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(54) RING NETWORK SYSTEM, NODE DEVICE, AND PROTECTION BAND TESTING METHOD FOR THE RING NETWORK SYSTEM

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(57) **ABSTRACT**

In a ring network system, a first node device includes means for sending out a control signal for controlling one of a plurality of second node devices so as to allow signals transmitted over a protection band to pass through the second node device; each of the second node devices includes means for receiving the control signal sent out from the first node device or another second node device, means for controlling the signals transmitted over the protection band to pass through the second node device during the reception of the control signal, and means for transferring the control signal to the adjacent first node device or to the adjacent second node device during the reception of the control signal; and the first node device further includes means for receiving the control signal transferred from the adjacent second node device.

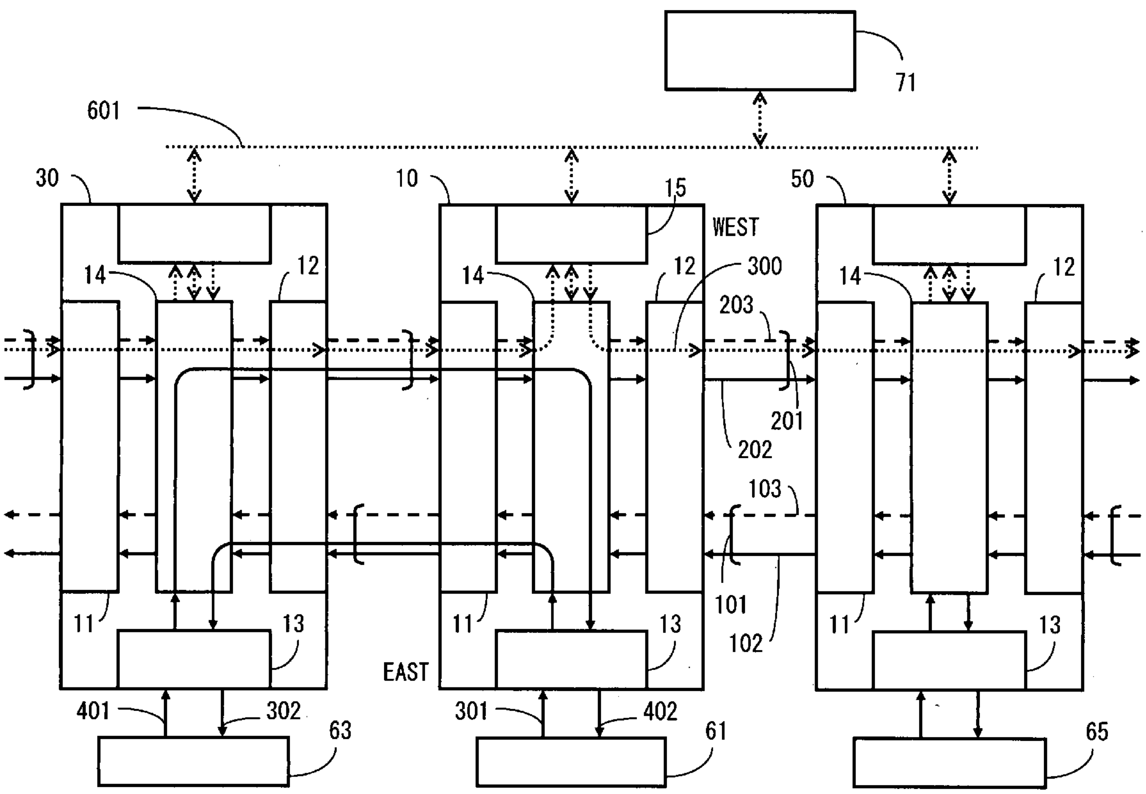


FIG. 1

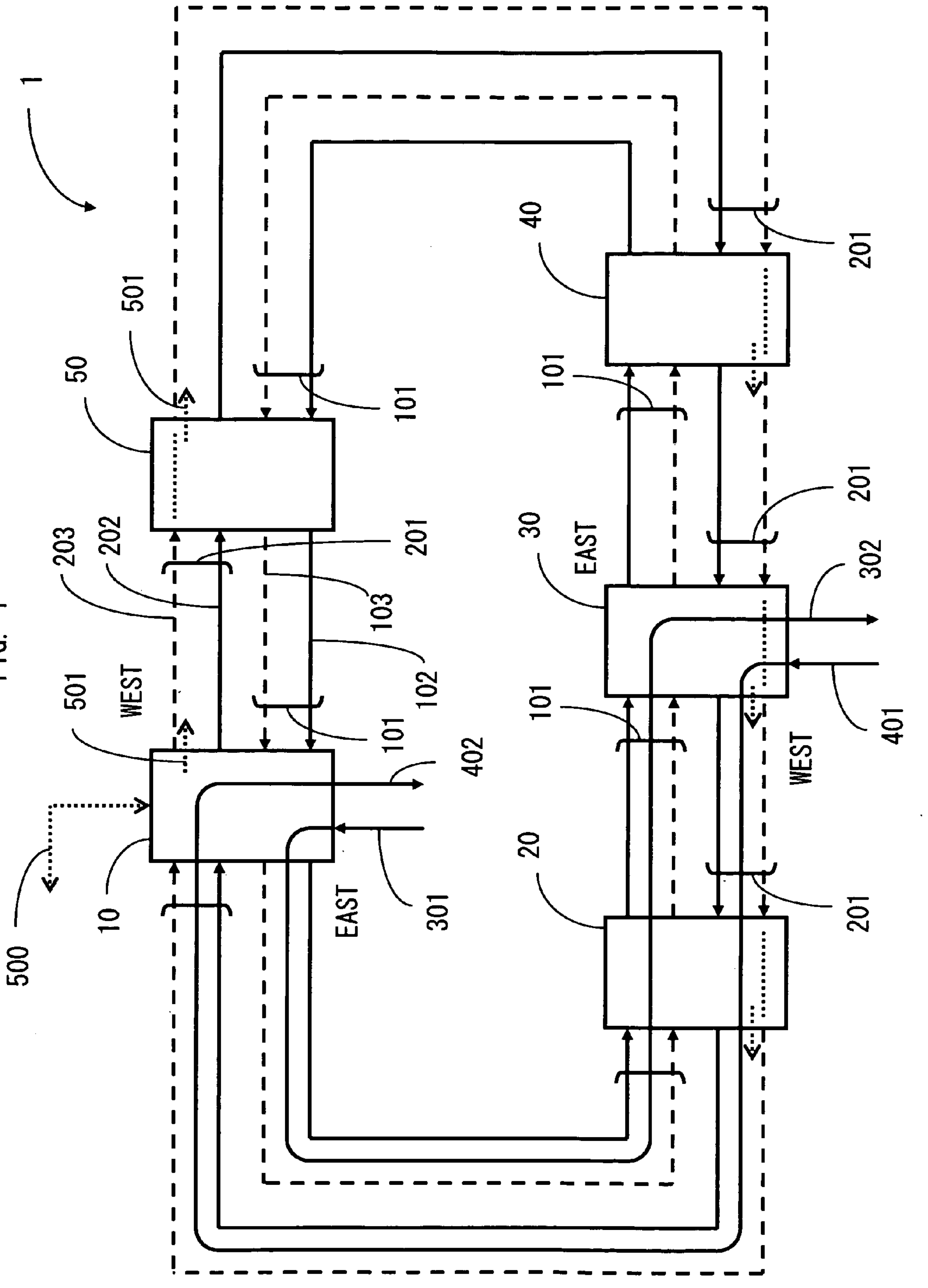

1
10
20
30
40
50
101
102
103
201
202
203
301
302
401
402
500
501
EAST
WEST

FIG. 2

K1byte		K2byte		
1-4 bit (1 2 3 4)	5-8 bit (5 6 7 8)	1-4 bit (1 2 3 4)	5-8 bit (5)	5-8 bit (6 7 8)
Switch Request	Destination Node ID	Source Node ID	Path	Switch Status
1111 : LP-S/SF-P	1111 : Node #16	1111 : Node #16	1 :	111 : MS-AIS
1110 : FS-S	1110 : Node #15	1110 : Node #15	Long	110 : MS-RDI
1101 : FS-R	1101 : Node #14	1101 : Node #14		101 : (reserved)
1100 : SF-S	1100 : Node #13	1100 : Node #13	0 :	100 : (reserved)
1011 : SF-R	1011 : Node #12	1011 : Node #12	Short	011 : (reserved)
1010 : SD-P	1010 : Node #11	1010 : Node #11		010 : Br&Sw
1001 : SD-S	1001 : Node #10	1001 : Node #10		001 : Br
1000 : SD-R	1000 : Node #9	1000 : Node #9		000 : Idle
0111 : MS-S	0111 : Node #8	0111 : Node #8		
0110 : MS-R	0110 : Node #7	0110 : Node #7		
0101 : WTR	0101 : Node #6	0101 : Node #6		
0100 : EXER-S	0100 : Node #5	0100 : Node #5		
0011 : EXER-R	0011 : Node #4	0011 : Node #4		
0010 : RR-S	0010 : Node #3	0010 : Node #3		
0001 : RR-R	0001 : Node #2	0001 : Node #2		
0000 : NR	0000 : Node #1	0000 : Node #1		

