulation.

In a further, preferred, embodiment of the method, provision is made such that the CDMA coded signal of the signaling and control information and the useful information signal are generated as an aggregate signal in a common network element. This means that both the CDMA coded signal as well as the useful information signal are generated in a common transmitter (modulator). This is done in that the signals that are initially in the form of electrical impulses are converted into optical signals with a suitable device, when the CDMA coded signal is impressed on the

useful information signal. Alternatively, the CDMA coded signal of the signaling and control information can be impressed on the useful information signal generated in a network element by an additional network element.

The aggregate signal that is formed in this way, which consists of the CDMA coded signal and the useful information signal, can be received by another network element. Of course, a plurality of aggregate signals can also be combined to form at least one wavelength multiplex signal.

In one development of the present invention, provision is made such that a supplementary signal that is identical to the aggregate signal or the wavelength multiplex signal is generated at the input of a network element. It is preferred that this be done by means of a so-called monitor coupler. The monitor coupler can be associated with a fibre optic line that carries the wavelength multiplex signal. It is preferred that the monitor coupler be followed by an optical filter element that then filters at least one aggregate signal of an optical channel out of the wavelength multiplex signal. As an alternative, provision can be made such that the monitor coupler be associated with an optically-selective element in which the wavelength multiplex signal is divided up into individual aggregate signals according to the wavelengths that are used. The monitor coupler is then associated with at least one fibre optic line that

carries an aggregate signal. Then, it is possible to dispense with the filter element described heretofore, which is to say that the aggregate signal can be sent directly to a CDMA decoder from the monitor coupler.

The aggregate signal that is now present is picked up by the CDMA decoder. To this end, the decoder is so configured that it picks up only the signals of the signaling and control information. This is possible because of the fact that the useful information is transmitted at a significantly higher transmission rate (M-bit range) than the signal signaling and control information (k-bit range). A comparison of the transmitted codewords with the codeword stored in the CDMA decoder is now performed in the CDMA decoder. In the event of agreement - as described in the introduction - the original bit sequence of the signaling and control information can now be recovered, when it is converted into the electrical range. Then, processing is possible in a suitable, subsequent device. During this processing, on the one hand, the control information for a network element is evaluated and, on the other hand, it is possible for other signaling and control information to be generated, so that additional network elements can be controlled or monitored. Finally, in a further development of the present invention, this new signal of the signaling and control information is again CDMA coded and impressed on the useful information signal. Thus, in an advantageous manner, it is possible to dispense with conversion

of the useful information into the electrical range, which contributes to considerable simplification and cost reduction within the overall network.

In addition, the present invention relates to a device for receiving signaling and control information, this being characterized in that the receiving device of the signaling and control information has at least one monitor coupler and a signaling device. According to the present invention, the monitoring coupler generates a supplementary signal that is identical to the signal comprising signaling and control information and useful information that is to be received, and this is supplied to the CDMA decoder that filters the signaling and control information from this signal and then decodes it; and in that the encoded signaling and control information is supplied to the signaling device that controls the network element. In particular because of the fact that the monitor coupler generates this supplementary signal from which the control information is filtered out in the CDMA decoder it is possible, in a particularly advantageous manner, to dispense with recovery of the useful information, since the signaling and control information is impressed on the useful signal and for this reason can be easily separated from it.

In another development of the device according to the present invention, provision is made such that a transmitter device with

a code multiplex coder is associated with the device. Because of this, it is possible to code the information generated in the signalling device again, so that it can ultimately be impressed on the useful information signal by addition, with a modulator.

In accordance with a first broad aspect, the invention provides a method for optically transmitting signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element, in which the useful information is transmitted in one or a plurality of channels, the signalling and control information and the useful information being transmitted in the form of a digital signal, the signalling and control information being transmitted by a code division multiplex method (CDMA) in the form of a CDMA signal of the signalling and control information, wherein the CDMA signal of the signalling and control information is impressed additively on a signal of the useful information, a percentage modulation of the CDMA signal of the signalling and control information being smaller than a percentage modulation of the signal of the useful information; and wherein a code used for the code multiplex method is unipolar or bipolar.

In accordance with a second broad aspect, the invention provides a method for optically transmitting signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element, in which the useful information is transmitted in one or a plurality of channels, the signalling and control information and the useful information being transmitted in the form of a digital signal, the signalling and control information being transmitted by a code division multiplex method (CDMA) in

the form of a CDMA signal of the signalling and control information, wherein the CDMA signal of the signalling and control information is impressed additively on a signal of the useful information, a percentage modulation of the CDMA signal being smaller than a percentage modulation of the signal of the useful information; and wherein the signal of the signalling and control information is impressed on an envelope of a signal from at least one channel of the useful information by intensity modulation.

In accordance with a third broad aspect, the invention provides a method for optically transmitting signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element, in which the useful information is transmitted in one or a plurality of channels, the signalling and control information and the useful information being transmitted in the form of a digital signal, the signalling and control information being transmitted by a code division multiplex method (CDMA) in the form of a CDMA signal of the signalling and control information, wherein the CDMA signal of the signalling and control information is impressed additively on a signal of the useful information, a percentage modulation of the CDMA signal being smaller than a percentage modulation of the signal of the useful information; and wherein the CDMA signal of the signalling and control information and the signal of the useful information are generated as an aggregate signal in a component group of a network element.

In accordance with a fourth broad aspect, the invention provides a method for optically transmitting signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element, in which

the useful information is transmitted in one or a plurality of channels, the signalling and control information and the useful information being transmitted in the form of a digital signal, the signalling and control information being transmitted by a code division multiplex method (CDMA) in the form of a CDMA signal of the signalling and control information, wherein the CDMA signal of the signalling and control information is impressed additively on a signal of the useful information, a percentage modulation of the CDMA signal being smaller than a percentage modulation of the signal of the useful information; and wherein the CDMA signal of the signalling and control information is impressed on the signal of the useful information generated in a network element by a modulator.

In accordance with a fifth broad aspect, the invention provides a method for optically transmitting signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element, in which the useful information is transmitted in one or a plurality of channels, the signalling and control information and the useful information being transmitted in the form of a digital signal, the signalling and control information being transmitted by a code division multiplex method (CDMA) in the form of a CDMA signal of the signalling and control information, wherein the CDMA signal of the signalling and control information is impressed additively on a signal of the useful information, a percentage modulation of the CDMA signal being smaller than a percentage modulation of the signal of the useful information; and wherein an aggregate signal consisting of the CDMA signal of the signalling and control information and the signal of the useful information is received by at least one network element.

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In accordance with a sixth broad aspect, the invention provides a method for optically transmitting signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element, in which the useful information is transmitted in one or a plurality of channels, the signalling and control information and the useful information being transmitted in the form of a digital signal, the signalling and control information being transmitted by a code division multiplex method (CDMA) in the form of a CDMA signal of the signalling and control information, wherein the CDMA signal of the signalling and control information is impressed additively on a signal of the useful information, a percentage modulation of the CDMA signal being smaller than a percentage modulation of the signal of the useful information; and wherein the signalling and control information is recovered if a transmitted codeword with which one bit of the signal of the signalling and control information is linked corresponds unambiguously with a codeword stored in a receiver.

In accordance with a seventh broad aspect, the invention provides a receiving device for signalling and control information transmitted by a code division multiplex method (CDMA) in the form of a CDMA signal of the signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element, in which the useful information is transmitted in one or a plurality of channels, the CDMA signal of the signalling and control information and a signal of the useful information being transmitted in the form of a digital signal, and the CDMA signal of the signalling and control information being impressed additively on the signal of the useful information

with a percentage modulation on the CDMA signal of the signalling and control information being smaller than a percentage modulation of the signal of the useful information, the receiving device incorporating a CDMA decoder, wherein the receiving device has at least one monitor coupler and a signalling device; wherein the monitor coupler generates a supplementary signal that is identical to a signal comprising the signalling and control information and the useful information, which is passed to the CDMA decoder that filters the signalling and control information from the supplementary signal and then decodes the signalling and control information into decoded signalling and control information; and wherein the decoded signalling and control information is passed to the signalling device that controls the at least one network element.

The present invention will be described in greater detail below on the basis of the drawings appended hereto. These drawings show the following:

Figure 1: the part of an optical network for transmitting useful information;

Figure 2: a block circuit diagram of a network element;

Figure 3: a first embodiment of a receiving device of the network element as shown in Figure 2;

Figure 4: a further embodiment of a receiving device;

Figure 5: a third embodiment of a receiving device;

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Figure 6: a first embodiment of a transmitting device of the network elements as in Figure 2;

Figure 7: a second embodiment of a transmitting device;

Figure 8: a third embodiment of a transmitting device;

Figure 9: a fourth embodiment of a transmitting device;

Figure 10: one embodiment of an optically selective element.

