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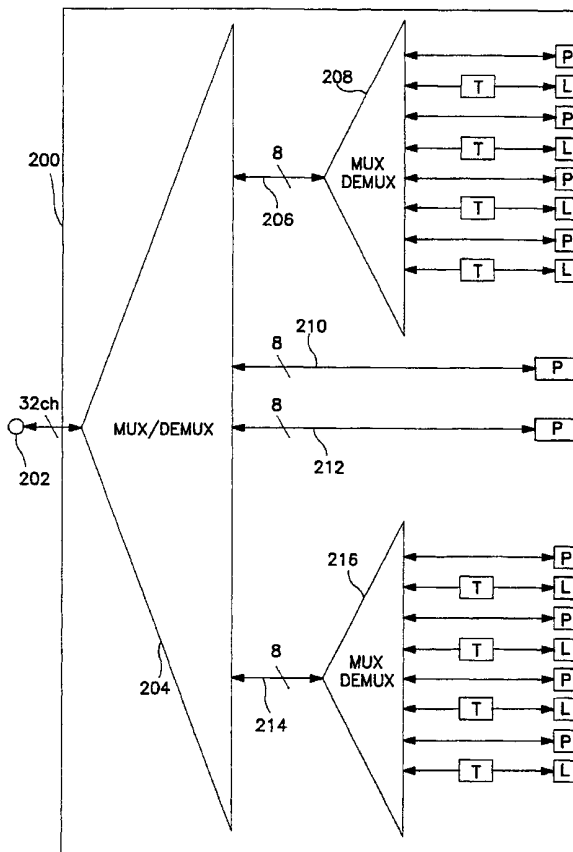
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(54) Title: PREVENTION OF LASING IN A CLOSED OPTICAL LOOP



(57) Abstract: A wavelength division multiplexed (WDM) optical communication system which includes a detection device for preventing lasing in a physically closed optical loop. The detection device is included on each pass-through interface of each node in the WDM system. Each pass-through interface is assigned to a channel for a subset of the facility signal. The detection device includes a normally open switch is closed only when a real optical signal of the subset of the facility signal is detected, with the subset of the facility signal then being passed by the closed switch. Accordingly, when the switch is open, noise is blocked from initiating a lasing condition in a physically closed optical loop which disrupts customer service on the other channels.



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TITLE

**Prevention of Lasing In A CLOSED OPTICAL LOOP**

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BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

The invention is in the field of optical  
10 telecommunications, and more particularly pertains to  
preventing a lasing condition in a physically closed  
optical loop of a ring or mesh network due to noise,  
which interrupts customer traffic in a wavelength  
division multiplexing system. The lasing condition is  
15 prevented by controlling the passing of a subset of a  
facility optical signal through a pass-through  
interface card and switching to a pass through mode  
only when a real optical signal is detected at the  
interface card.

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## BACKGROUND OF THE INVENTION

Wavelength division multiplexing (WDM) is an approach for increasing the capability of existing fiber optic networks. A WDM system employs plural optical signal channels, each channel being assigned a particular wavelength or band of wavelengths. In a WDM system optical signal channels are generated, multiplexed to form an optical signal known as a system facility, which is comprised of the individual optical signal channels or bands of the individual optical channels transmitted over a single waveguide, and demultiplexed such that each channel wavelength or band is individually routed to a designated receiver.

15

In a ring or mesh network of a WDM system a phenomenon known as a lasing condition occurs when a channel or a band of channels in a system facility is not receiving a real optical signal, and noise therein is at a sufficient level to cause lasing in a physically closed optical loop, resulting in an optically closed loop, thus increasing power consumption and draining power from the other channels or bands of channels, thus interrupting customer traffic. A physically closed loop is one in which elements in the loop are connected. An optically closed loop is a physically closed loop in which an optical signal (a real signal or a noise signal) is being passed through the loop.

30 Applicants are not aware of any teaching in the prior art of preventing such lasing conditions. Detecting of light for the total system facility on the line side is

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known, however, with such detection being for the protection of maintenance personnel from laser light, as opposed to preventing a lasing condition.

5 Fig. 1 is a block diagram of a prior art system as in U.S. patent 5,278,686 utilizing such protection from laser light for maintenance personnel. A typical WDM system includes a plurality of Optical Line Terminals (OLTS) connected in a point-to-point, chain, ring or  
10 mesh configuration. One such OLT 2 is shown connected to a protection device 4 which in turn is connected to a pre-amp 6. The OLT 2 includes a multiplexer/demultiplexer 8 connected on the channel side to pass-through interface cards 10 and 12 which  
15 are connected, respectively, to channel input/output terminals 14 and 16. The multiplexer on the facility (line) side is connected to line side input/output terminal 18 which is connected to the protection device 4. The pre-amp 6 is also connected to a line  
20 side input/output terminal 20.

For a demultiplexing operation a multiplexed facility signal comprised of wavelengths  $\lambda_1-\lambda_N$  is received at line side terminal 20 and is amplified by pre-amp 6 and  
25 in turn is provided to protection device 4. If the protection device 4 detects the facility signal, it is provided to the input terminal 18 of OLT 2 and is demultiplexed by demultiplexer 8. The individual demultiplexed wavelengths  $\lambda_1-\lambda_N$  are provided to pass-  
30 through interface cards 10 and 12, respectively, and in turn to output terminals 14 and 16. As is understood, the multiplexing operation is in the reverse order.

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On the other hand, if protection device 4 detects that the facility signal is not present, the signal path to terminal 18 is opened, such that if the optical fiber connected to terminal 18 is removed by maintenance  
5 personnel, and subsequently the facility signal is applied to the protection device 4, the maintenance personnel are protected since the laser light does not emanate from terminal 18. In practice when the cable is reconnected the system is reset.

10

Fig. 2 is a detailed diagram of the protection device 4, which includes an optical coupler 21, a detector 22, a comparator 24 and an optical switch 26 which has a control terminal 28 and a reset  
15 terminal 30. As discussed above, the facility signal applied to line side terminal 20 is amplified by pre-amp 6 and applied to protection device 4. In normal operation, the switch 26 is in a closed position and the facility signal is applied to output terminal 18  
20 and then to OLT 2. An optical coupler 21 couples on the order of 5% of the facility signal, which is then detected by the detector 22 and applied to a first input terminal of the comparator 24 for comparison with a reference signal  $V_R$  at a second input terminal  
25 thereof. If the detected signal is greater than  $V_R$  a control signal is applied to terminal 28 to maintain switch 26 in the closed condition for passing the facility signal to terminal 18. On the other hand if the detected signal is less than or equal to  $V_R$  the  
30 control signal is not provided to terminal 28 and switch 26 is switched to an open condition, thus blocking the facility signal from being provided to

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terminal 18. Accordingly, when the optical fiber  
connected to terminal 18 is removed maintenance  
personnel are protected from laser light emanating from  
terminal 18. When the optical fiber is reconnected, a  
5 reset signal from a management system (not shown) is  
applied to reset terminal 30 which returns the switch  
26 to the normal mode of operation.

Thus, the prior art teaches the opening of a normally  
10 closed switch when the absence of an optical facility  
signal is detected, such that the switch blocks the  
passage of a subsequently detected optical facility  
signal until the switch is reset to the normally closed  
position, thus protecting maintenance personal from  
15 laser light.

In contrast, the present invention teaches the closing  
of a normally open switch on a pass-through interface  
card only when a real optical signal of a subset of a  
20 facility signal is detected, thus blocking a noise  
signal and preventing lasing in a physically closed  
optical loop.

#### SUMMARY OF THE INVENTION

25

In view of the above, it is an aspect of the invention  
to prevent lasing in a physically closed optical loop  
in a WDM system.