FIG. 3

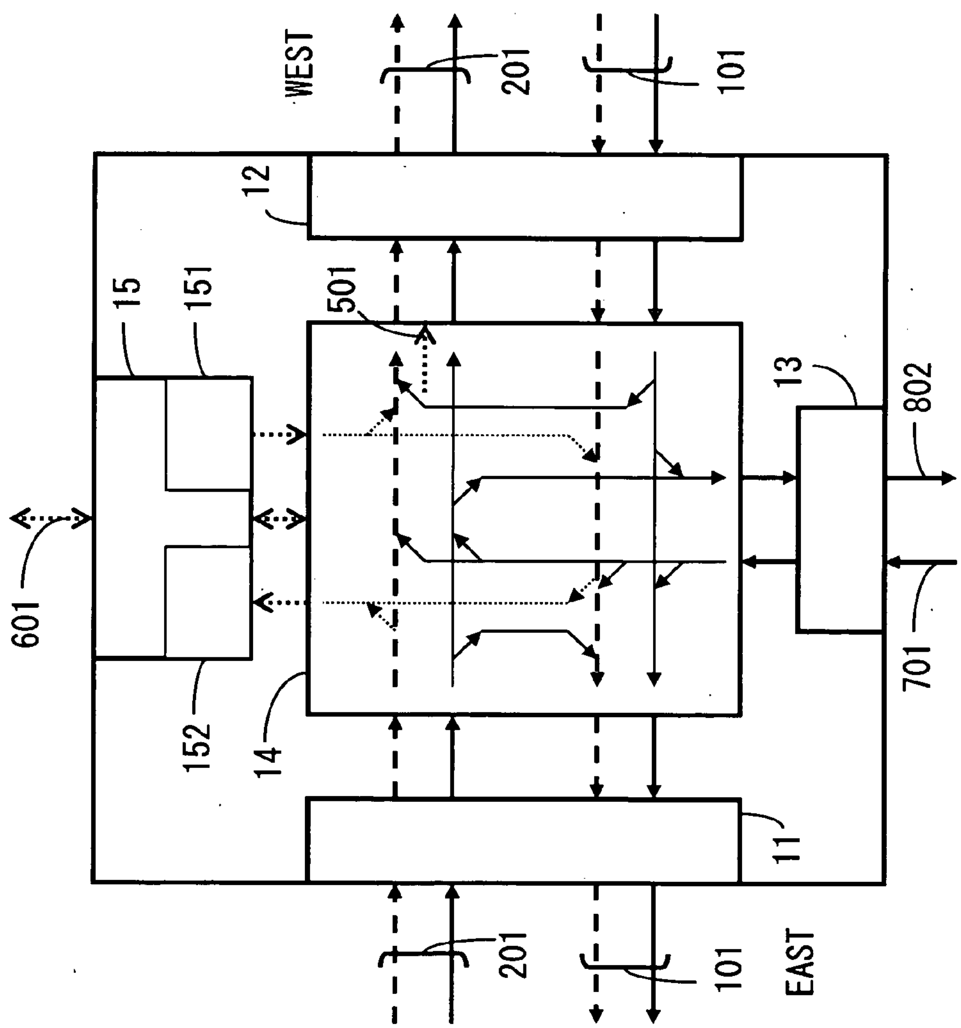


FIG. 4

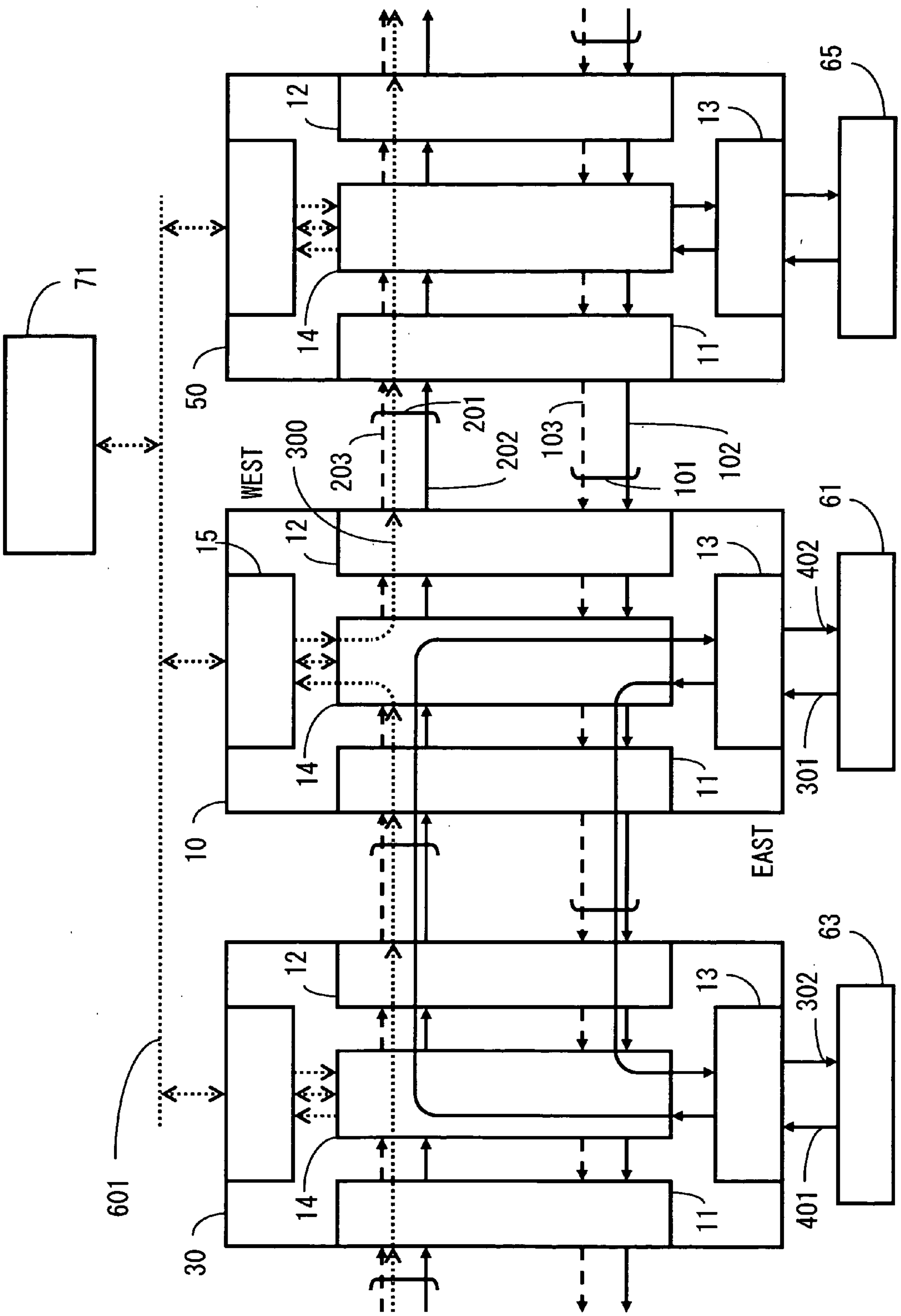

71
601
50
10
30
WEST
EAST
11
12
13
14
15
65
61
63
101
102
103
201
202
203
300
301
302
401
402

FIG. 5

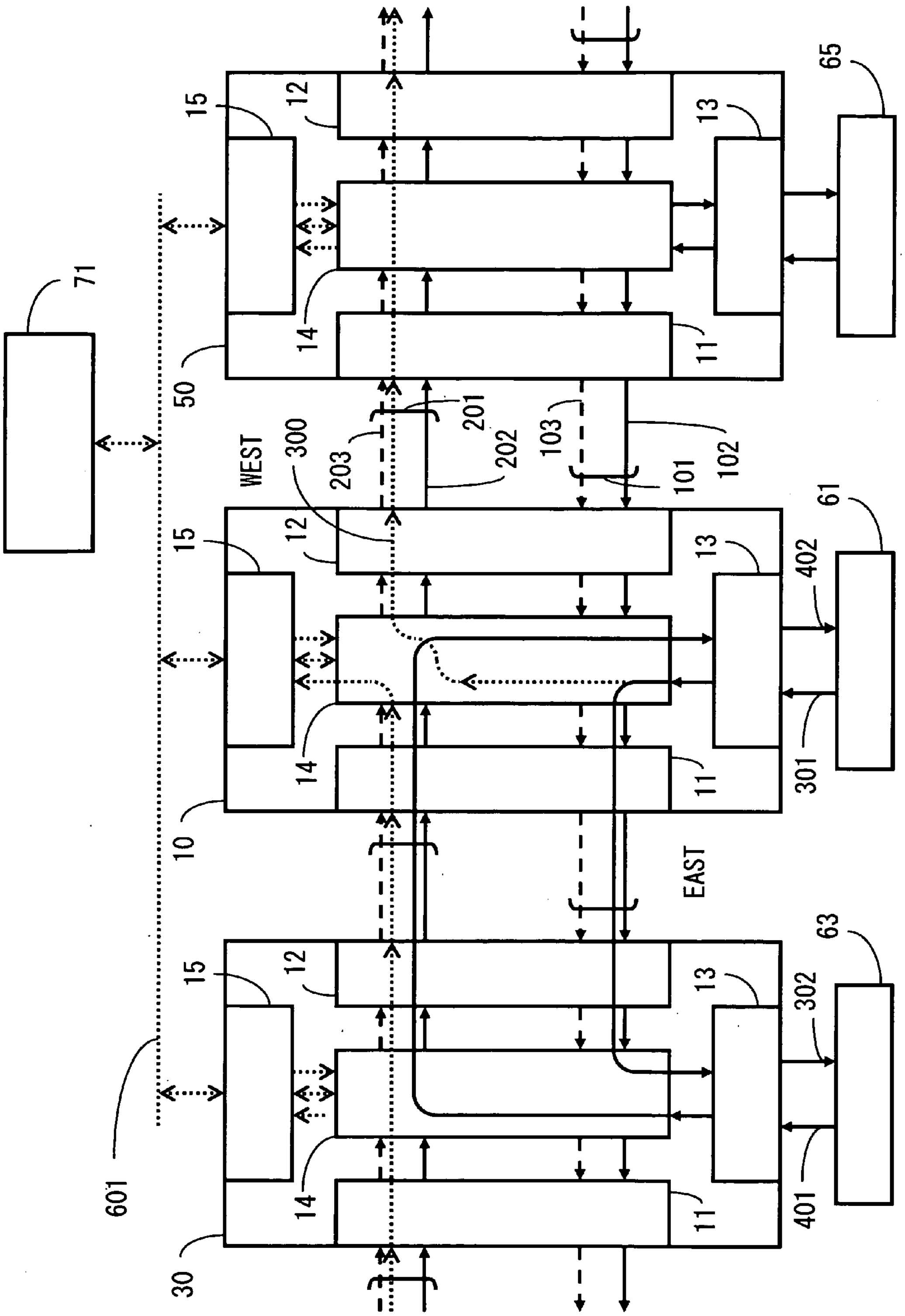

71
601
50
10
30
15
12
13
14
11
65
61
63
WEST
EAST
300
201