Figure 1 shows sections of an optical network one that includes the network elements 2a to 2g. The network elements 2a to 2f are designated as network nodes. The network element 2g is an optical amplifier 3, for example. The individual network

elements 2a to 2g are connected to each other by fibre optic lines 4. The network element 2a can be configured as in-feed 5, which contains only a transmitting device for optical signals.

Figure 2 shows the network element 2e. It is connected to only two optical fibre lines 4; hereinafter, it will be assumed, purely as an example, that the network element 2e has an input 6 and an output 7 to which the optical fibre lines 4 are connected. The network element 2e includes an optically-selective element 8 as well as a signaling device 9, which are used to evaluate and process the signaling and control information. It can be seen that the signaling device 9 incorporates an input 10 and output 11. A receiving device 12 is associated with the network element 2e, and this is arranged between the element 8 and the input 10 of the signaling device 9 (Figure 3).

The receiving device 12 for signaling and control information comprises a monitor coupler 13 (monitor branch), an optical wavelength-selective element, in particular filter 14, a receiver 15 that permits optical/electrical conversion of a signal, and a CDMA decoder 16. The receiving device 12 is connected to the input 10 of the signaling device 9. As has already been discussed, the element 8 is connected to a fibre optic line 4 both at input 6 and at output 7. The monitor coupler 13 is associated with the input 6 of the element 8, and is connected to the filter 14 by way of a fibre optic line 4' that is once again

connected to the receiver 15 by way of another fibre optic line 4'. The receiver 15 converts an optical signal into an electrical signal and passes this to the CDMA decoder 16 by way of a line 4''. The CDMA decoder 16 is connected conductively to the signaling device 9.

The operation of the receiving device will be described in greater detail below on the basis of Figure 3, proceeding from the fact that a wavelength multiplex signal of wavelength λ_1 to λ_n is supplied to the network elements 2a, this wavelength multiplex signal being accessible at the input 6 of the optical element 8.

By power division, for example, the monitor coupler 13 generates two wavelength multiplex signals of wavelength λ_1 to λ_n that are identical to each other, one part of the signal reaching the element 8 and the other part of the signal being sent to the filter 14 by way of the fibre optic line 4'. The filter 14 is so configured that it preferably only filters out a wavelength λ_i from the wavelength multiplex signal. Thus, at the output of the filter 14 there is an aggregate signal of wavelength λ_i and this is passed to the receiver 15 on the fibre optic line 4'. The receiver 15 converts the aggregate signal into an electrical signal and passes this to the CDMA decoder 16 by way of the line 4''. The CDMA decoder 16 is, in particular, so configured that does not identify the signal of the useful information, which can

be achieved, for example, in that it incorporates a filter function with which it is possible to identify only the CDMA coded signal of the signaling and control information from the output signal. This is possible in that the useful information is transmitted at a significantly higher data rate than the signaling and control information, so that an electrical filter element can be used here. Because of this, the signaling and control information can be transmitted asynchronously relative to the useful signal.

Within CDMA decoder 16, a codeword is stored under software control and this serves, as it were, as a key for the signaling and control information that is intended for this network element 2e, and this can be decoded thereby. Once the signaling and control information has been decoded, it is passed on to the signaling device 9. This evaluates this information and controls the network element 8, for example. Control of this can kind can then be provided if the network element 2e has an additional output. Then, it is possible to split the wavelength multiplex signal into different part-signals after the input 6, with the part-signals then being passed to the outputs. Thus, the element 8 fulfils a kind of switching function for the wavelength multiplex signal. The division of the wavelength multiplex signal, which is to say, the decision as to which wavelengths are to be made available at which output, is controlled by the

signaling device on the basis of the signaling and control information that is made available to it.

In Figure 4, purely as an example, the network element 2b is used for a further example of the receiving device. This incorporates an element 8' that has an input 6 and two outputs 7 and 7'. The wavelength multiplex signal with the wavelength λ_1 to λ_n is present at the input 6. The element 8' splits this wavelength multiplex signal up such that only one signal is present at the output 7, this being of wavelength λ_i. Therefore, there is a single aggregate signal present here and this is once again split into two identical part-signals by the monitor coupler 13. One part-signal passes on fibre optic line 4' to the receiver 15, that once again effects a conversion from the optical range into the electrical range, and passes the electrical signal to the CDMA decoder 16. As already described, the CDMA decoder is conductively connected to the signaling device 9. The other part signal is passed at the output 7' by way of the fibre optic line 4 to the network element 2g, amplified in this, and then passed on to the network node 2d.

In the embodiments shown in Figure 4, the signaling and control information is decoded in the same way as in the embodiment shown in Figure 3, it being possible to dispense with only the filter 14, since there is no wavelength multiplex signal at the monitor coupler 13, but only an aggregate signal has to be tapped off.

In Figure 4, it can also seen that the network element 2g is connected to the signaling device 9. This connection can be made either by way of existing fibre optic lines, or it can be effected by a radio connection or an electrical line. As has already been discussed, the network element 2g is an optical amplifier 3 that can amplify an optical signal that has been attenuated by line losses in the fibre optic line. As an example, the degree of amplification provided by the amplifier 3 can be regulated by the signaling device 9 although, on the other hand, it is also possible to pass on error messages from the amplifier 3 to the signaling device 9. These error messages can be called up, preferably at the location of the network elements 2b, so that repairs or maintenance operations can be initiated. As has been discussed above, the signalling device 9 shown in Figure 4 controls the optically selective element 8'.

Figure 5 shows an embodiment that incorporates an element 8'', to the input 6 of which the wavelength multiplex signal is passed. The element 8'' incorporates an optical/electrical converter 17 that converts the wavelength multiplex signal into an electrical signal. The output 7 of the element 8'' is an electrical line 18 from which a branch 19 is conductively connected to the CDMA decoder 16. The CDMA decoder operates as has been described above, so that it is possible to dispense with a description of this at this point.

After the branch 19, the electrical line 18 passes to a modulator (not shown herein) that converts the electrical signal back into an optical signal.

A modulator of this type is shown in Figure 6A. Once the signalling device 9 has received the signalling and control information, evaluated this, and -- possibly -- generated new signalling and control information, this is passed to the output 11 of the signalling device 9 of a transmitting device 25 by way of an electrical connecting line 22, the transmitting device 25 incorporating a CDMA coder 21. The CDMA coder 21 links the individual bits of the signalling and control information with a codeword, so that it can be associated with a further network element. CDMA coding is followed by passage on electrical connecting line 22' to a junction 23, so that an aggregate signal can be passed to the modulator 20 in electrical form. The modulator 20 incorporates an electrical/optical converter 24 that converts the electrical aggregate signal into an optical signal. The signal of the signalling and control information has already been impressed on the aggregate signal. It is passed to the network 1 by way of the fibre optic line 4.

As is shown in Figure 6B, as an alternative, in place of the modulator 20 there is an element 8''' that has an electrical connection on the input side. Electrical/optical conversion into a signal that is then passed to the network 1 by way of a fibre

optic line 4 takes place within the element 8'''. Reference should be made to Figure 6A for the description of the transmitting device 25.

Figure 7 shows a modulator 20', with which it is possible to impress a signal originating from the transmitting device 25 with signalling and control information onto an optical signal which has been made available to it by way of the fibre optic line 4, by addition. The useful information is transmitted with this signal. Because of the addition of the two signals, there will be an aggregate signal at the output 26 of the modulator, and this signal is then supplied to the element 8 by way of the input 6. At its output 7, the aggregate signal is once again passed to the network 1 by way of the fibre optic line 4.

Figure 8 shows another version of a transmitting device 25. The transmitting device 25 has an optical source 27 that converts th- CDMA coded information from the signalling device 9 or from the CDMA coder 21 into optical signals. The signalling and control information is injected into the fibre optic line 4 through a fibre optic line 4' by way of a coupler 28. Because of this, an aggregate signal can be transmitted to the element 8, said signal containing the useful information and the signalling and control information.

As an alternative to Figure 8, provision can be made such that a modulator 20'' follows an element 8, this serving to impress CDMA coded signalling and control information from the transmitting device 25 on to the useful signal so that it can be passed through the fibre optic line 4 to the network 1 as an aggregate signal (see Figure 9). Identical parts, or those that fulfill the same functions as described in the preceding descriptions, bear the same reference numbers.

Figure 10 shows an optically selective element 8a that--unlike the optically selective element 8--has two inputs 6 and two outputs 7. At one input 6, there is a wavelength multiplex signal with the wavelengths λ_1 to λ_n by way of the fibre optic line 4. At the other input 6, there is another wavelength multiplex signal with the wavelengths λ_{n+1} to λ_m. In the following description, purely as an example and for the purpose of simplification, it is assumed that at each input 6 of the element 8a there is a wavelength multiplex signal that is made up solely of two different wavelengths. As an example, these are the wavelengths λ_1 and λ_2, as well as the wavelengths λ_3 and λ_4. The wavelength multiplex signal (λ_1, λ_2) can be accessed through a monitor coupler 13. It is preferred that the monitor coupler 13 be connected to the filter 14, as is shown in Figure 3. To this extent, reference should be made to be appropriate description for details covering the way in which this signal is processed.