30 It is another aspect of the invention to prevent lasing  
in a physically closed optical loop in a WDM system by  
blocking a noise signal and passing a subset of a

facility signal only when a real optical signal thereof is detected.

It is yet another aspect of the invention to prevent  
5 lasing in a physically closed optical loop in a WDM  
system by closing a normally open switch on a pass-  
through interface card in an optical line terminal only  
when a real optical signal of a subset of a facility  
signal is detected, thus blocking a noise signal, and  
10 preventing lasing in a physically closed optical loop.

It is a further aspect of the invention to detect a  
real optical signal of a subset of a facility signal  
using an optical power measurement.

15

It is yet a further aspect of the invention to detect a  
real optical signal of a subset of a facility signal  
using detection of a pilot tone.

20 It is still a further aspect of the invention to detect  
a real optical signal of a subset of a facility signal  
using detection of the data forming the subset of the  
facility signal.

25 BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of a prior art WDM system;

Fig. 2 is a detailed block diagram of the prior art  
30 protection device 4 of Fig. 1;



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Fig. 3 is a block diagram of an optical line terminal having a two-stage multiplexer/demultiplexer;

Fig. 4 is a general block diagram of two pass-through interface cards of first and second optical line terminals which are connected back-to-back according to the invention;

Fig. 5 is a block diagram of a pass-through interface card according to a first embodiment of the invention;

Fig. 6 is a flow chart of the method of operation of the processor 340 of Fig. 5;

Fig. 7 is a block diagram of a pass-through interface card according to a second embodiment of the invention;

Fig. 8 is a flow chart of the method of operation of the processor 382 of Fig. 7;

Fig. 9 is a block diagram of a pass-through interface card according to a third embodiment of the invention;

Fig. 10 is a flow chart of the method of operation of the processor 420 of Fig. 9; and

Figs. 11A, 11B and 11C are block diagrams of lightpath setups according to the invention.

## DETAILED DESCRIPTION

Fig. 3 is a block diagram illustration a modular OLT 200 having two stages of multiplexing/demultiplexing. 5 The operation of the OLT 200 is described with respect to the demultiplexing operation, however, it is to be understood that the multiplexing operation is merely the reverse operation. The OLT terminal 200 has an input/output line interface terminal 202 which is 10 connected to an external fiber facility and receives on a single optical fiber a facility signal of N, for example 32, multiplexed wavelengths which are demultiplexed by a multiplexer/demultiplexer 204, which is situated on a first modular card, into a subset of 15 the facility signal of M, for example 4, bands of 8 wavelengths each. The first band 206 ( $\lambda_1$ - $\lambda_8$ ) is demultiplexed into a further subset of the facility signal into its 8 individual wavelengths by a multiplexer/demultiplexer 208, which is situated on a 20 second modular card, with each such wavelength being provided to a pass-through interface card (P) or a local interface card (L) via transponder (T). Each of the pass-through interface cards (P) is situated on a different modular card, and each of the transponder (T) and its associated local port (L) are situated together 25 on yet another modular card. The second band 210 ( $\lambda_9$ - $\lambda_{16}$ ) is provided directly to a pass-through interface card (P), and the third band 212 ( $\lambda_{17}$ - $\lambda_{24}$ ) is provided directly to another pass-through interface card (P). 30

The fourth band 214 ( $\lambda_{25}$ - $\lambda_{32}$ ) is demultiplexed into a further subset of the facility signal of its 8

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individual wavelengths by a multiplexer/demultiplexer 216, which is situated on a modular card, with each such wavelength being provided to a pass-through interface card (P) or a local interface card (L) via a  
5 transponder (T).

As is known in the art, a local interface card (L) includes, or connects to, a local port for connection to client equipment (not shown), and a pass-through  
10 interface card includes, or connects to, a pass-through port for being directly optically connected to another OLT.

It is to be appreciated that a single stage of  
15 multiplexing/demultiplexing may be used in the practice of the invention, for multiplexing/demultiplexing the facility signal into either its individual wavelengths or bands of the individual wavelengths.

20 When a plurality of OLTs are connected together back-to-back via their respective pass-through ports to form a chain network, or are connected in a ring or mesh configuration network, the phenomenon of lasing in a physically closed optical loop can occur during the  
25 absence of a real optical signal of a subset of a facility signal which is suppose to be present at a given pass-through interface card. As discussed above, noise generated by devices in the system, such as optical amplifiers, may cause lasing in a physically  
30 closed optical loop in the network, resulting in an optically closed loop which results in disruption of customer service.

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Fig. 4 is a block diagram of a pass-through interface card 300 in a first OLT connected to a pass-through interface card 302 in a second OLT. The interface cards 300 and 302 generally show the invention,  
5 including a discrimination means such as a real (valid) signal detector 304 and a connection means such as an optical switch 306. The optical switch 306 has an input terminal 308, an output terminal 310, an enable terminal 312 and a control terminal 314. The interface  
10 cards 300 and 302 are coupled in one direction by an optical fiber 316 and in the other direction by an optical fiber 318. It is to be appreciated that an optical coupling device may be used to couple interface cards 300 and 302.

15

The operation of interface card 300 will be described with the understanding that interface card 302 operates in a like manner. The switch 306 is enabled to be in a switching mode in response to an enable signal being  
20 applied to enable terminal 312 from a system manager (not shown). The switch is normally in an open state, thus blocking passage of any signal or noise on fiber 318. If detector 304 detects a real optical signal on line 318, a control signal is applied to control  
25 terminal 314 for placing switch 306 in a closed state, thus passing the real optical signal. Thus, noise which is at a lower level (value) than a real optical signal is blocked due the switch being closed if a real optical signal is not detected.

30

Fig. 5 is a block diagram of a pass-through interface card 320 according to a first embodiment of the

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invention. The interface card 320 includes a real-signal detector 322, a switch 324 having an input terminal 326, an output terminal 328 and a control terminal 330, a fiber optic line 332, and an optical  
5 coupler 334.

The real-signal detector 322 includes an optical-electro converter 336 which is connected to the optical coupler 334 for tapping off on the order of 5% of the  
10 optical signal from fiber optic line 332 and converting it to an electric current. The electric current from converter 336 is provided to an A/D converter and power measurement device which measures the power of the digital value of the current. The measured power is  
15 then provided to a processor 340 for determining if the measured power is greater than a threshold power, which is indicative of a real-signal. If so, a control signal is applied from processor 340 to the control terminal 330 of switch 324 for closing same to pass the  
20 real signal on fiber optic line 332 to a fiber optic output line 342.

Fig. 6 is a flow chart of the method performed by processor 340 to determine if the measured power is  
25 indicative of a real-signal. At step 350 a determination is made as to whether or not the measured power is greater than a threshold level  $P_T$ . If not, the processor 340 waits for a subsequent power measurement. On the other hand, if the measured power is greater  
30 than the threshold  $P_T$ , a determination is made at step 352 as to whether or not the pass-through card 320 is provisioned to be active. If not, even though the

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real-signal is detected the switch 324 is not made active, and the processor 340 waits for pass-through card 320 to be made active. On the other hand, if the pass-through card 320 is provisioned to be active, at  
5 step 354 the processor 340 generates a control signal which is provided to control terminal 330 of switch 324 for closing same and passing the real-signal on optical fiber 332 to optical fiber 342.

10 Fig. 7 is a block diagram of a pass-through interface card 360 according to a second embodiment of the invention. The interface card 360 includes a real-signal detector 362, a switch 364 having an input terminal 366, an output terminal 368 and a control  
15 terminal 370, a fiber optic line 372, and an optical coupler 374.