202
203
101
102
103
402
301
302
401

FIG. 6

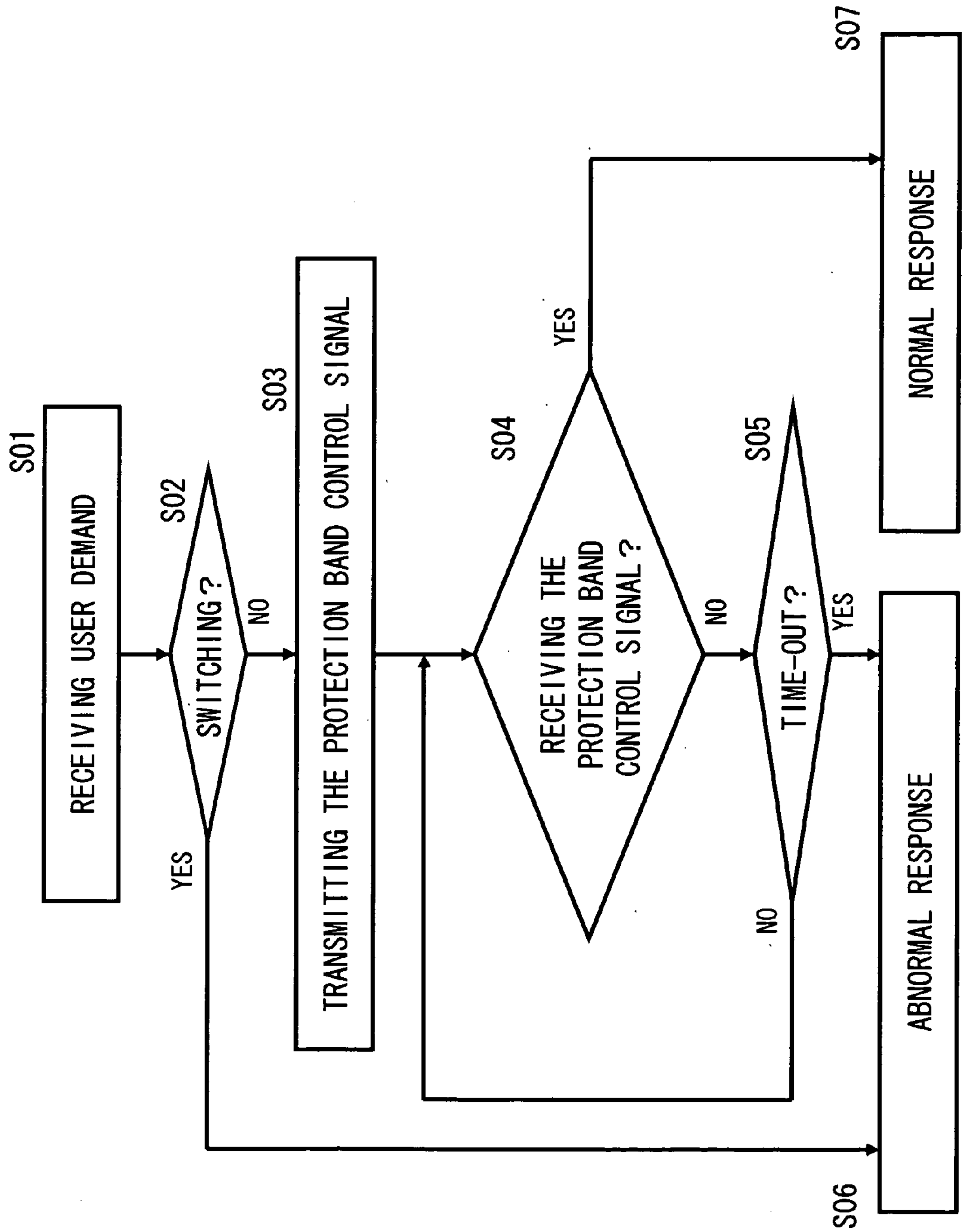

S01
RECEIVING USER DEMAND
S02
SWITCHING?
YES
NO
S03
TRANSMITTING THE PROTECTION BAND CONTROL SIGNAL
S04
RECEIVING THE PROTECTION BAND CONTROL SIGNAL?
YES
NO
S05
TIME-OUT?
YES
NO
S06
ABNORMAL RESPONSE
S07
NORMAL RESPONSE