The element 8a serves to separate the individual channels of wavelength multiplex signals from each other and/or to swap them with each other. To this end, at each input 6 it has a device 29 that is provided so as to make the individual wavelengths of a multiplex signal available in separated form. A coupler 30 that follows the device 29 makes it possible to distribute the individual channels from the signalling and control information once again, depending on the control parameters. In other words, once the multiplex signals have been separated into individual aggregate signals, wavelength conversion of the desired aggregate signals takes place in the coupler 30. Because of this, it is possible that, although there is a wavelength multiplex signal with the wavelengths λ_1 and λ_2, and a further wavelength multiplex signal with the wavelengths λ_3 and λ_4 at the outputs, in the output side for example, there is the information of the input side wavelength λ_3. The output side wavelength λ_{3a} then preferably contains the input information of the input side wavelength λ_1.

An additional monitor coupler 31 is associated with the element 8a that here, purely as an example, is associated with the line of wavelength λ_4. Such a monitor coupler 31 can also be associated with a plurality of lines within the element 8a.

Of course, it is possible to provide the element 8a with more than two inputs and outputs, the number of the inputs preferably corresponding to the number of outputs.

The element 8a that is described in Figure 10 can, of course, be modified according to the preceding descriptions. For example, it has an electrical input and an optical output or vice versa, so that this element 8a can be used in all of the embodiments described heretofore.

Finally, it should be noted that all the receiving devices and transmitting devices can be combined as desired after appropriate modification.

28030-59

CLAIMS:

1. Method for optically transmitting signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element, in which the useful information is transmitted in one or a plurality of channels, the signalling and control information and the useful information being transmitted in the form of a digital signal, the signalling and control information being transmitted by a code division multiplex method (CDMA) in the form of a CDMA signal of the signalling and control information, wherein the CDMA signal of the signalling and control information is impressed additively on a signal of the useful information, a percentage modulation of the CDMA signal of the signalling and control information being smaller than a percentage modulation of the signal of the useful information; and

wherein a code used for the code division multiplex method is unipolar or bipolar.

2. Method as defined in Claim 1, wherein the code is a multi-stage code.

3. Method as defined in any one of Claims 1 and 2, wherein the signal of the signalling and control information is impressed on an envelope of a signal from at least one channel of the useful information by intensity modulation.

4. Method for optically transmitting signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element, in which the useful information is transmitted in one or a plurality of channels, the signalling and control information and the useful

information being transmitted in the form of a digital signal, the signal of the signalling and control information being transmitted by a code division multiplex method (CDMA) in the form of a CDMA signal of the signalling and control information, wherein the CDMA signal of the signalling and control information is impressed additively on a signal of the useful information, a percentage modulation of the CDMA signal of the signalling and control information being smaller than a percentage modulation of the signal of the useful information; and

wherein the signal of the signalling and control information is impressed on an envelope of a signal from at least one channel of the useful information by intensity modulation.

5. Method as defined in any one of Claims 1 to 4, wherein the CDMA signal of the signalling and control information and the signal of the useful information are generated as an aggregate signal in a component group of a network element.

6. Method for optically transmitting signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element, in which the useful information is transmitted in one or a plurality of channels, the signalling and control information and the useful information being transmitted in the form of a digital signal, the signalling and control information being transmitted by a code division multiplex method (CDMA) in the form of a CDMA signal of the signalling and control information, wherein the CDMA signal of the signalling and control information is impressed additively on a signal of the useful information, a percentage modulation of the CDMA

signal of the signalling and control information being smaller than a percentage modulation of the signal of the useful information; and

wherein the CDMA signal of the signalling and control information and the signal of the useful information are generated as an aggregate signal in a component group of a network element.

7. Method as defined in any one of Claims 1 to 4, wherein the CDMA signal of the signalling and control information is impressed on the signal of the useful information generated in a network element by a modulator.

8. Method for optically transmitting signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element, in which the useful information is transmitted in one or a plurality of channels, the signalling and control information and the useful information being transmitted in the form of a digital signal, the signalling and control information being transmitted by a code division multiplex method (CDMA) in the form of a CDMA signal of the signalling and control information, wherein the CDMA signal of the signalling and control information is impressed additively on a signal of the useful information, a percentage modulation of the CDMA signal of the signalling and control information being smaller than a percentage modulation of the signal of the useful information; and

wherein the CDMA signal of the signalling and control information is impressed on the signal of the useful information generated in a network element by a modulator.

9. Method as defined in any one of Claims 1 to 4, 7, 8, wherein an aggregate signal consisting of the CDMA signal of the signalling and control information and the signal of the useful information is received by at least one network element.

10. The method as defined in any one of Claims 5 and 6 wherein the aggregate signal is received by at least one network element.

11. Method for optically transmitting signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element, in which the useful information is transmitted in one or a plurality of channels, the signalling and control information and the useful information being transmitted in the form of a digital signal, the signalling and control information being transmitted by a code division multiplex method (CDMA) in the form of a CDMA signal of the signalling and control information, wherein the CDMA signal of the signalling and control information is impressed additively on a signal of the useful information, a percentage modulation of the CDMA signal of the signalling and control information being smaller than a percentage modulation of the signal of the useful information; and

wherein an aggregate signal consisting of the CDMA signal of the signalling and control information and the signal of the useful information is received by at least one network element.

12. Method as defined in Claim 9 or 11, wherein when the aggregate signal is received, an additional signal that is identical to it is generated.

13. Method as defined in Claim 12, wherein the useful information is transmitted in a plurality of channels by a wavelength multiplex signal; and wherein the aggregate signal is separated from the wavelength multiplex signal by means of a filter.

14. Method as defined in Claim 13, wherein the signalling and control information is recovered from the aggregate signal with a receiver and a CDMA decoder.

15. Method as defined in any one of Claims 1 to 14, wherein the signalling and control information is recovered if a transmitted codeword with which one bit of the signal of the signalling and control information is linked corresponds unambiguously with a codeword stored in a receiver.

16. Method for optically transmitting signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element, in which the useful information is transmitted in one or a plurality of channels, the signalling and control information and the useful information being transmitted in the form of a digital signal, the signalling and control information being transmitted by a code division multiplex method (CDMA) in the form of a CDMA signal of the signalling and control information, wherein the CDMA signal of the signalling and control information is impressed additively on a signal of the useful information, a percentage modulation of the CDMA signal of the signalling and control information being smaller than a percentage modulation of the signal of the useful information; and

wherein the signalling and control information is recovered if a transmitted codeword with which one bit of

the signal of the signalling and control information is linked corresponds unambiguously with a codeword stored in a receiver.

17. Method as defined in Claim 15 or 16, wherein the signal of the signalling and control information that has been recovered and processed is again CDMA coded and again impressed on the signal of the useful information.

18. Receiving device for signalling and control information transmitted by a code division multiplex method (CDMA) in the form of a CDMA signal of the signalling and control information for monitoring and controlling single or multi-channel useful information in optical networks with at least one network element, in which the useful information is transmitted in one or a plurality of channels, the CDMA signal of the signalling and control information and a signal of the useful information being transmitted in the form of a digital signal, and the CDMA signal of the signalling and control information being impressed additively on the signal of the useful information with a percentage modulation on the CDMA signal of the signalling and control information being smaller than a percentage modulation of the signal of the useful information, the receiving device incorporating a CDMA decoder, wherein the receiving device has at least one monitor coupler and a signalling device; wherein the monitor coupler generates a supplementary signal that is identical to a signal comprising the signalling and control information and the useful information, which is passed to the CDMA decoder that filters the signalling and control information from the supplementary signal and then decodes the signalling and control information into decoded signalling and control information; and wherein the decoded signalling and control

information is passed to the signalling device that controls the at least one network element.

19. Device as defined in Claim 18, wherein the receiving device incorporates a filter that filters an aggregate signal, consisting of a CDMA signal and a useful information signal, from the supplementary signal.

20. Device as defined in Claim 18 or 19, wherein a transmitting device supplies new signalling and control information generated in the signalling device from the decoded signalling and control information to a network.

21. Device as defined in Claim 20, wherein the transmitting device comprises a CDMA coder that CDMA codes the new signalling and control information.