The real-signal detector 362 includes an optical-electro converter 376 which is connected to the optical  
20 coupler 374 for tapping off on the order of 5% of the optical signal from fiber optic line 372 and converting it to an electric current. The electric current from converter 376 is provided to a low-pass filter 378 for passing a pilot tone carried by the optical signal.  
25 The filtered signal is applied to an A/D convertor for conversion to a digital signal for application to the processor 382 for determining if the pilot tone assigned to that card is detected. If so, a control signal is applied from the processor 382 to the control  
30 terminal 370 of switch 364 for closing same to pass the real-signal on fiber optic line 372 to fiber optic line 384.

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Fig. 8 is a flow chart of the method performed by processor 382 to determine if the pilot tone assigned to interface card 360 is present on optical line 372, which is indicative of a real signal. At step 386 a  
5 determination is made as to whether or not the pilot tone is detected. This may be performed by various frequency detection methods including taking power samples. If not, the processor 382 waits for a subsequent pilot tone detection. On the other hand, if  
10 the pilot tone is detected, a determination is made at step 388 as to whether or not the pass-through card 360 is provisioned to be active. If not, even though the real signal is detected the switch 364 is not closed, and the processor 382 waits for pass-through card 380  
15 to be made active. On the other hand, if the pass-through card 362 is provisioned to be active, at step 390 the processor 382 generates a control signal which is provided to control terminal 370 of switch 364 for closing same and passing the real-signal on optical  
20 fiber 372 to optical fiber 384.

Fig. 9 is a block diagram of a pass-through interface card 400 according to a third embodiment of the invention. The interface card 400 includes a real-  
25 signal detector 402, a switch 404 having an input terminal 406, an output terminal 408 and a control terminal 410, a fiber optic line 412, and an optical coupler 414.

30 The real-signal detector 402 includes an optical receiver 416 which is connected to the optical coupler 414 for tapping off on the order of 5% of the optical

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signal from fiber optic line 412 and providing it to a SONET framer 418 for framing. The resultant frame is provided to a processor for determining if the resultant frame is a valid SONET frame. If so, a control signal is applied from the processor 420 to the control terminal of switch 404 for closing same to pass the real-signal on fiber optic line 412 to fiber optic line 424.

10 Fig. 10 is a flow chart of the method performed by processor 420 to determine if a valid SONET frame is present on fiber optic line 412, which is indicative of a real-signal. At step 430 a determination is made as to whether or not a SONET frame is detected, which detection method is known in the art. If not, the processor 420 waits for a predetermined time interval to again check again for a valid SONET frame. On the other hand, if the valid SONET frame is detected, a determination is made at step 432 as to whether or not the pass-through card 400 is provisioned to be active. If not, even though the real-signal is detected the switch 404 is not closed, and the processor 420 waits for pass-through card 400 to be made active. On the other hand, if the pass-through card 400 is provisioned to be active, at step 434 the processor 420 generates a control signal which is provided to control terminal 410 of switch 404 for closing same and passing the real-signal on optical fiber 412 to optical fiber 424.

30 Figs. 11A, 11B and 11C are block diagrams of lightpath setups in a chain network. It is understood that the



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chain network forms part of a ring or mesh network.  
The optical route of a lightpath is assumed to traverse  
a plurality of optical nodes connected back-to-back via  
their respective pass-through interfaces. The drawings  
5 are simplified to convey the property of interest,  
i.e., that a subset of a facility signal is passed or  
blocked at a given pass-through interface.

In Fig. 11A the line side interface of an optical node  
10 500 is connected to the line side interface of an  
optical node 502 for passing the facility signal via  
optical fiber 504.

The optical node 502 is connected back-to-back to an  
15 optical node 506 for passing a subset of the facility  
signal via optical fiber 508.

The line side interface of optical node 506 is  
connected to the line side interface of an optical node  
20 510 for passing the facility signal via optical fiber  
512.

The optical node 510 is connected back-to-back to an  
optical node 514 for passing the subset of the facility  
25 signal via optical fiber 516.

The line side interface of optical node 514 is  
connected to the line side interface of an optical node  
518 for passing the facility signal via optical fiber  
30 520.

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Thus, it is seen that a chain network is set up from node 500 to node 518 via intermediate nodes 502, 506, 510 and 514 for bi-directional communication. The back-to-back connection between the pass-through interface cards of the respective optical nodes for passing the subset of the facility signal is as shown in Fig. 4. It is to be appreciated that there are n pass-through cards at each node for n respective subsets of the facility signal.

10

Initially, a transponder 522 of node 500 begins transmitting the facility signal in the direction of node 518, and a transponder 524 of node 518 begins transmitting the facility signal in the direction of node 500. At node 502 a subset of the facility signal passes directly through pass-through card 300 to pass-through card 302 of node 506 via optical fiber 508 (i.e., line 316 as shown in Fig. 4). Switch 306 of pass-through card 302 of node 506 is not enabled, thus blocking the sub-set of the facility signal. In a like manner, at node 514 a subset of the facility signal transmitted from transponder 524 of node 518 passes directly through pass-through card 302 of node 514 via optical fiber 516 (i.e., line 318 as shown in Fig. 4). Switch 306 of pass-through card 300 of node 110 is not enabled, thus blocking the sub-set of the facility signal.

Fig. 11B illustrates switch 306 in pass-through card 302 of node 506 being enabled and detecting a real signal, and for passing the real signal directly through pass-through card 300 of node 510 to pass-

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through card 302 of node 514. Switch 306 of pass-through card 302 of node 514 is not enabled, thus blocking the subset of the facility signal. Switch 306 in pass-through card 300 of node 510 is likewise  
5 enabled and detects a real signal, and passes the real signal directly through pass-through card 302 of node 506 to pass-through card 300 of node 502. Switch 306 of pass-through card 300 of node 502 is not enabled, thus blocking the subset of the facility signal.

10

Fig. 11C illustrates switch 306 in pass-through card 302 of node 514 being enabled, and detecting a real signal for passing the sub-set of the facility signal to transponder 524 of node 518 via optical fiber 520.  
15 Likewise, switch 306 in pass-through card 300 of node 502 is enabled, and detects a real signal for passing the sub-set of the facility signal to transponder 522 of node 500. As discussed with respect to Fig. 4, if the real signal detector 304 doesn't detect a real  
20 signal, the switch 306 is turned off, thus blocking noise signals and preventing lasing in a physically closed optical loop.

What is Claimed is:

1. An optical pass-through interface, comprising:  
an input terminal to which a subset of a facility signal is applied;  
an output terminal;  
discrimination means for discriminating whether a real optical signal of the subset of the facility signal is present at said input terminal;  
connection means for connecting said input terminal to said output terminal only when said discrimination means discriminates that a real optical signal of the subset of the facility signal is present at said input terminal.
2. The combination claimed in Claim 1, wherein said connection means comprises a switch which is connected between the input terminal and output terminal of said interface, with said switch normally being in an open condition, and being switched to a closed condition only when said discrimination means detects the real optical signal, for connecting said input terminal to said output terminal of said interface.
3. The combination claimed in Claim 2, wherein said discrimination means discriminates whether a real optical signal of the subset of the facility signal is present at said input terminal based on a power measurement of the subset of the facility signal.

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4. The combination claimed in Claim 2, wherein said discrimination means discriminates whether a real optical signal of the subset of the facility signal is present at said input terminal based on detecting a pilot tone which is assigned to the pass-through interface.

5. The combination claimed in Claim 2, wherein said discrimination means discriminate whether a real optical signal of the subset of the facility signal is present at said input terminal based on detecting a valid frame of the subset of the facility signal.