FIG. 7

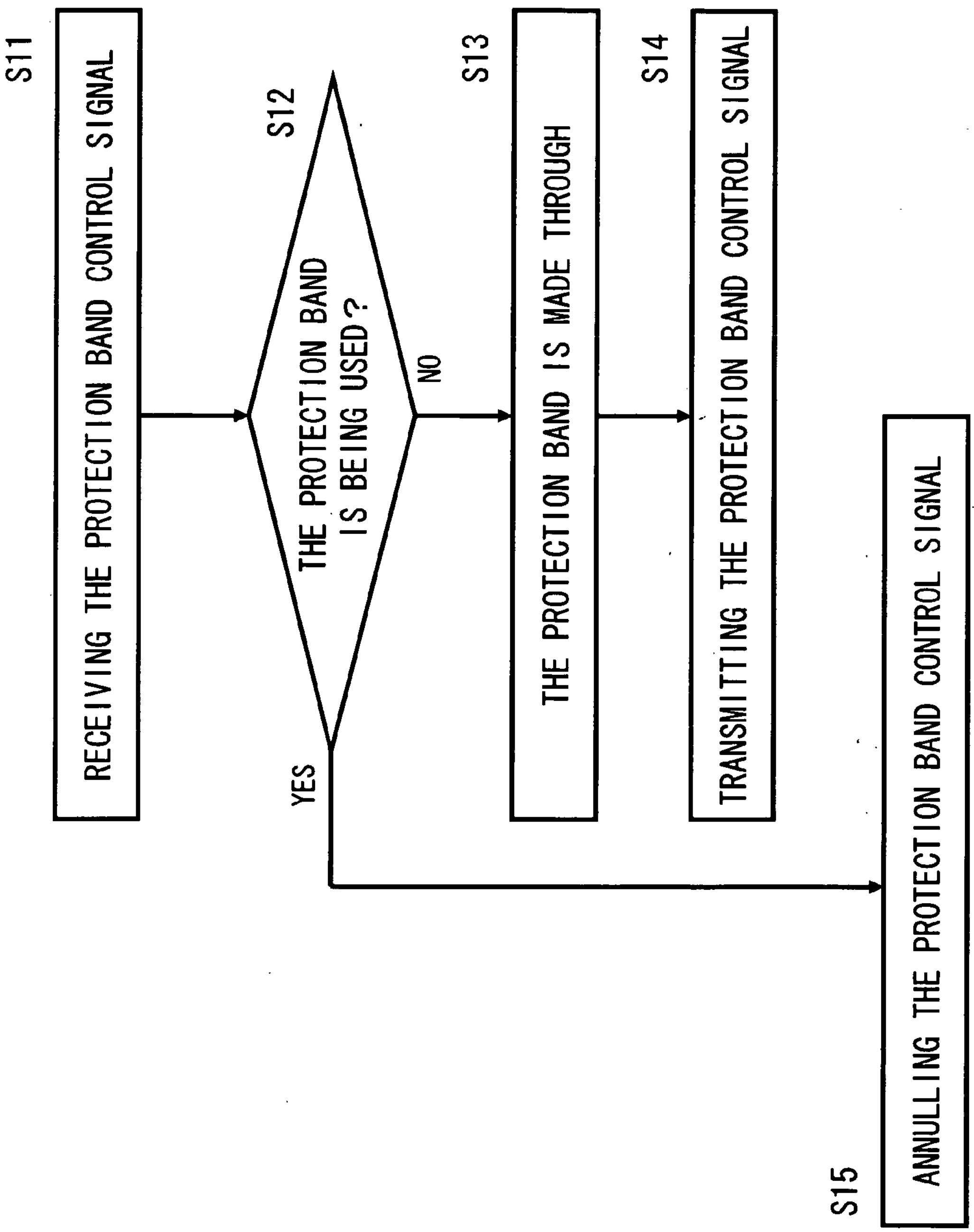
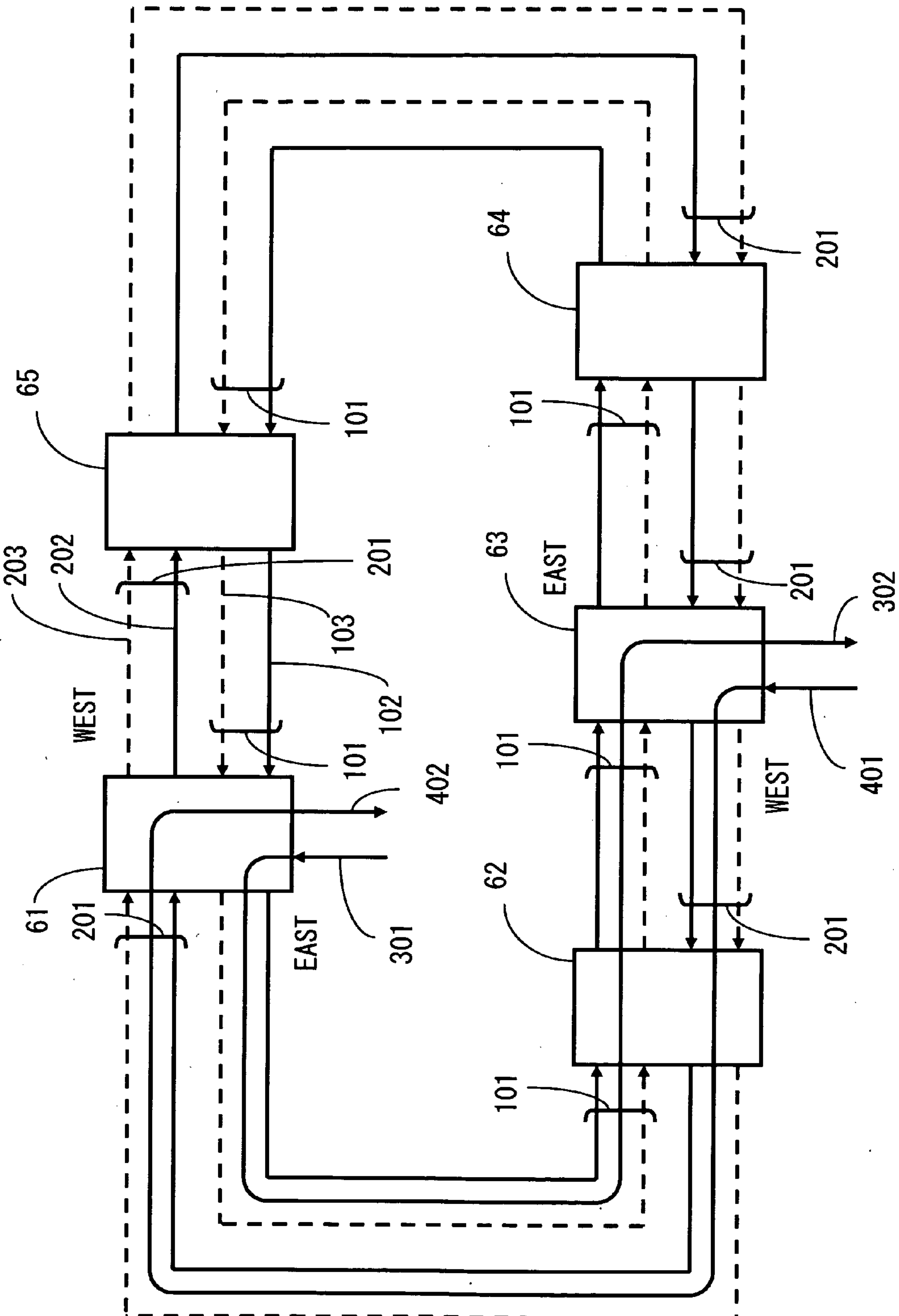