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PATENT AGENTS
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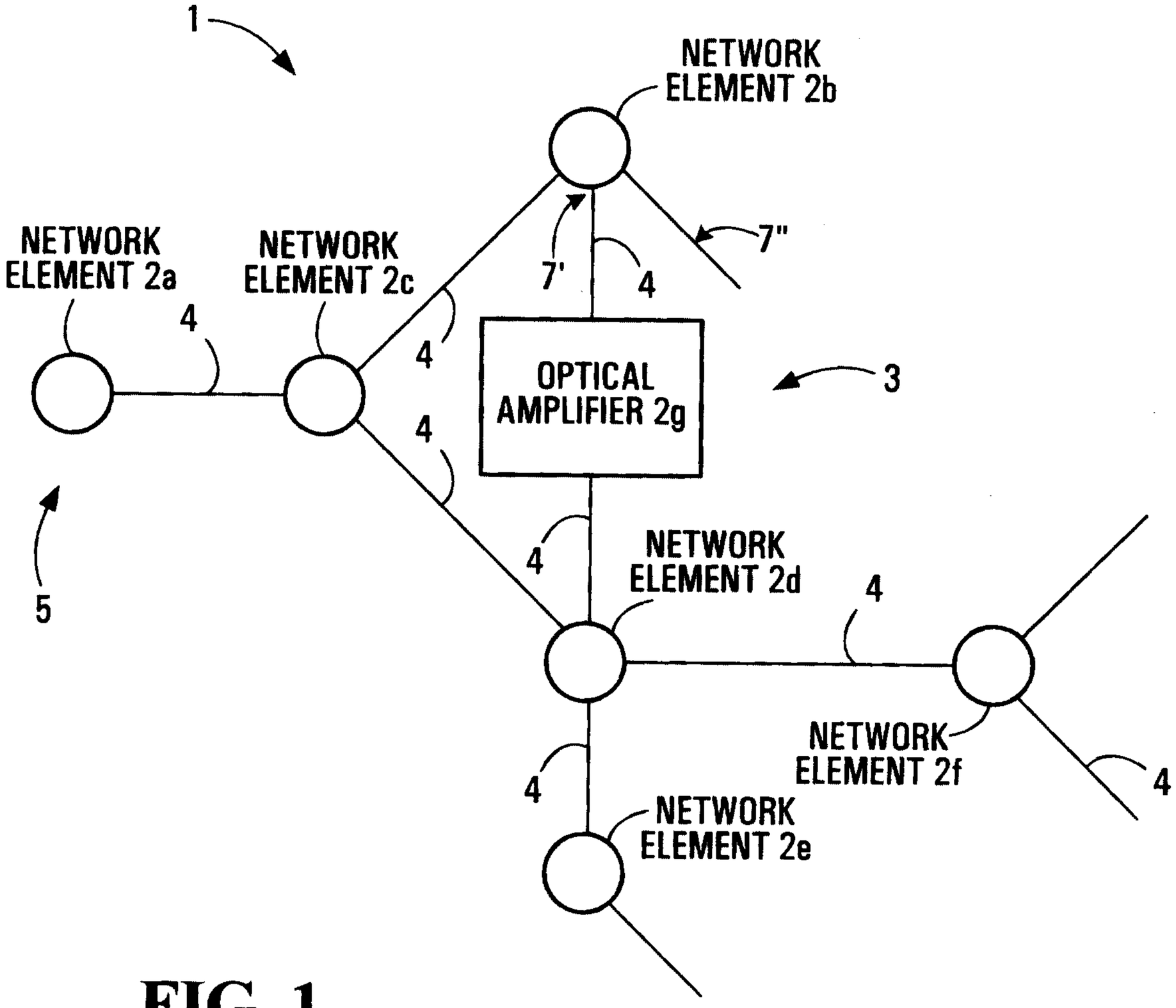

1
NETWORK ELEMENT 2b
NETWORK ELEMENT 2a
NETWORK ELEMENT 2c
7'
4
7"
4
4
4
OPTICAL AMPLIFIER 2g
3
5
4
NETWORK ELEMENT 2d
4
NETWORK ELEMENT 2f
4
4
NETWORK ELEMENT 2e