6. A wavelength division multiplexed optical communication system which prevents lasing in a physically closed optical loop, comprising:

a first optical node having a line side interface for receiving a facility signal and a pass-through interface for receiving subsets of the facility signal, the pass-through interface including at least first and second subset pass-through interfaces, the first subset pass-through interface receiving a first subset of the facility signal and the second subset pass-through interface receiving a second subset of the facility signal;

a second optical node having a line side interface for receiving a facility signal and a pass-through interface for receiving subsets of the facility signal, the pass-through interface including at least first and second subset pass-through interfaces, the first subset pass-through interface receiving the first subset of the facility signal and the second subset pass-through

interface receiving a second subset of the facility signal;

node coupling means for coupling the pass-through interface of said first optical node to the pass-through interface of said second optical node; and

each of said subset pass-through interfaces including noise blocking means for blocking a noise signal, thus preventing lasing in the physically closed optical loop.

7. The combination claimed in Claim 6, wherein said noise blocking means includes:

discrimination means for discriminating whether a valid subset of the facility signal is received by said subset pass-through interface, with the noise signal being blocked when said discriminating means discriminates that a valid subset of the facility signal is not being received.

8. A wavelength division multiplexed optical communication system which prevents lasing in a physically closed optical loop, comprising:

a first optical node having a line side interface for receiving a facility signal and a pass-through interface for receiving subsets of the facility signal, the pass-through interface including at least one subset pass-through interface for receiving a subset of the facility signal;

a second optical node having a line side interface for receiving a facility signal and a pass-through interface for receiving subsets of the facility signal, the pass-through interface including at least one

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subset pass-through interface for receiving a subset of the facility signal;

node coupling means for coupling the pass-through interface of said first optical node to the pass-through interface of said second optical node; and

said one subset pass-through interface including noise blocking means for blocking a noise signal, thus preventing lasing in the physically closed optical loop.

9. The combination claimed in Claim 8, wherein said noise blocking means includes:

discrimination means for discriminating whether a valid subset of the facility signal is received by said one subset pass-through interface, with the noise signal being blocked when said discriminating means discriminates that a valid subset of the facility signal is not being received.

10. The combination claimed in Claim 9, wherein said discrimination means discriminates whether a valid subset of the facility signal is received by said one subset pass-through interface based on a power measurement of the subset of the facility signal.

11. The combination claimed in Claim 9, wherein said discrimination means discriminates whether a valid subset of the facility signal is received by said one subset pass-through based on detecting a pilot tone which is assigned to said subset pass-through interface.

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12. The combination claimed in Claim 9, wherein said discrimination means discriminate whether a valid subset of the facility signal is received by said one subset pass-through interface based on detecting a valid frame of the subset of the facility signal.

13. A wavelength division multiplexed optical communication system including an optical node which prevents lasing in a physically closed optical loop, said optical node comprising:

a first optical demultiplexer which demultiplexes N optical wavelengths of a wavelength division multiplexed optical facility signal into M optical bands, where N and M are each integers and  $N > M$ ;

at least a second optical demultiplexer which demultiplexes one of the M optical bands into x individual wavelengths, where  $x > 1$ ;

M-1 pass-through interfaces for receiving M-1 optical bands from said first optical demultiplexer;

X pass-through interfaces for receiving X individual wavelengths from said second optical demultiplexer; and

each of said M-1 pass-through interfaces and each of said X pass-through interfaces including noise blocking means for blocking a noise signal, thus preventing lasing in the physically closed optical loop.

14. The combination claimed in Claim 13, wherein said noise blocking means includes:

discrimination means for discriminating whether a valid signal is received by its associated pass-through



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interface, with the noise signal being blocked when said discriminating means discriminates that a valid signal is not being received.

15. The combination claimed in Claim 13, wherein said discrimination means discriminates whether a valid signal is being received based on a power measurement of the received signal.

16. The combination claimed in Claim 13, wherein said discrimination means discriminates whether a valid signal is received by said pass-through interface based on detecting a pilot tone which is assigned to said pass-through interface.

17. The combination claimed in Claim 13, wherein said discrimination means discriminate whether a valid signal is received by said pass-through interface based on detecting a valid frame.

18. A wavelength division multiplexed optical communication system including an optical node which prevents lasing in a physically closed optical loop, said optical node comprising:

an optical demultiplexer which demultiplexes N optical wavelengths of a wavelength division multiplexed optical facility signal into M optical bands, where N and M are each integers and  $N > M$ ;

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pass-through interfaces for receiving the M optical bands from said optical demultiplexer; and

each of said M pass-through interfaces including noise blocking means for blocking a noise signal, thus preventing lasing in the physically closed optical loop.

19. The combination claimed in Claim 18, wherein said noise blocking means includes:

discrimination means for discriminating whether a valid signal is received by its associated pass-through interface, with the noise signal being blocked when said discriminating means discriminates that a valid signal is not being received.

20. The combination claimed in Claim 18, wherein said discrimination means discriminates whether a valid signal is being received based on a power measurement of the received signal.

21. The combination claimed in Claim 18, wherein said discrimination means discriminates whether a valid signal is received by said pass-through interface based on detecting a pilot tone which is assigned to said pass-through interface.

22. The combination claimed in Claim 18 wherein said discrimination means discriminate whether a valid signal is received by said pass-through interface based on detecting a valid frame.

- 25 -

23. A wavelength division multiplexed optical communication system including an optical node which prevents lasing in a physically closed optical loop, said optical node comprising:

an optical demultiplexer which demultiplexes N optical wavelengths of a wavelength division multiplexed optical facility signal into the N optical wavelengths, where N is an integer,

N pass-through interfaces for receiving the N optical wavelengths from said optical demultiplexer; and

each of said N pass-through interfaces including noise blocking means for blocking a noise signal, thus preventing lasing in the physically closed optical loop.

24. The combination claimed in Claim 23, wherein said noise blocking means includes:

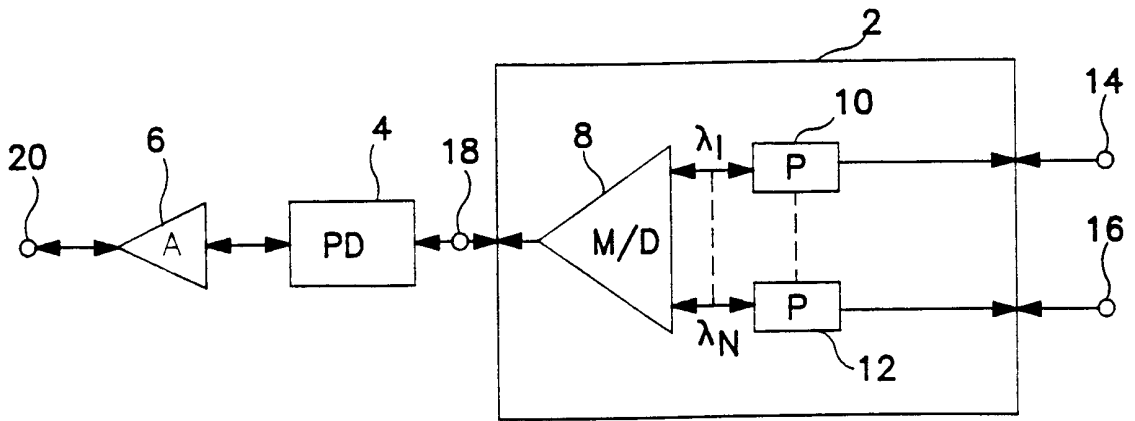
discrimination means for discriminating whether a valid signal is received by its associated pass-through interface, with the noise signal being blocked when said discriminating means discriminates that a valid signal is not being received.