S11
RECEIVING THE PROTECTION BAND CONTROL SIGNAL
S12
THE PROTECTION BAND IS BEING USED?
YES
NO
S13
THE PROTECTION BAND IS MADE THROUGH
S14
TRANSMITTING THE PROTECTION BAND CONTROL SIGNAL
S15
ANNULLING THE PROTECTION BAND CONTROL SIGNAL

FIG. 8



PRIOR ART

FIG. 9

PRIOR ART

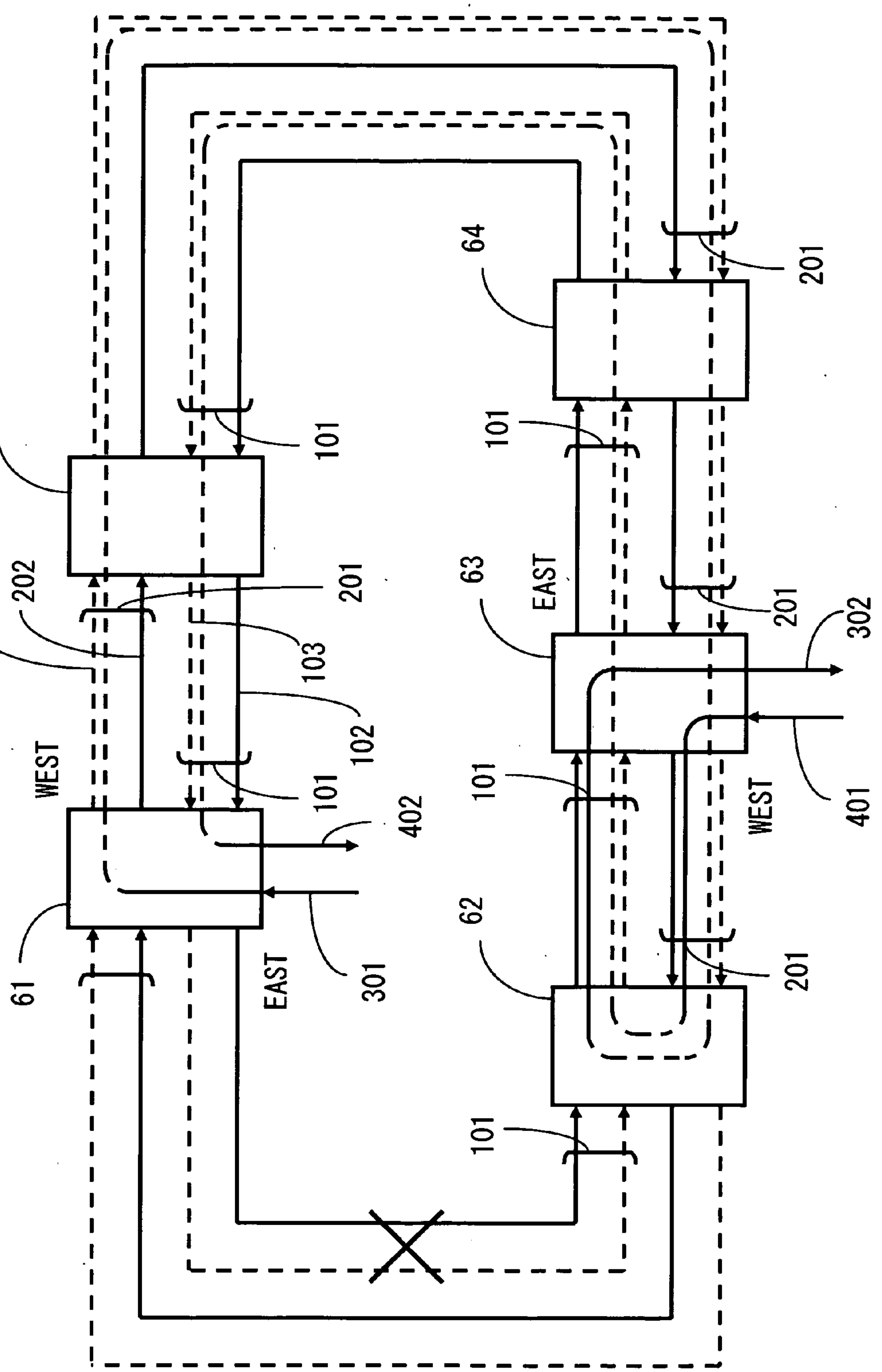


FIG. 10

PRIOR ART

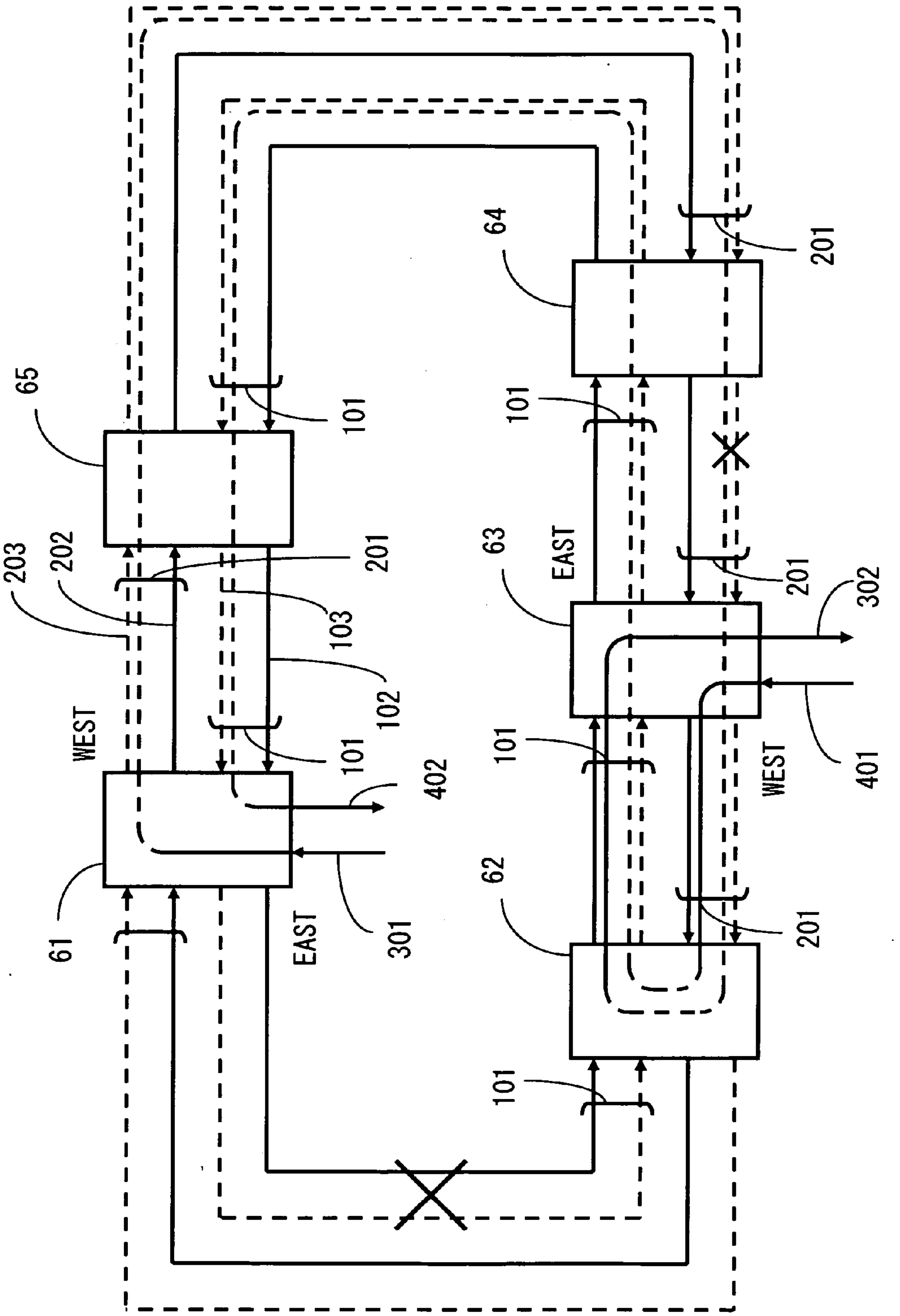
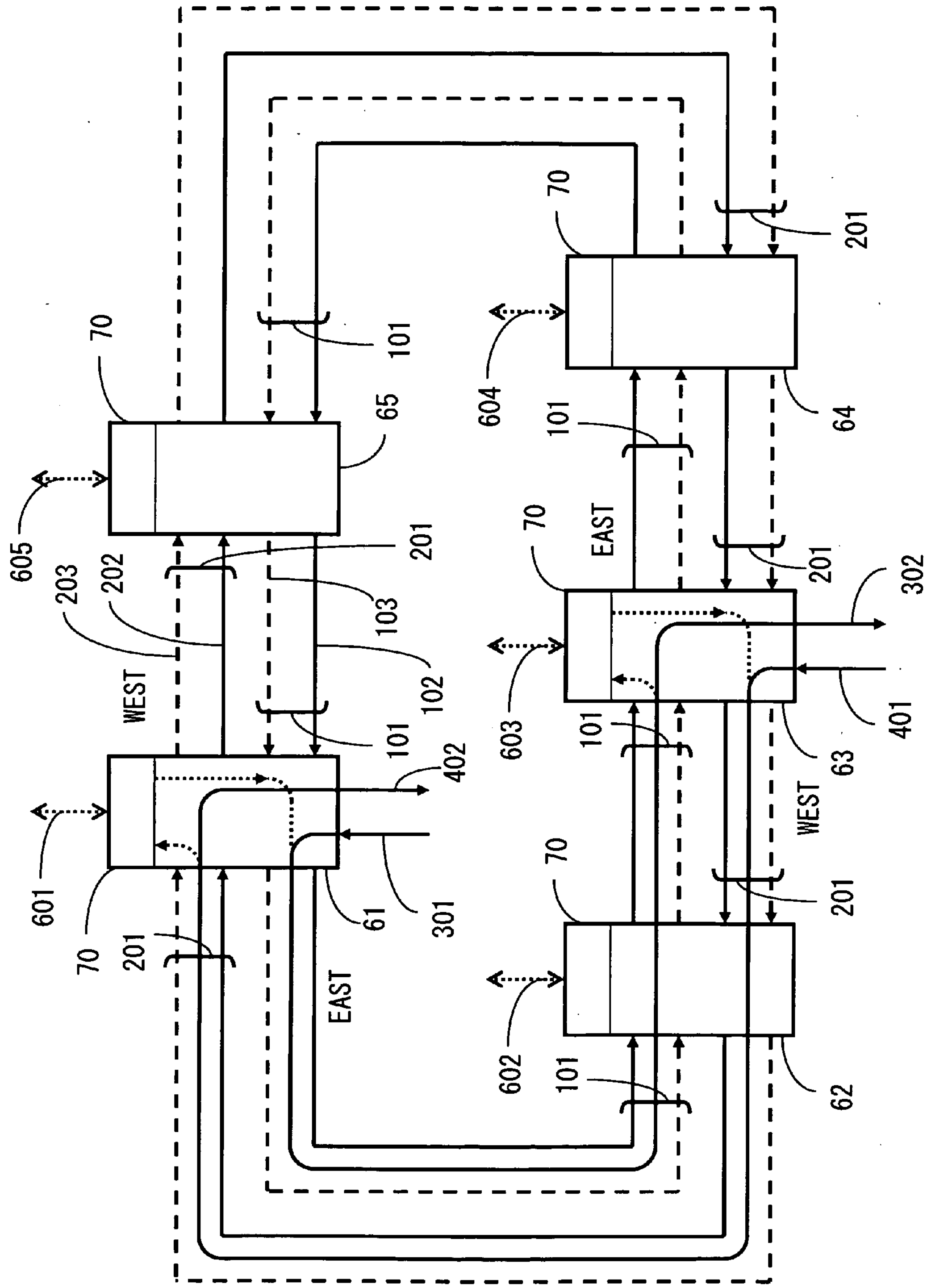


FIG. 11

PRIOR ART



RING NETWORK SYSTEM, NODE DEVICE, AND PROTECTION BAND TESTING METHOD FOR THE RING NETWORK SYSTEM

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a ring network system in which a plurality of node devices are connected in a ring configuration and in which a working band and a protection band combine to form a redundant transmission band pair, to a node device, and to a protection band testing method for the ring network system.

[0003] 2. Description of the Related Art

[0004] A synchronous optical network (SONET) ring is a ring network in which a plurality of SONET/synchronous digital hierarchy transmission (SDH) devices (or SONET devices) with add-drop multiplexer (ADM) capabilities act as node devices. The SONET ring is used in networks, ranging in size from small citywide networks to large nationwide networks. Typical redundancy schemes for the SONET ring include a bi-directional line switched ring (BLSR), which comes in two varieties: a two-fiber BLSR (2F-BLSR) and a four-fiber BLSR (4F-BLSR). In the 2F-BLSR, a transmission band of a single optical fiber for each of different directions (EAST direction and WEST direction) is divided into a current band (working band) and a backup band (protection band). The current band is used for transmitting signals under normal line conditions, while the backup band is used for diverting the signals in the case of a line failure. In the 4F-BLSR, both current and backup optical fibers are provided for each of EAST and WEST directions. Hereinafter, a 2F-BLSR SONET ring will be described in detail.

[0005] FIG. **8** is a diagram for illustrating the 2F-BLSR. Node devices **61**, **62**, **63**, **64**, and **65** are SONET devices with ADM capabilities. An EAST line **101** is an optical fiber for EAST direction, and a WEST line **201** is an optical fiber for WEST direction. A working band **102** and a protection band **103** are provided for the EAST line **101**, and a working band **202** and a protection band **203** are provided for the WEST line **201**. An ADD line **301** is added to the working band **102** of the EAST line **101** at the node device **61**. A DROP line **302** is dropped from the working band **102** of the EAST line **101** at the node device **63**. An ADD line **401** is added to the working band **202** of the WEST line **201** at the node device **63**. A DROP line **402** is dropped from the working band **202** of the WEST line **201** at the node device **61**.