FIG. 1

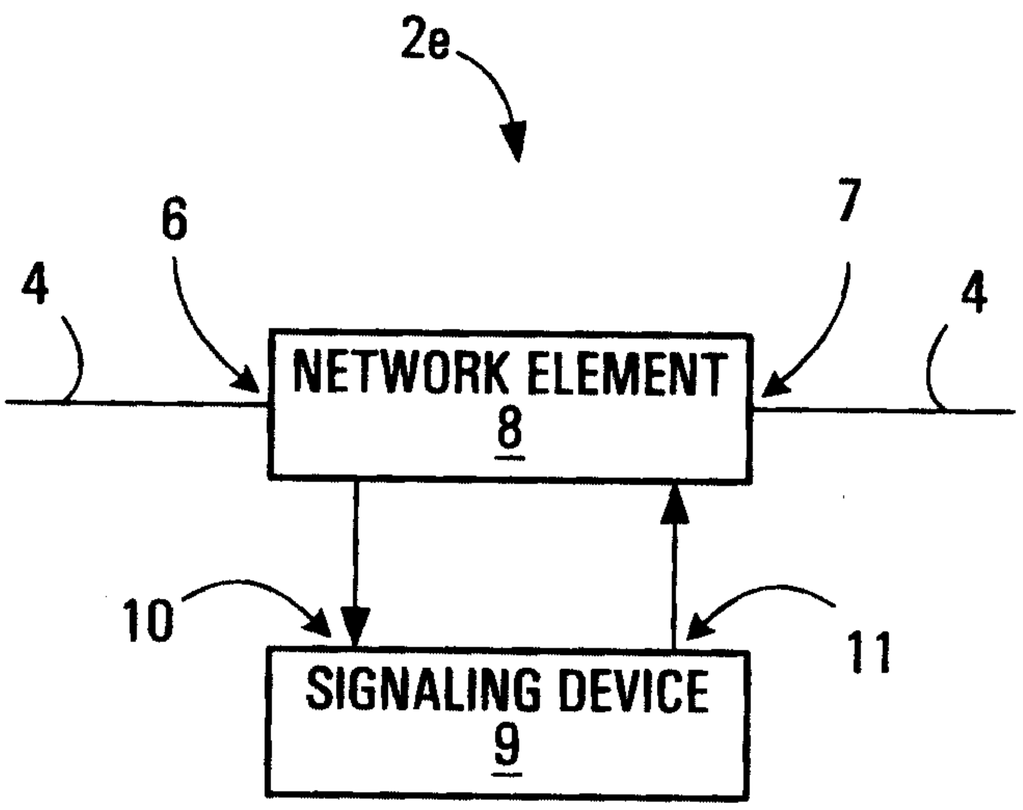

2e
6
7
4
4
NETWORK ELEMENT
8
10
11
SIGNALING DEVICE
9

FIG. 2

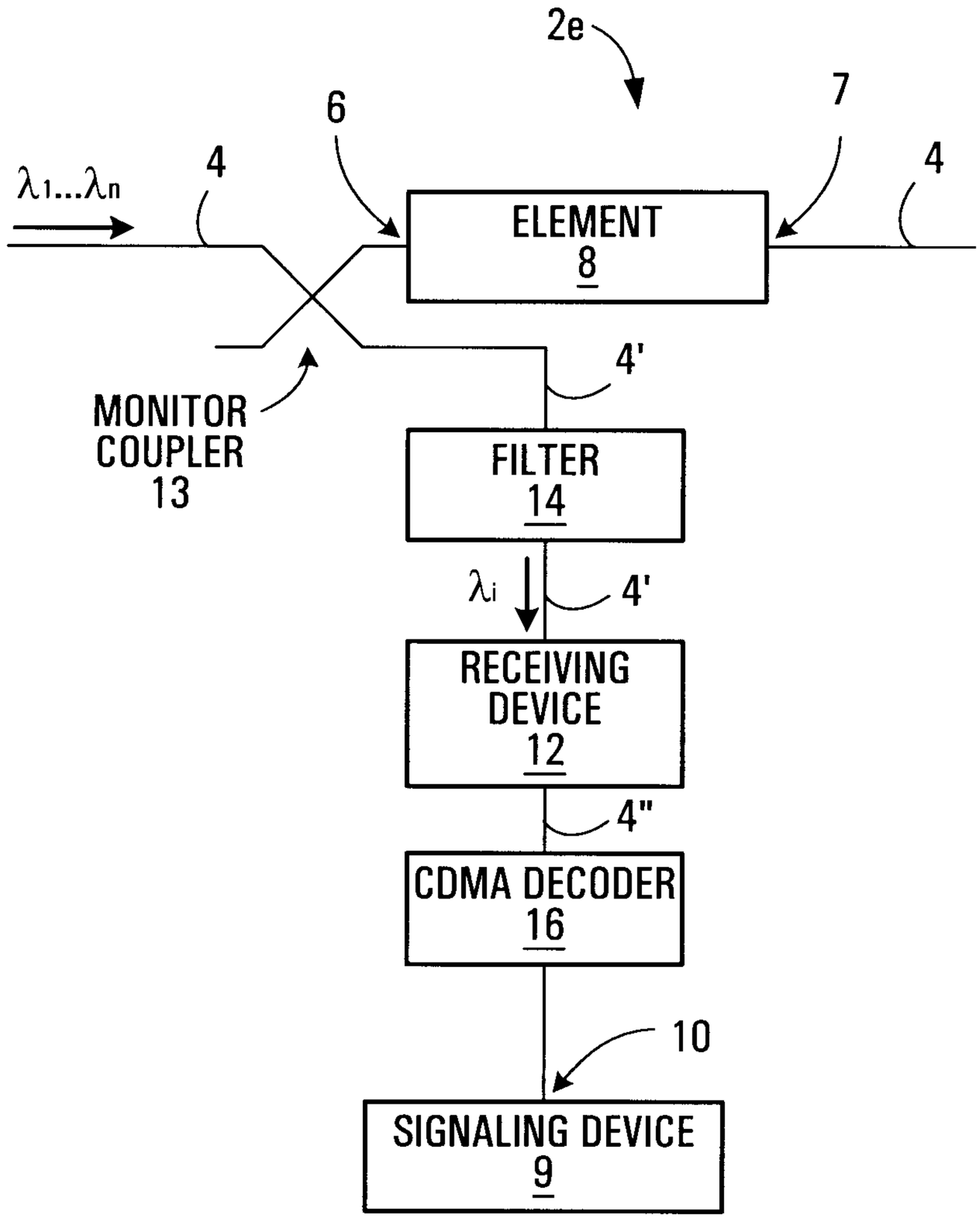

2e
6
7
4
4
λ1...λn
ELEMENT
8
4'
MONITOR
COUPLER
13
FILTER
14
λi
4'
RECEIVING
DEVICE
12
4"
CDMA DECODER
16
10
SIGNALING DEVICE
9

FIG. 3

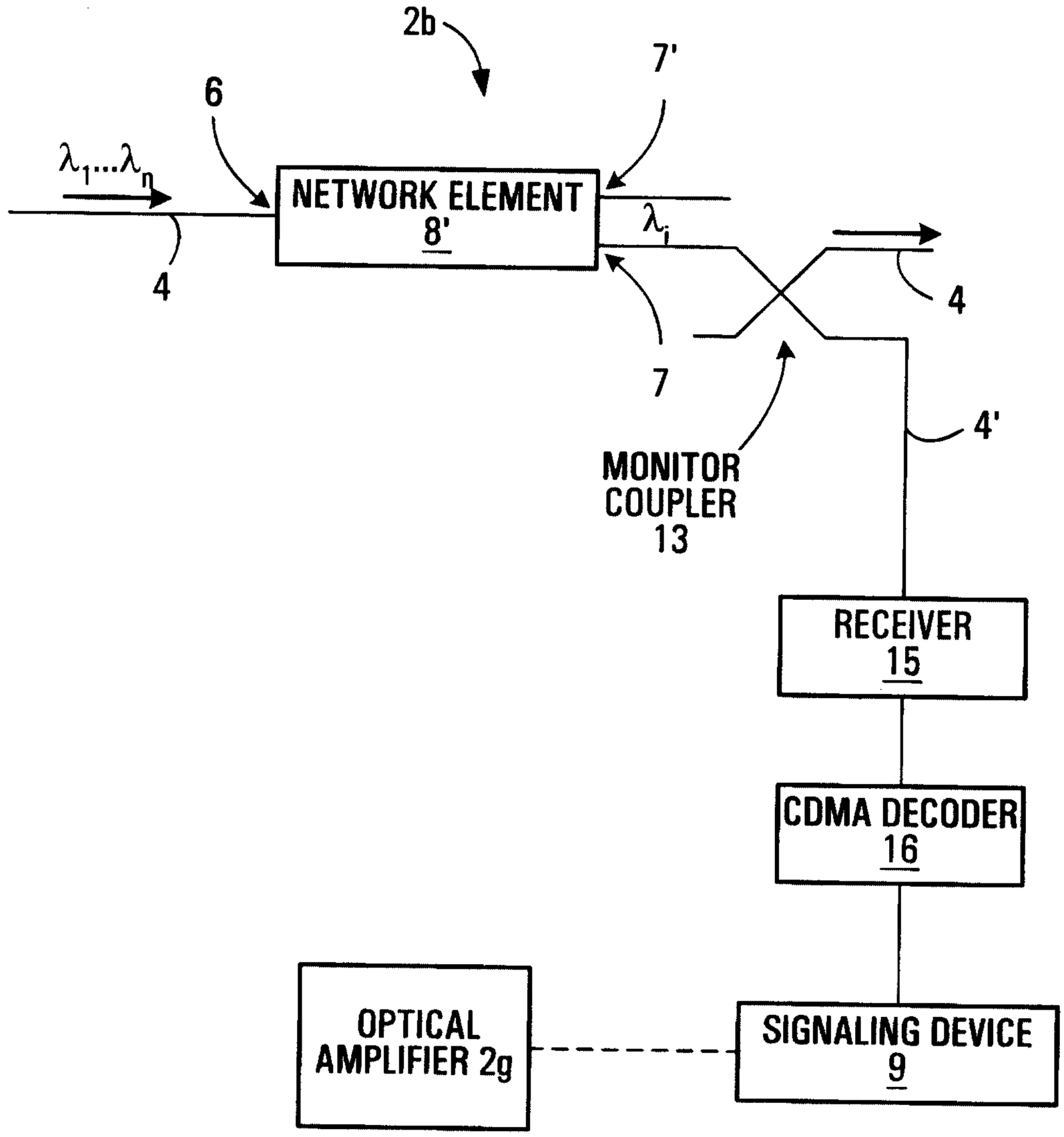

2b
6
7'
$\lambda_1 \ldots \lambda_n$
NETWORK ELEMENT
8'
λ_i
4
4
7
4'
MONITOR
COUPLER
13
RECEIVER
15
CDMA DECODER
16
OPTICAL
AMPLIFIER 2g
SIGNALING DEVICE
9