25. The combination claimed in Claim 23, wherein said discrimination means discriminates whether a valid signal is being received based on a power measurement of the received signal.

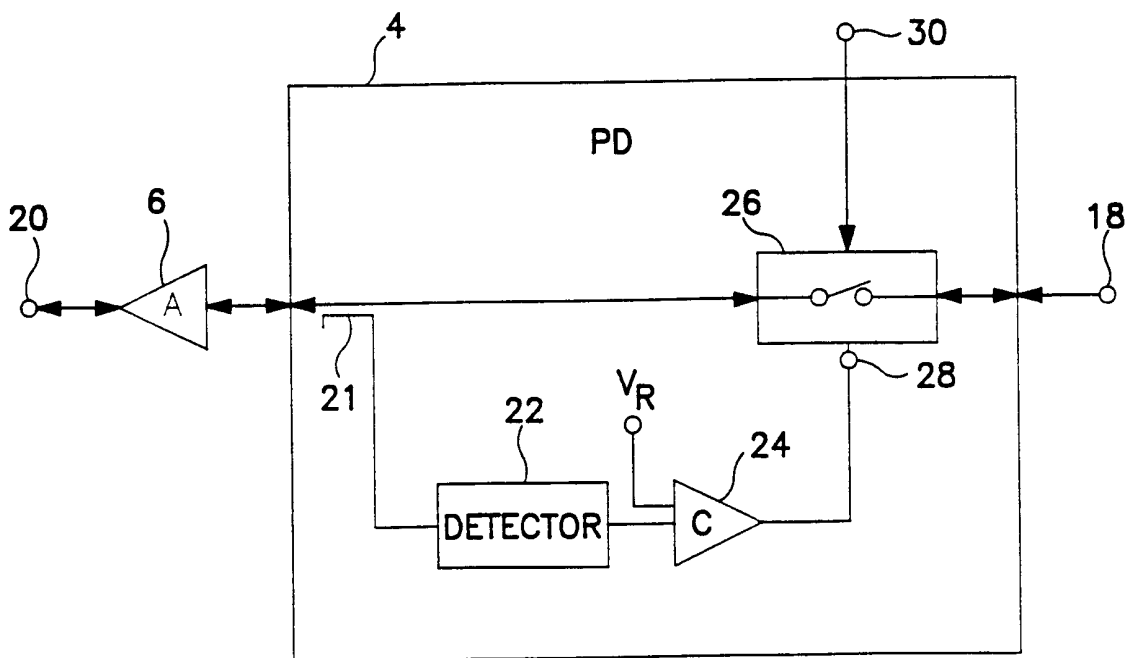
26. The combination claimed in Claim 23, wherein said discrimination means discriminates whether a valid signal is received by said pass-through interface based

on detecting a pilot tone which is assigned to said pass-through interface.

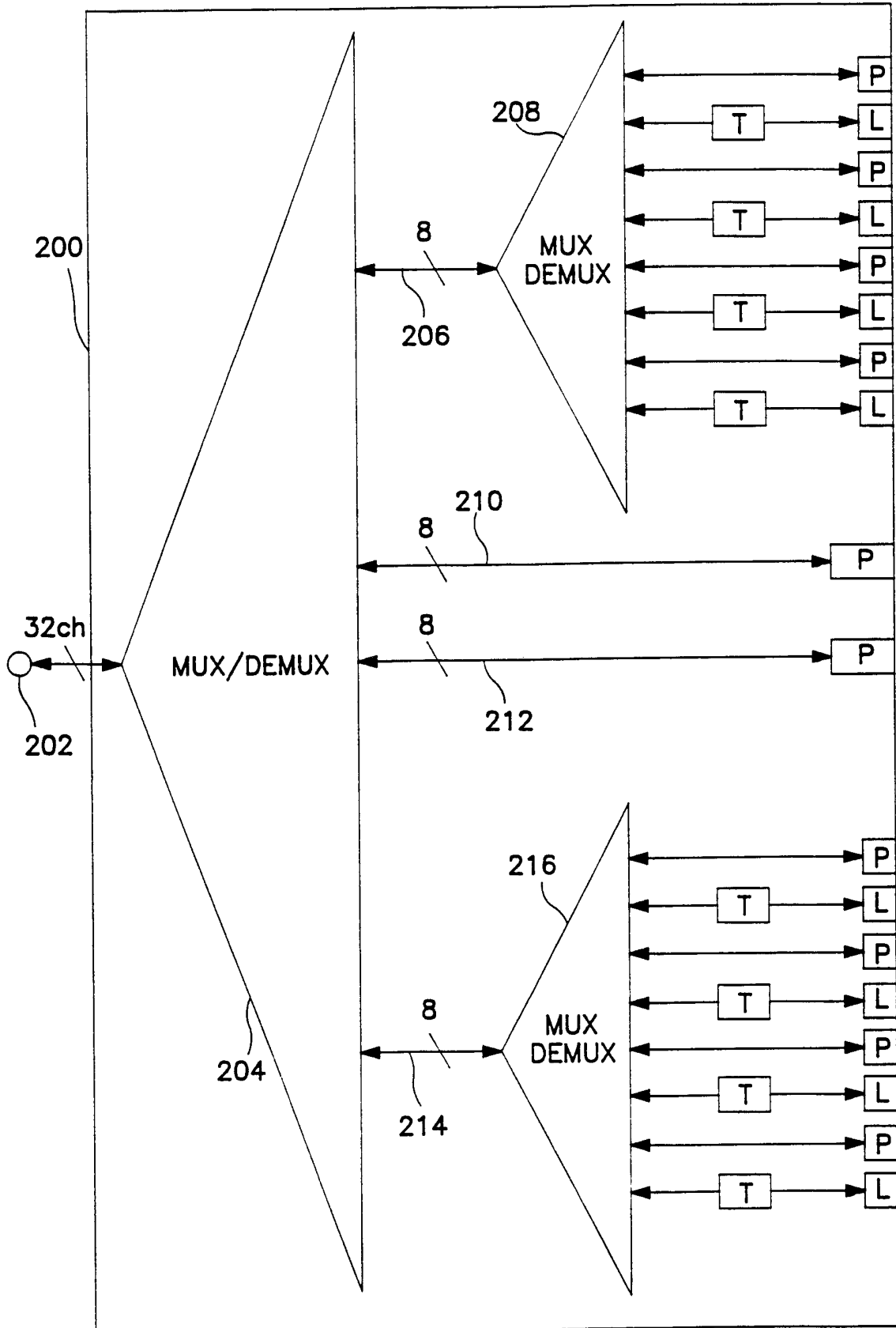
27. The combination claimed in Claim 23, wherein said discrimination means discriminate whether a valid signal is received by said pass-through interface based on detecting a valid frame.