[0006] The node devices **61** to **65** are connected in a ring configuration via the EAST line **101** and the WEST line **201**. The transmission band of the EAST line **101** is divided into two sub-bands, i.e., the working band **102** for current use and the protection band **103** for backup. Likewise, the transmission band of the WEST line **201** is divided into two sub-bands, i.e., the working band **202** for current use and the protection band **203** for backup. In general, the widths of a working band and a protection band are the same. For example, when an optical carrier 48 (OC48) line with a capacity of 2.4 Gbps is used, 48 channels of a synchronous transport signal-**1** (STS-**1**) for each of the EAST line **101** and the WEST line **201** are assigned equally to the working band and protection band, i.e., channels **1** to **24** are assigned to the working band and channels **25** to **48** are assigned to the protection band.

[0007] The following describes an example in which concatenated synchronous transport signal-**3***c* (STS-**3***c*) signals are transmitted between the node device **61** and the node device **63** over channels **1** to **3**. The node device **61** adds signals on the ADD line **301** to channels **1** to **3** of the EAST line **101**. The node device **62** allows the signals on channels **1** to **3** of the EAST line **101** to pass through (THRU). The node device **63** drops the signals on channels **1** to **3** of the EAST line **101** to the DROP line **302**. Likewise, the node device **63** adds signals on the ADD line **401** to channels **1** to **3** of the WEST line **201**. The node device **62** allows the signals on channels **1** to **3** of the WEST line **201** to pass through. The node device **61** drops the signals on channels **1** to **3** of the WEST line **201** to the DROP line **402**. For the node devices **61**, **62**, and **63**, a network management system (NMS, not shown) manages ADD control, DROP control, THRU control, and the selection of appropriate channels by using ADM control signals for controlling ADM switching functions and channels to be switched.