FIG. 4

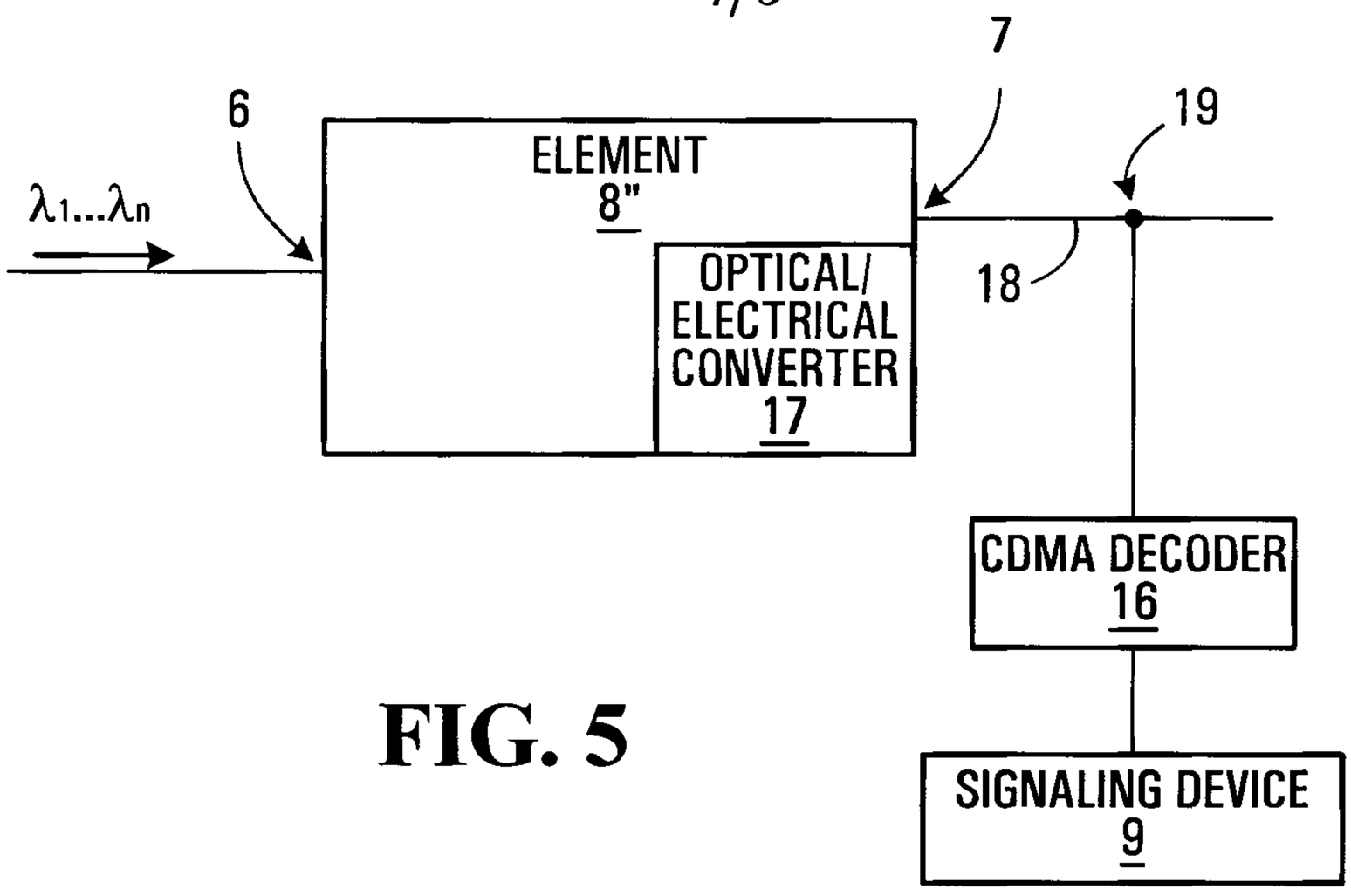


FIG. 5

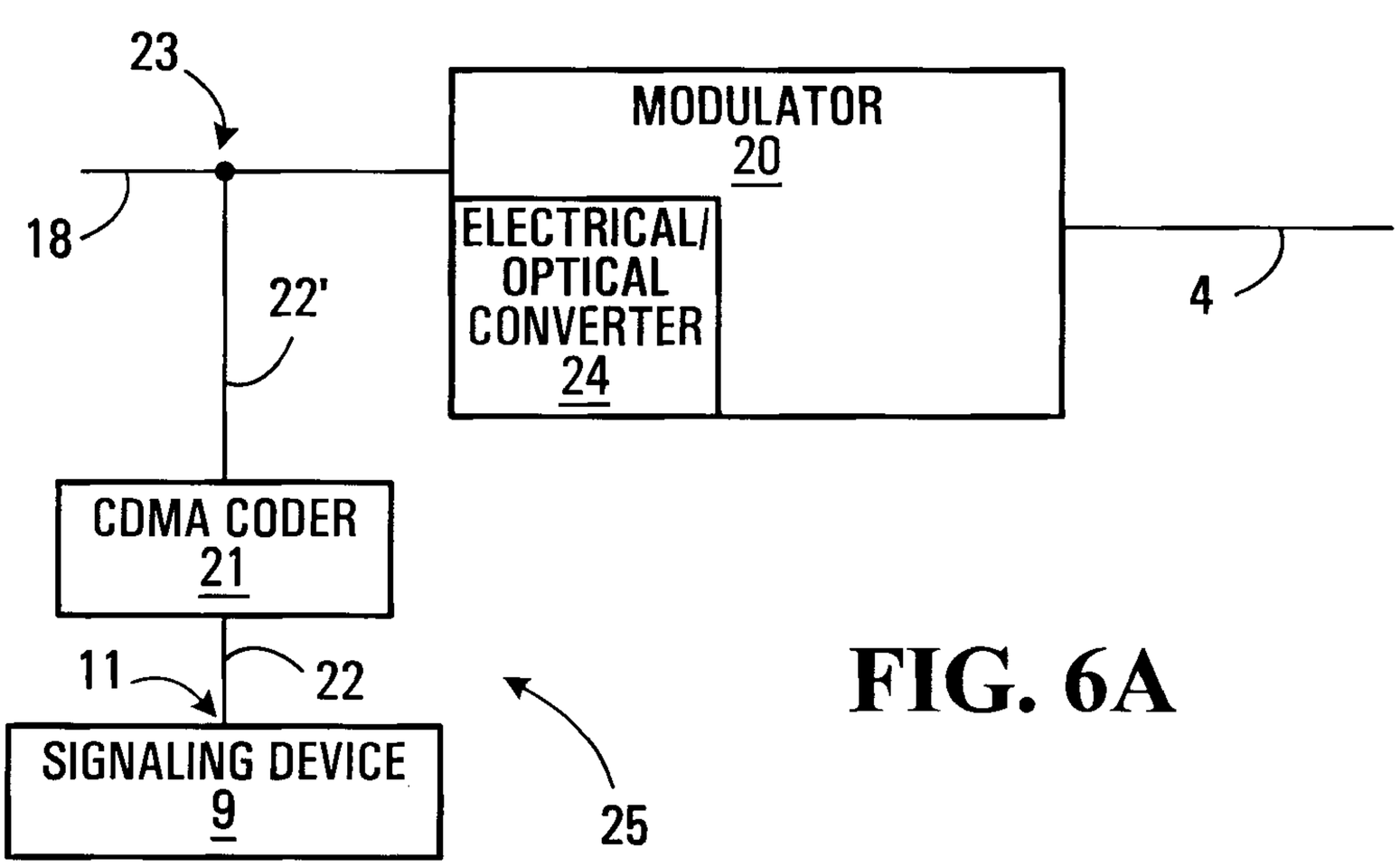


FIG. 6A

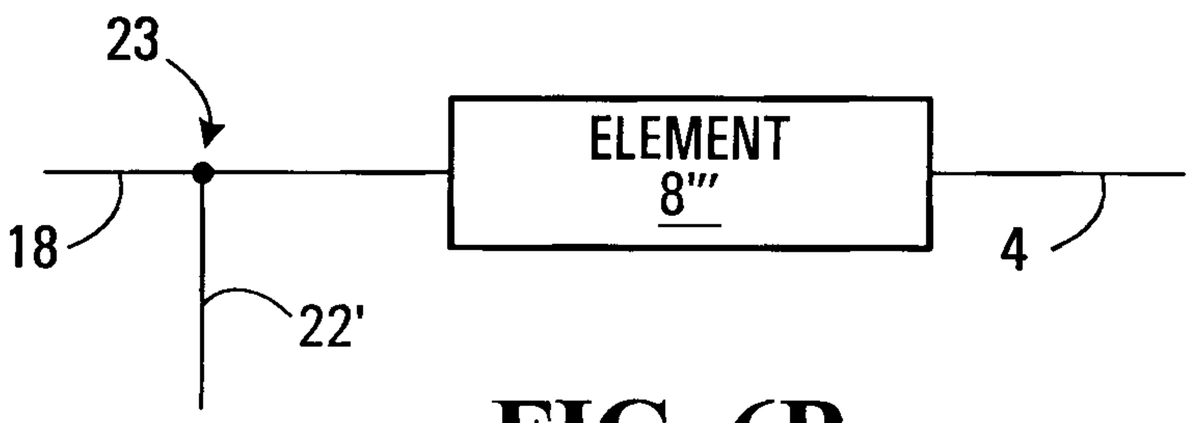


FIG. 6B

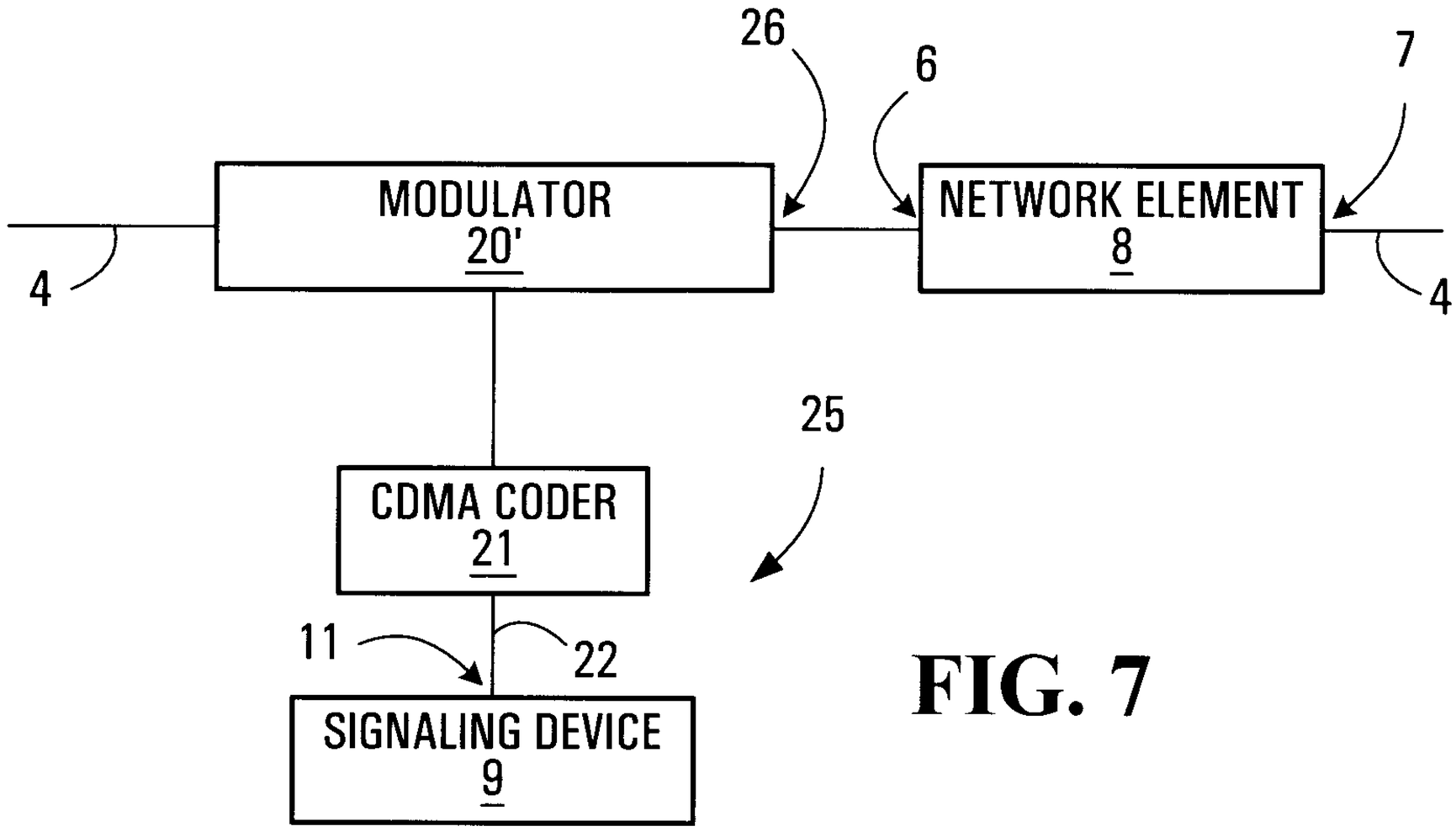

26
6
7
MODULATOR
20'
NETWORK ELEMENT
8
4
4
25
CDMA CODER
21
11
22
SIGNALING DEVICE
9

FIG. 7

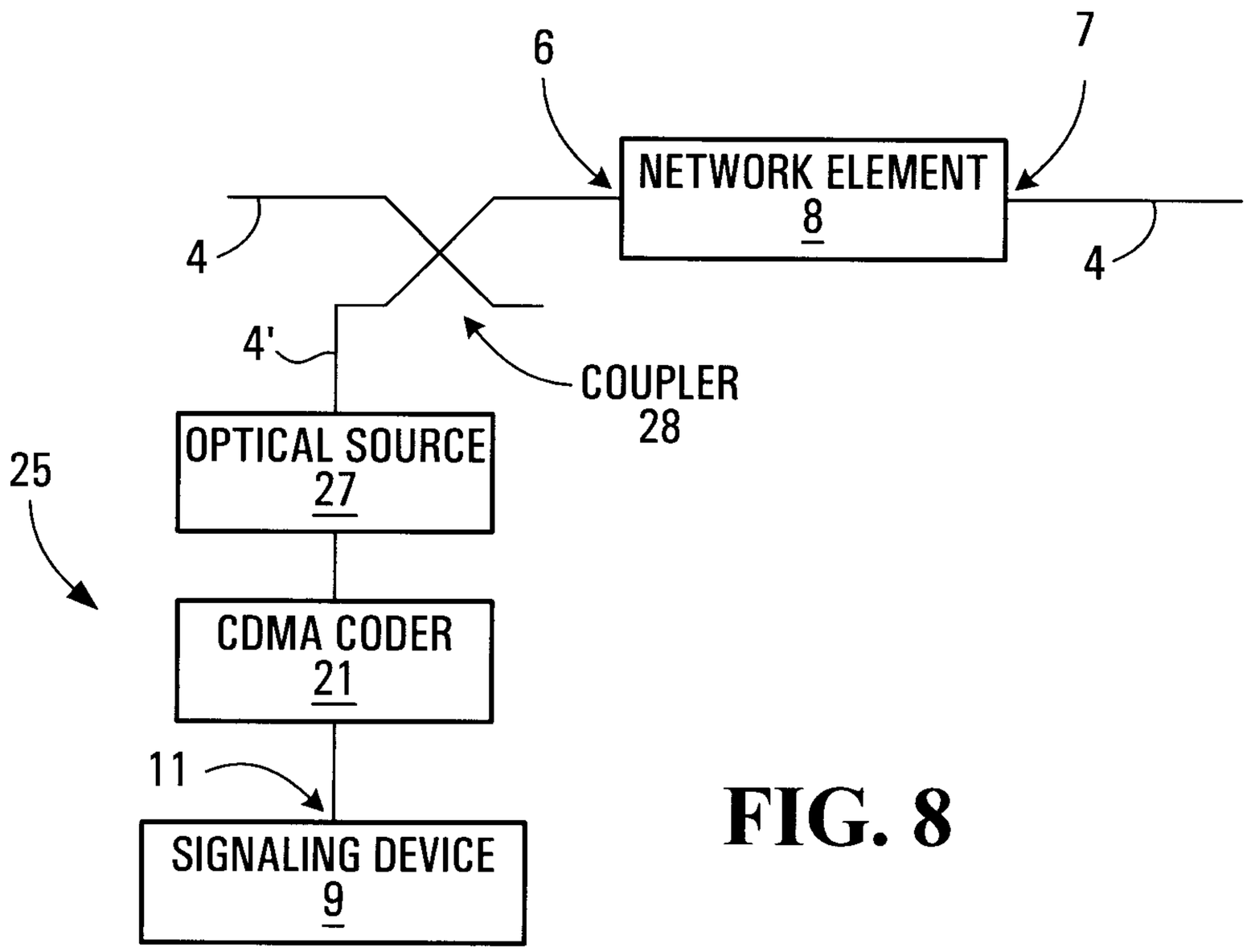