**FIG. 1**  
PRIOR ART



**FIG. 2**  
PRIOR ART



**FIG. 3**  
*SUBSTITUTE SHEET (RULE 26)*

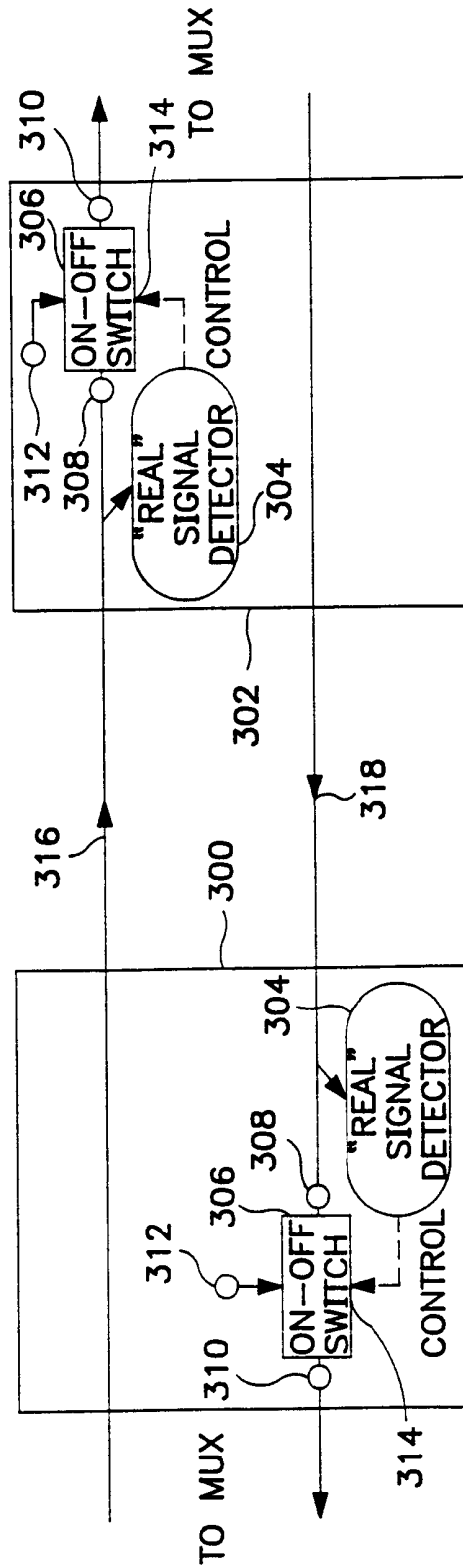


FIG. 4

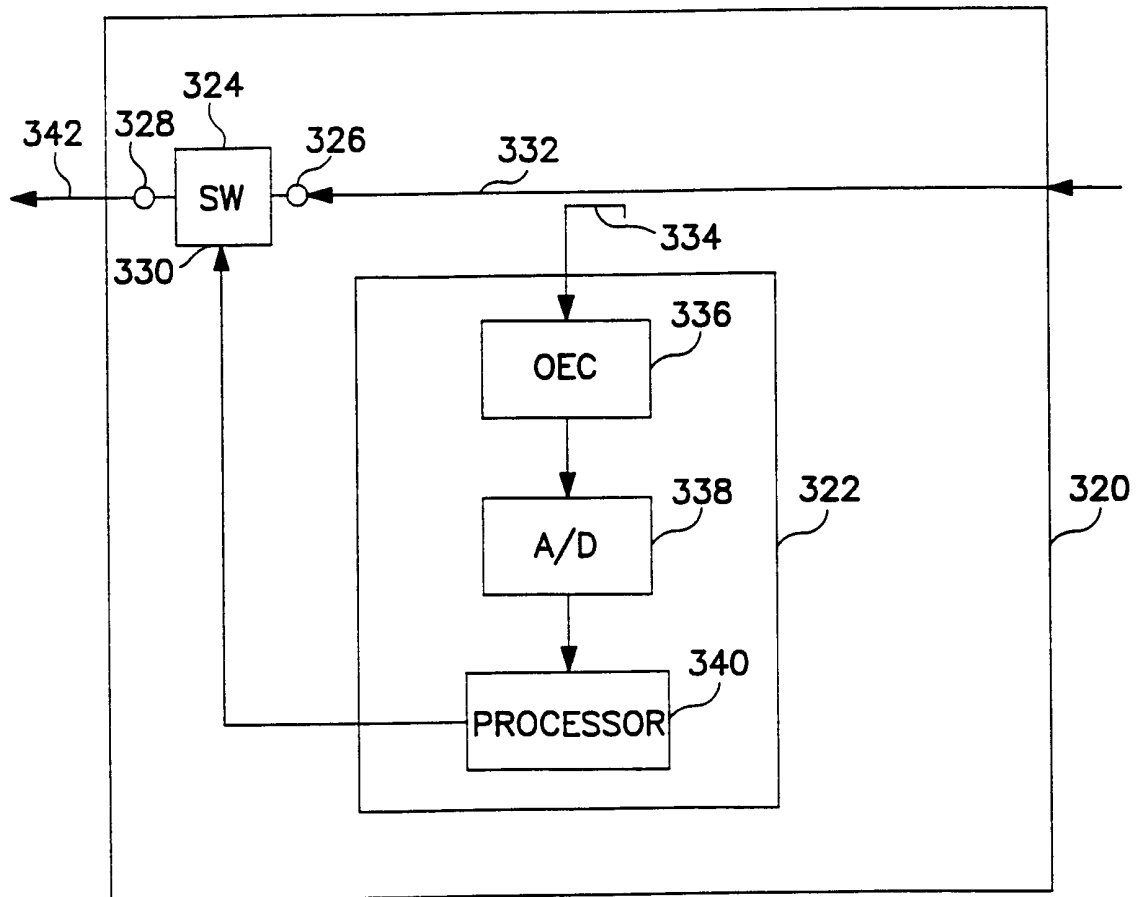


FIG. 5



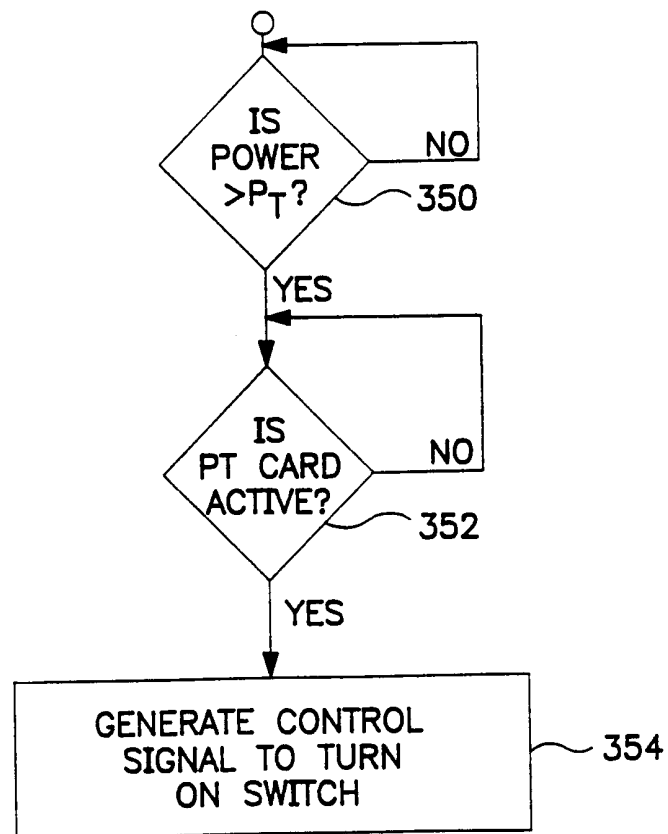


FIG. 6

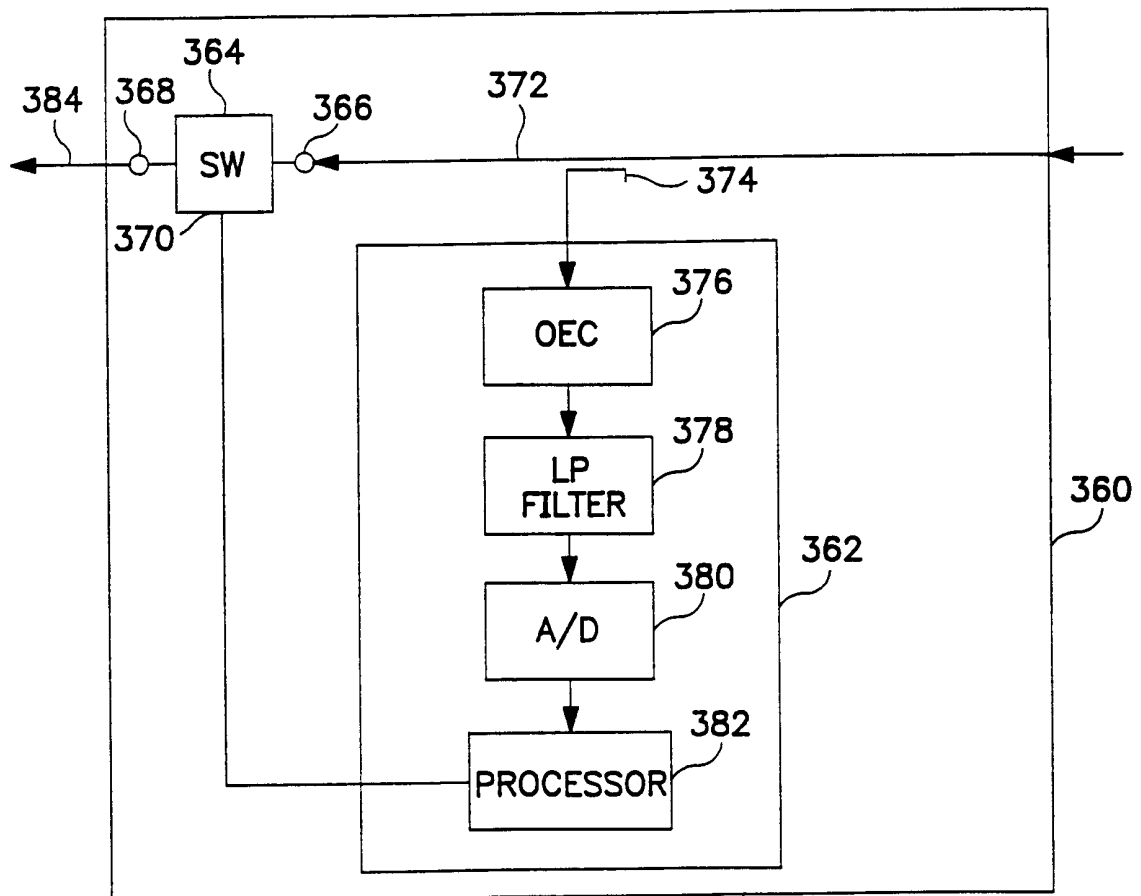


FIG. 7

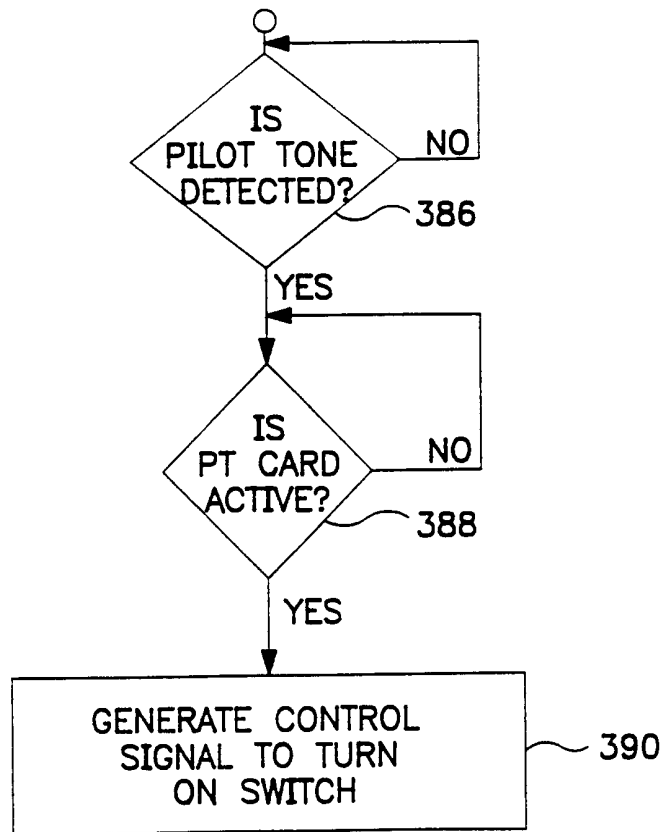


FIG. 8

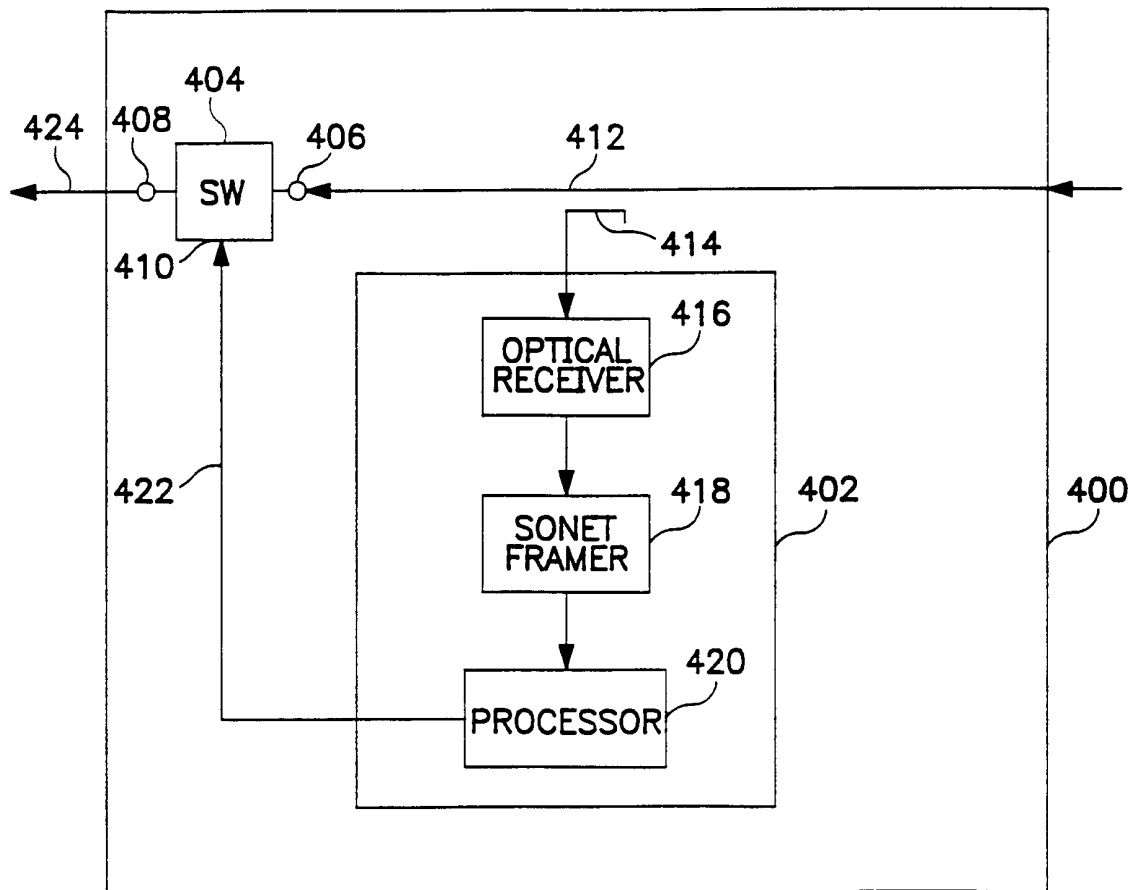


FIG. 9

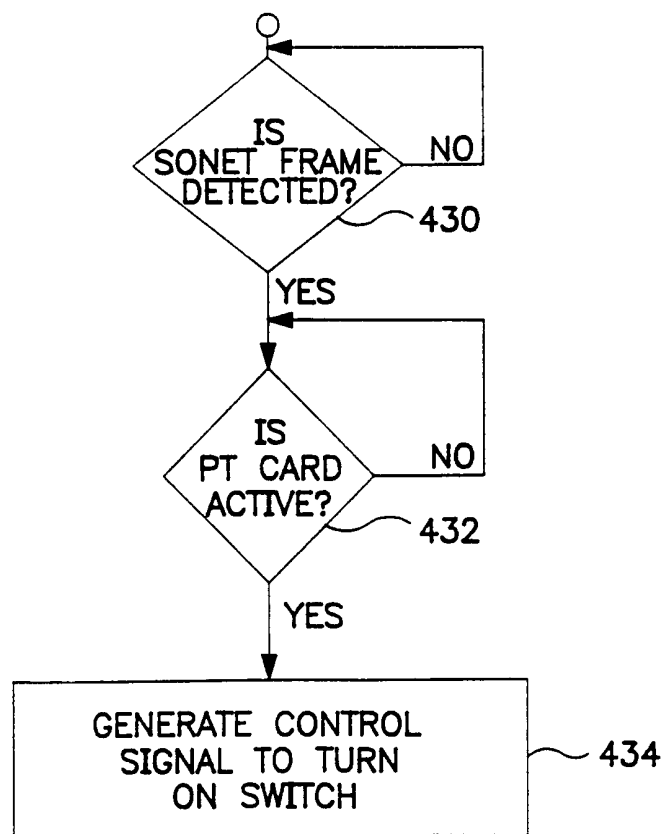


FIG. 10

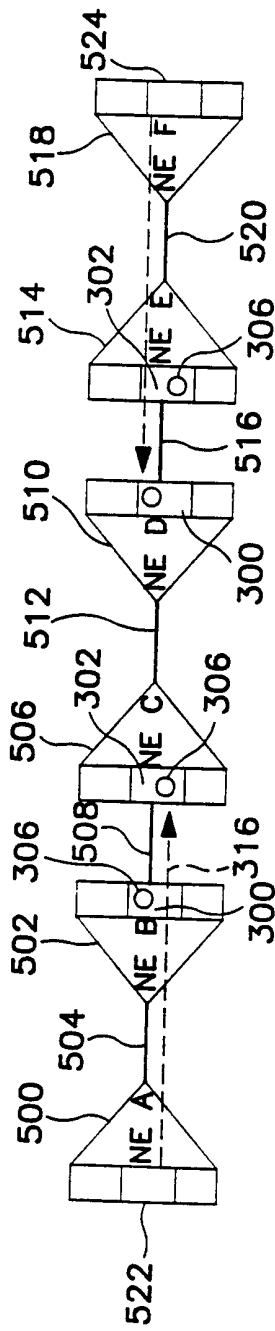


FIG. IIA

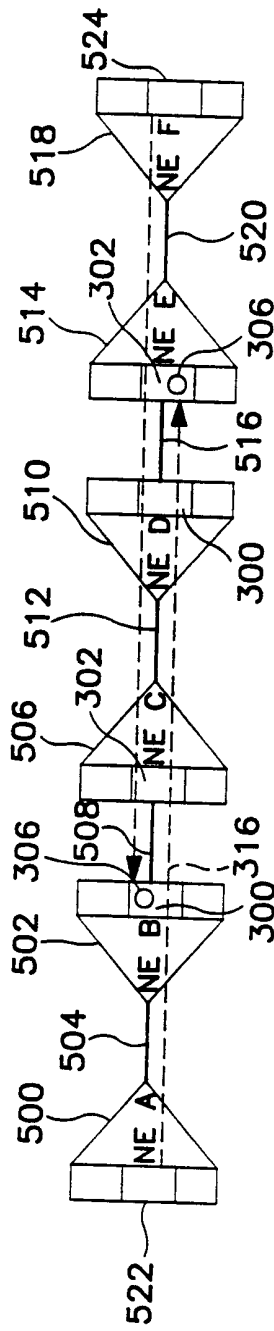


FIG. IIB

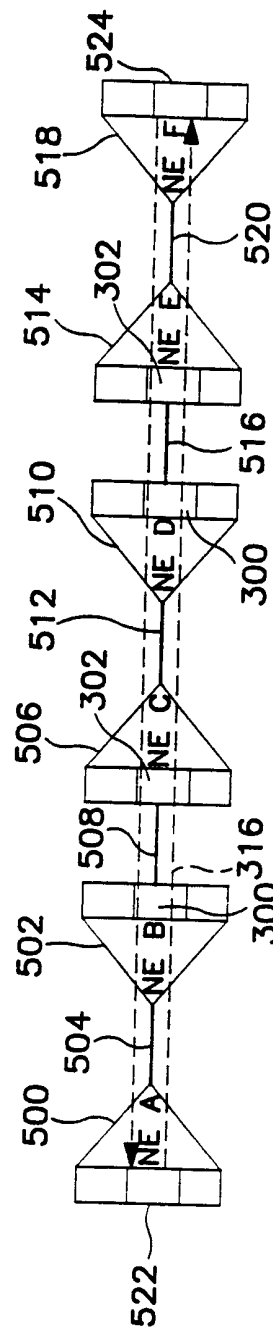


FIG. IIC

# INTERNATIONAL SEARCH REPORT

Int. Application No  
PCT/US 00/28377

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC 7 H04B10/08 H04J3/08 H04L12/437				
According to International Patent Classification (IPC) or to both national classification and IPC				
<b>B. FIELDS SEARCHED</b>				
Minimum documentation searched (classification system followed by classification symbols) IPC 7 H04B H04J H04L				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched				
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, WPI Data, PAJ, INSPEC				
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>				
Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.		