[0008] FIG. **9** is a diagram (**1**) illustrating the redundancy capabilities of a 2F-BLSR network, which has the same system configuration as that of the 2F-BLSR network illustrated in FIG. **8**. The following describes switching operation performed for the protection of line signals when transmission over the EAST line **101** between the node device **61** and the node device **62** is interrupted due to a fiber failure or the like.

[0009] First, the node device **61** adds signals on the ADD line **301** to channels **25** to **27** corresponding to the protection band **203** of the WEST line **201**. The node devices **65**, **64**, and **63** allows the signals on channels **25** to **27** of the WEST line **201** to pass through. The node device **62** directs the signals on channels **25** to **27** to channels **1** to **3** corresponding to the working band **102** of the EAST line **101**. The node device **63** drops the signals on channels **1** to **3** of the EAST line **101** to the DROP line **302**. Then, the node device **62** directs signals on channels **1** to **3** of the WEST line **201** to channels **25** to **27** corresponding to the protection band **103** of the EAST line **101**. The node devices **63**, **64**, and **65** allows the signals on channels **25** to **27** of the EAST line **101** to pass through. The node device **61** drops the signals on channels **25** to **27** of the EAST line **101** to the DROP line **402**. Thus, the signals transmitted over the failed line can be protected by the above-described switching operation in the ring network system.

[0010] In the switching operation of the ring network system described above, auto protection switching (APS) bytes constituting K1 and K2 bytes of the section overhead of a SONET/SDH frame are used. To protect signals on the failed line, a loopback circuit is created by the exchange of messages between nodes (e.g., the node devices **61** and **62** in FIG. **9**) at both sides of the point of failure. In addition, the other nodes (e.g., the node devices **63**, **64**, and **65** in FIG. **9**) need to allow the APS bytes containing the destination address to pass through. Japanese Unexamined Patent Application Publication No. 7-95225 discusses a method in which the address of a working node device is compared with addresses contained in APS bytes so as to increase the speed of pass-through processing for allowing the APS bytes to pass through.

[0011] FIG. **10** is a diagram (**2**) illustrating the redundancy capabilities of a 2F-BLSR network. FIG. **10** illustrates the same switching operation as that illustrated in FIG. **9**.

[0012] Generally, in a system with redundancy capabilities, line conditions of a protection band are not monitored. Therefore, when a channel failure in the protection band occurs, for example, on the WEST line **201** and between the node device **64** and the node device **63** and affects channels **25** to **27**, it can only be found after the completion of the switching operation illustrated in FIG. **9** that the signals on channels **1** to **3** cannot be protected by the switching operation.

[0013] FIG. **11** illustrates a line test performed on a 2F-BLSR network, which has the same system configuration as that of the 2F-BLSR network illustrated in FIG. **8**, except that each of the node devices **61** to **65** in FIG. **11** includes a test controller **70**. The following describes a line test performed on the working band **102** from the node device **61** to the node device **63**, and on the working band **202** from the node device **63** to the node device **61**.

[0014] The node devices **61** to **65** are connected to the network management system (NMS, not shown). For a line test, the NMS sends control signals **601** to **605** to the node devices **61** to **65**, respectively, and the node devices **61** to **65** send the corresponding response signals **601** to **605** back to the NMS. To perform a test for evaluating the communication quality of a path, for example, from the node device **61** to the node device **63** under the control of the NMS, a test signal generation unit of the test controller **70** for the node device **61** sends out a test signal to the working band **102** of the EAST line **101**. Then, a test signal measurement unit of the test controller **70** for the node device **63** performs a measurement on the transmitted test signal to evaluate the communication quality. Likewise, a test signal generation unit of the test controller **70** for the node device **63** sends out a test signal to the working band **202** of the WEST line **201**. Then, a test signal measurement unit of the test controller **70** for the node device **61** performs a measurement on the transmitted test signal to evaluate the communication quality. The minimum unit of measurement for the evaluation of communication quality is STS-**1**, which is the channel unit. For the evaluation of communication quality, the number of occurrences of error signals and the cumulative number of occurrences of error signals per day or per 15 minutes are counted.

[0015] In general, measurement for the evaluation of communication quality, such as that described above, is performed only on the working band of the ring network system and not on the protection band.

[0016] As described above, in the SONET BLSR network, it is possible to check the communication quality of channels in the working band. However, channels in the protection band are defined as "unused" and there is no means for creating a path for checking the communication quality of the channels. Therefore, the communication quality of channels in the protection band cannot be evaluated. The communication quality of such channels can only be evaluated when the channels are defined as being in the working band after the completion of switching operation performed due to a line failure.

SUMMARY OF THE INVENTION

[0017] Accordingly, an object of the present invention is to provide a ring network system that includes a means for setting a path for checking the communication quality of a protection band and is capable of creating, in the protection band, a ring path starting at a first node device, passing through a second node device, and ending at the first node device.

[0018] According to an aspect of the present invention, a ring network system includes a first node device, a plurality of second node devices, and a transmission line for connecting the first node device and the plurality of second node devices in a ring configuration. In the ring network system, each of the first device and the second devices combines a working band used as a normal band for transmitting signals and a protection band used as an alternative band for diverting signals to form a redundant transmission band pair. The first node device includes means for sending out a protection band control signal for controlling one of the second node devices so as to allow signals transmitted over the protection band to pass through the second node device. Each of the second node devices includes means for receiving the protection band control signal sent out from the first node device or another second node device, means for controlling the signals transmitted over the protection band to pass through the second node device during the reception of the protection band control signal, and means for transferring the protection band control signal to the adjacent first node device or to the adjacent second node device during the reception of the protection band control signal. The first node device further includes means for receiving the protection band control signal transferred from the adjacent second node device. A ring path that starts at the first node device, passes through the plurality of second node devices, and ends at the first node device is created in the protection band, and is used to evaluate the communication quality of the protection band.

[0019] The present invention makes it possible to provide a ring network system that includes a means for setting a path for checking the communication quality of a protection band and is capable of creating, in the protection band, a ring path starting at the first node device, passing through the second node devices, and ending at the first node device. In the ring network system, a test signal generation unit of the first node device sends out test signals to the ring path created in the protection band, and a test signal measurement unit of the first node device performs measurements on the test signals. The communication quality of the protection band can thus be evaluated.

[0020] According to another aspect of the present invention, the ring network system is characterized in that the control signal is valid when a destination address and a source address in APS bytes have the same value.

[0021] According to this aspect, it is possible to provide a ring network system capable of creating a path for checking the communication quality of a protection band when a destination address and a source address in APS bytes received by a node device of the ring network system are the same.

[0022] The present invention makes it possible to check the communication quality of a protection band of a ring network system. Therefore, when a transmission band is switched from a working band to a protection band for line protection in the case of a line failure, the occurrence of another line failure after the line switching due to degradation in the communication quality of the protection band can be prevented.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] FIG. **1** illustrates an exemplary ring network system.

[0024] FIG. **2** is a table for explaining K1 byte and K2 byte.

[0025] FIG. **3** is a diagram illustrating an exemplary configuration of a node device.

[0026] FIG. **4** is a diagram (**1**) illustrating exemplary operations of node devices.

[0027] FIG. **5** is a diagram (**2**) illustrating exemplary operations of node devices.

[0028] FIG. **6** is a flowchart illustrating an exemplary operation of a first node device.

[0029] FIG. **7** is a flowchart illustrating an exemplary operation of a second node device.

[0030] FIG. **8** is a diagram for illustrating a 2F-BLSR.

[0031] FIG. **9** is a diagram (**1**) illustrating the redundancy capabilities of a 2F-BLSR network.

[0032] FIG. **10** is a diagram (**2**) illustrating the redundancy capabilities of a 2F-BLSR network.

[0033] FIG. **11** is a diagram illustrating an exemplary line test.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0034] The present invention will now be described in detail with reference to the drawings. Throughout the drawings, the same or like components are denoted by the same reference numerals.