6
7
NETWORK ELEMENT
8
4
4
4'
COUPLER
28
OPTICAL SOURCE
27
25
CDMA CODER
21
11
SIGNALING DEVICE
9

FIG. 8

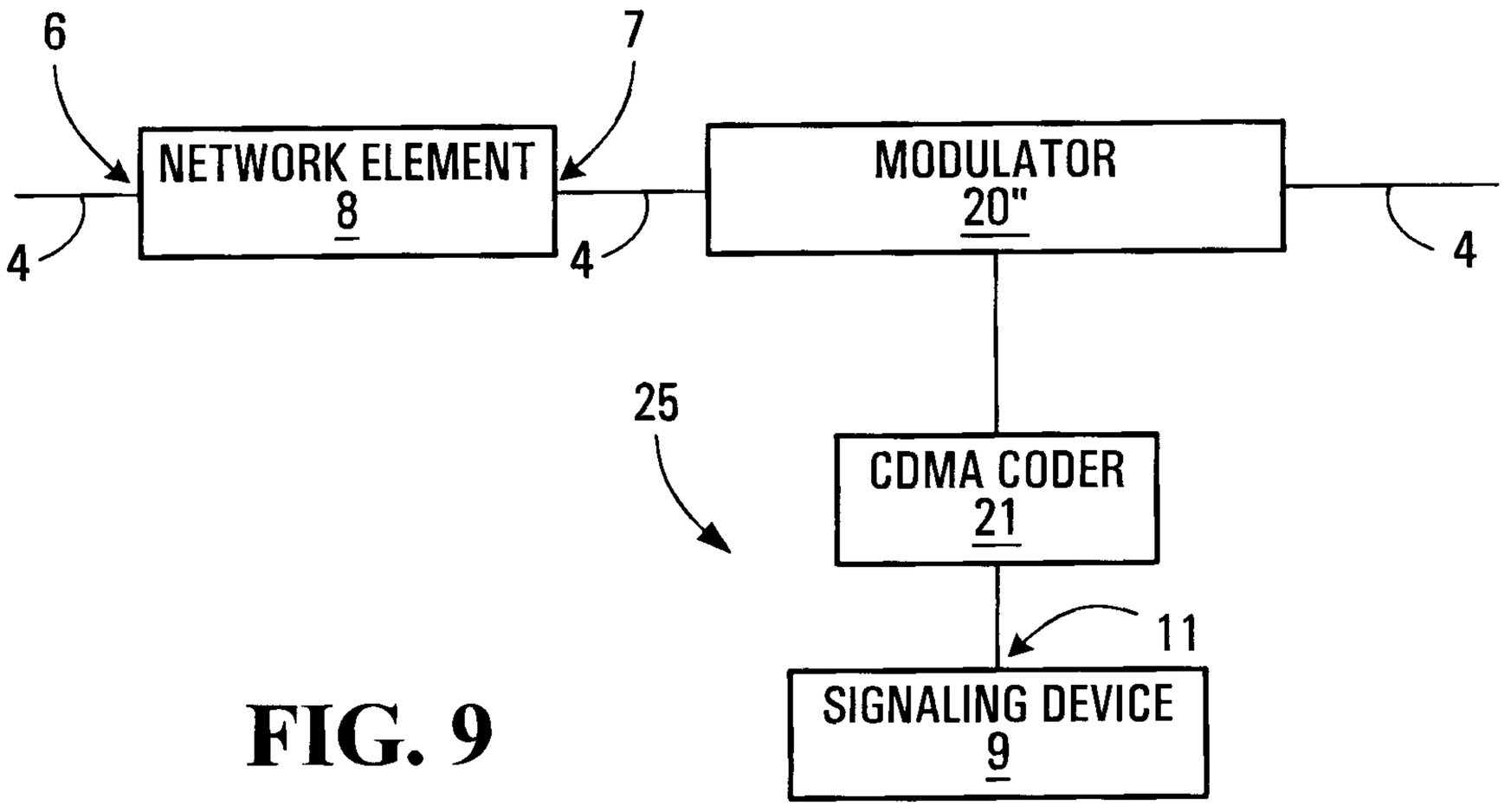

6
7
NETWORK ELEMENT
8
MODULATOR
20"
4
4
4
25
CDMA CODER
21
11
SIGNALING DEVICE
9

FIG. 9

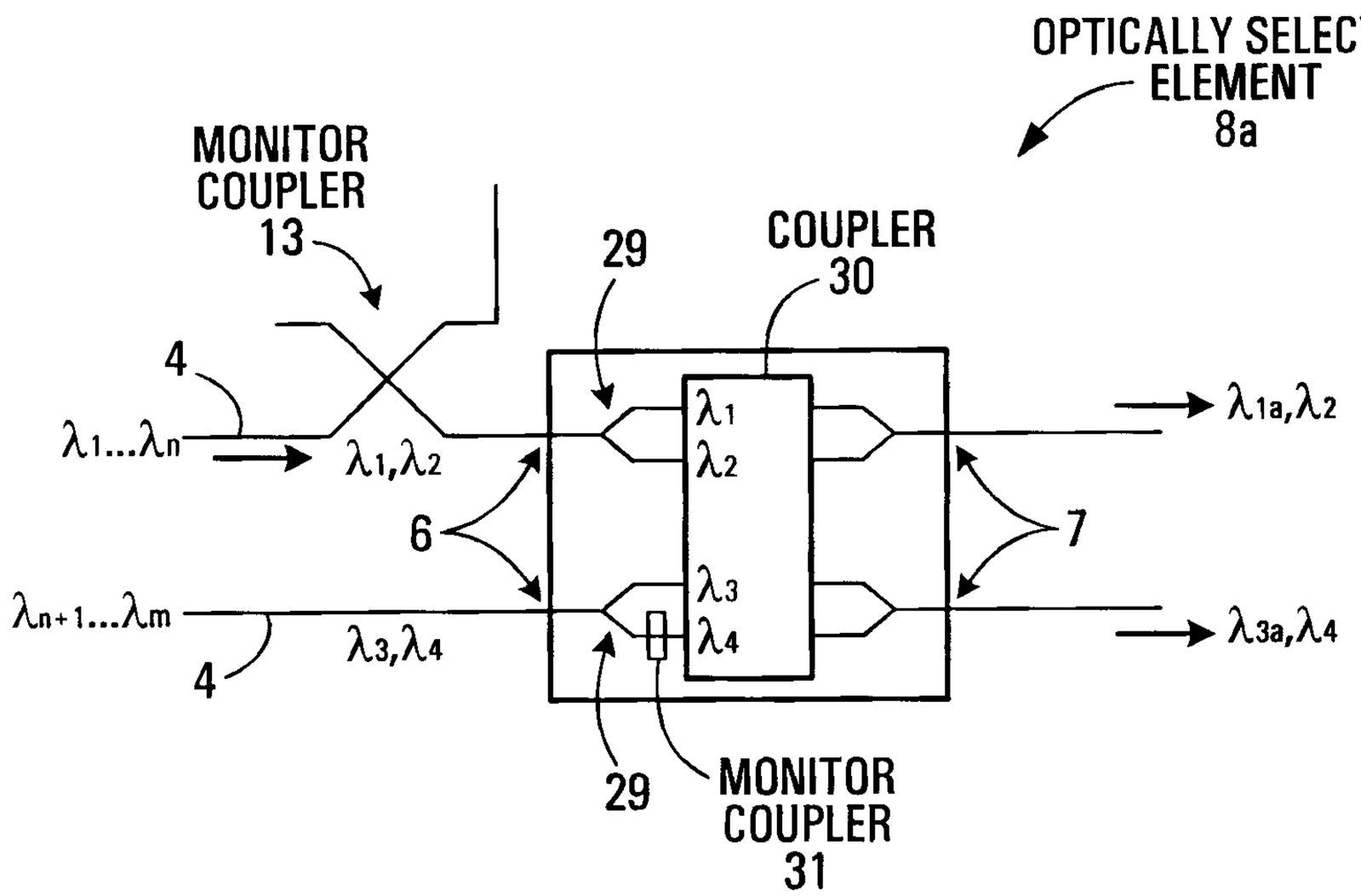
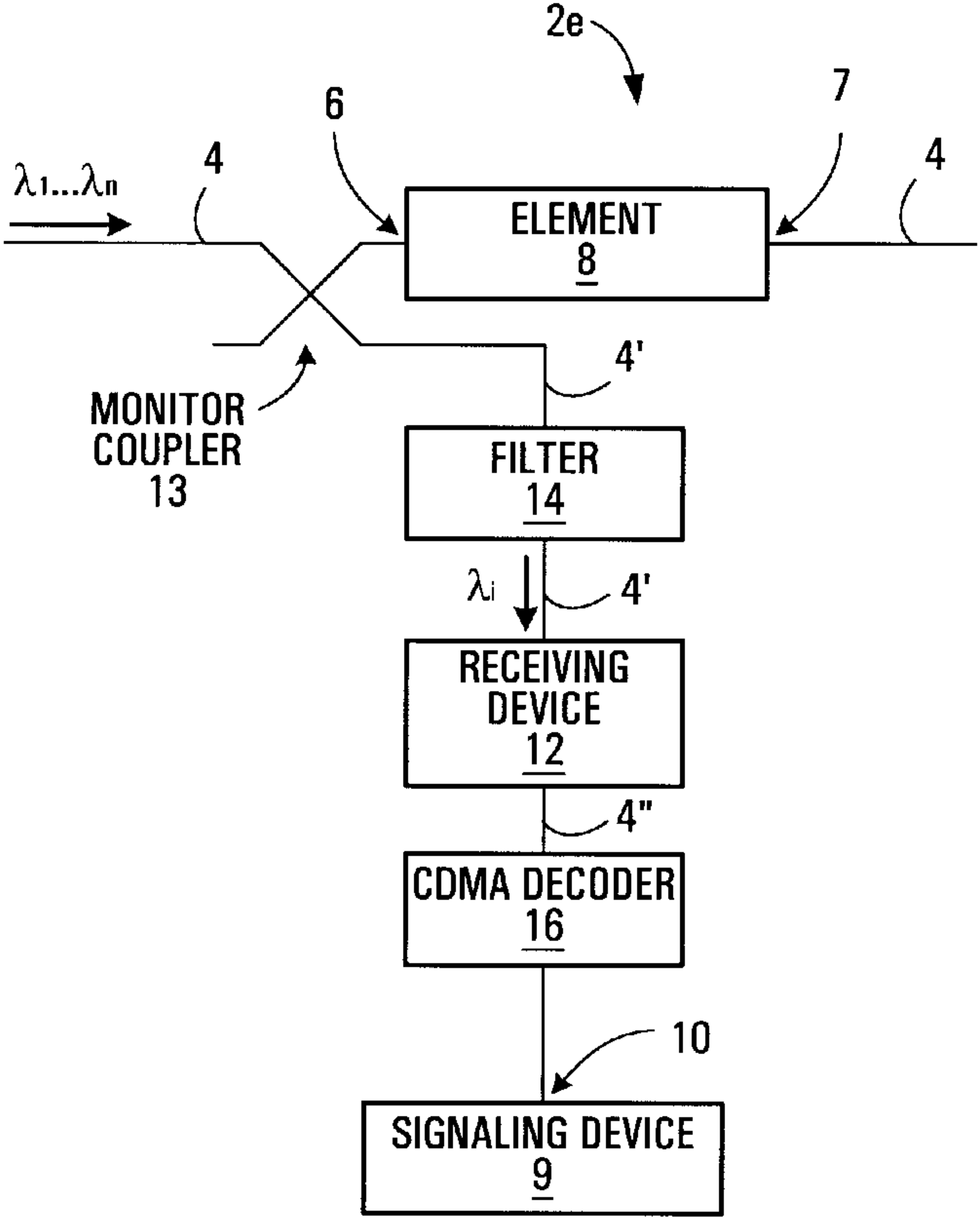

OPTICALLY SELECTIVE
ELEMENT
8a
MONITOR
COUPLER
13
29
COUPLER
30
4
λ1...λn
λ1,λ2
λ1
λ2
λ1a,λ2
6
7
λ3
λ4
λn+1...λm
λ3,λ4
λ3a,λ4
4
29
MONITOR
COUPLER
31

FIG. 10


2e
6
7
4
$\lambda_1 \ldots \lambda_n$
4
ELEMENT
8
4'
MONITOR
COUPLER
13
FILTER
14
λ_i
4'
RECEIVING
DEVICE
12
4"
CDMA DECODER
16
10
SIGNALING DEVICE
9