X  Y  X  Y	EP 0 903 882 A (LUCENT TECHNOLOGIES INC) 24 March 1999 (1999-03-24) paragraph '0030!; figure 6  ----- US 5 680 235 A (JOHANSSON BENGT) 21 October 1997 (1997-10-21) column 6, line 5 - line 49; figure 2D  -----	8, 18, 23  9-11, 19-21, 24-26  1-4  9-11, 19-21, 24-26		
<input type="checkbox"/> Further documents are listed in the continuation of box C.				
<input checked="" type="checkbox"/> Patent family members are listed in annex.				
° Special categories of cited documents :				
<table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none; vertical-align: top;">                     *A* document defining the general state of the art which is not considered to be of particular relevance                      *E* earlier document but published on or after the international filing date                      *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)                      *O* document referring to an oral disclosure, use, exhibition or other means                      *P* document published prior to the international filing date but later than the priority date claimed                 </td> <td style="width: 50%; border: none; vertical-align: top;">                     *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention                      *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone                      *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.                      *&amp;* document member of the same patent family                 </td> </tr> </table>			*A* document defining the general state of the art which is not considered to be of particular relevance *E* earlier document but published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. *&* document member of the same patent family
*A* document defining the general state of the art which is not considered to be of particular relevance *E* earlier document but published on or after the international filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the international filing date but later than the priority date claimed	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. *&* document member of the same patent family			
Date of the actual completion of the international search  <p style="text-align: center; font-weight: bold;">15 February 2001</p>	Date of mailing of the international search report  <p style="text-align: center; font-weight: bold;">22/02/2001</p>			
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer  <p style="text-align: center; font-weight: bold;">Cochet, B</p>			

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Information on patent family members

Int. l. Application No PCT/US 00/28377
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