First Embodiment

[0035] FIG. **1** illustrates an exemplary ring network system (ring network system **1**) of the present invention. An EAST line **101**, which is typically an optical fiber, is a transmission line for connecting node devices **10**, **20**, **30**, **40**, and **50** in EAST direction in a ring configuration. A WEST line **201**, which is typically an optical fiber, is a transmission line for connecting the node devices **10**, **20**, **30**, **40**, and **50** in WEST direction in a ring configuration. A working band **102** and a protection band **103** are provided for signals transmitted over the EAST line **101**. The working band **102** is provided for current use and the protection band **103** is provided for backup. Likewise, a working band **202** and a protection band **203** are provided for signals transmitted over the WEST line **201**. The working band **202** is provided for current use and the protection band **203** is provided for backup. An ADD line **301** is added at the node device **10**. A DROP line **302** is dropped at the node device **30**. Likewise, an ADD line **401** is added at the node device **30**. A DROP line **402** is dropped at the node device **10**. A control/response signal **500** is a signal for interfacing with a network management system (NMS, not shown). A protection band control signal **501** is used to establish a path in a protection band for checking the communication quality of the protection band. The protection band control signal **501** is a control signal transmitted from each of the node devices **10**, **20**, **30**, **40**, and **50** to the adjacent node device in WEST direction. Although not illustrated in FIG. **1**, there is also the protection band control signal **501** transmitted from each node device to the adjacent node device in EAST direction.

[0036] The ring network system **1** in FIG. **1** has a SONET ring configuration, which is the same as that described with reference to FIG. **8**. Specifically, the ring network system **1** is a 2F-BLSR network in which a transmission band of a single optical fiber for each of different directions (EAST direction and WEST direction) is divided into a current band (working band) and a backup band (protection band). The node devices **10**, **20**, **30**, **40**, and **50** are SONET devices with ADM capabilities and are connected via the EAST line **101** and the WEST line **201**. The transmission band of the EAST line **101** is divided into two sub-bands, i.e., the working band **102** for current use and the protection band **103** for backup. Likewise, the transmission band of the WEST line **201** is divided into two sub-bands, i.e., the working band **202** for current use and the protection band **203** for backup. In general, the widths of a working band and a protection band are the same. For example, when an optical carrier 48 (OC48) line with a capacity of 2.4 Gbps is used, 48 channels of a synchronous transport signal-**1** (STS-**1**) for each of the EAST line **101** and the WEST line **201** are assigned equally to the working band and protection band, i.e., channels **1** to **24** are assigned to the working band and channels **25** to **48** are assigned to the protection band.

[0037] Both the EAST line **101** and the WEST line **201** have a SONET/SDH frame format (not shown). For example, the line overhead (LOH) of a SONET OC48 frame and the multiplex section overhead (MSOH) of an SDH synchronous transport module-**16** (STM-**16**) frame has an APS field containing K1 and K2 bytes, which are used for the control of line switching operations and for the transfer of line statuses.

[0038] FIG. **2** is a table for explaining K1 and K2 bytes. The first to fourth bits of K1 byte represent switch request signals (or switch requests) for the control of line switching operations. For example, FS-S (FS: forced switch) corresponding to switch request **1110** and FS-R corresponding to switch request **1101** represent control signals for directing transmitted signals from a working line toward a protection line in response to certain commands, when the protection line is in a normal state. Specifically, FS-S represents a control signal acting as a forced span switch and FS-R represents a control signal acting as a forced ring switch. Additionally, SD-S (SD: signal degrade) corresponding to switch request **1001** and SD-R corresponding to switch request **1000** represent control signals for directing transmitted signals from the working line toward the protection line, when the protection line is in a normal state, upon detection of signal degradation on the working line. Specifically, SD-S represents a control signal indicating that there is span signal degradation on the working line, while SD-R represents a control signal indicating that there is ring signal degradation on the working line. SD-P corresponding to switch request **1010** represents a signal used in a 4F-BLSR network and indicating that there is signal degradation on a protection line.

[0039] The fifth to eighth bits of K1 byte represent destination node IDs. The first to fourth bits of K2 byte represent source node IDs.

[0040] The fifth bit of K2 byte represents line types. The sixth to eighth bits of K2 byte represent signals for transferring line statuses and line switching statuses.

[0041] A source node device (represented by a source node ID) from which the node device is to be switched transmits a switch request signal to a destination node device (represented by a destination node ID) to which the node device is to be switched.

[0042] The following describes an example in which the node device **10** in FIG. **1** checks the line conditions of a protection band.

[0043] Upon receipt of the control signal **500** from the NMS, the node device **10** sends out to the adjacent node device **50** the protection band control signal **501** for establishing a path for checking the communication quality of a protection band. Upon receipt of the protection band control signal **501**, the node device **50** puts the protection band **203** into a "pass-through" state in which signals transmitted from the node device **10** over the protection band **203** (e.g., channels **25** to **48**) are directly transmitted to the node device **40**. Then, the node device **50** transfers the protection band control signal **501** to the adjacent node device **40**. Likewise, upon receipt of the protection band control signal **501**, the node device **40** puts the protection band **203** into a "pass-through" state and transfers the protection band control signal **501** to the adjacent node device **30**. Upon receipt of the protection band control signal **501**, the node device **30** puts the protection band **203** into a "pass-through" state and transfers the protection band control signal **501** to the adjacent node device **20**. Upon receipt of the protection band control signal **501**, the node device **20** puts the protection band **203** into a "pass-through" state and transfers the protection band control signal **501** to the adjacent node device **10**. Then, upon receipt of the protection band control signal **501**, the node device **10** sends out the response signal **500** to the NMS.

[0044] With the above-described operation of the node devices **10**, **20**, **30**, **40**, and **50** in the ring network, a path starting and ending at the node device **10** is created in the protection band **203** of the ring network system **1**.

[0045] FIG. **3** is a diagram illustrating an exemplary configuration of a node device. The node device includes line interfaces **11** and **12**, an intra-office line interface **13**, an ADM unit **14**, and a test controller **15** including a test signal generation unit **151** and a test signal measurement unit **152**. A control/response signal **601** is a signal for interfacing the node device with an NMS. An ADD line **701** and a DROP line **802** are lines for interfacing the node device with intra-office devices.

[0046] Signals transmitted over the EAST line **101** are received at the line interface **12**. In the ADM unit **14**, signals on a predetermined "drop" channel are transmitted through the intra-office line interface **13** to the DROP line **802**. Signals from the ADD line **701** are transmitted through the intra-office line interface **13**, added to a predetermined "add" channel, and transmitted through the line interface **11** to the EAST line **101**.

[0047] Likewise, signals transmitted over the WEST line **201** are received at the line interface **11**. In the ADM unit **14**, signals on a predetermined "drop" channel are transmitted through the intra-office line interface **13** to the DROP line **802**. Signals from the ADD line **701** are transmitted through the intra-office line interface **13**, added to a predetermined "add" channel, and transmitted through the line interface **12** to the WEST line **201**.

[0048] The control signal **601** from the NMS is detected at the test controller **15**, which controls add-drop operations in the ADM unit **14**, controls the protection band control signal **501** for establishing a path for checking the communication quality of a protection band, and performs control for setting signals for K1 and K2 bytes.

[0049] The ADM unit **14** is capable of performing add/drop operations on channel signals on the EAST line **101** and WEST line **201**, allowing the channel signals to pass through, returning and diverting the channel signals from the working band to appropriate channels in the protection band for protecting line signals, directing test signals generated by the test signal generation unit **151** to specific channels in the protection band, and directing the test signals in the protection band to the test signal measurement unit **152**. The ADM unit **14** is also capable of directing signals on the ADD line **701** to the protection band and directing signals in the protection band to the DROP line **802**.

[0050] According to the present embodiment described above, it is possible to create, in a protection band of a ring network, a ring path for transmitting test signals to the protection band, and thus possible to test the state of the protection band.

Second Embodiment

[0051] FIG. **4** is a diagram (**1**) illustrating exemplary operation of node devices. Of all the node devices **10** to **50** in the ring network system **1** illustrated in FIG. **1**, the node devices **20** and **40** are omitted in FIG. **4**. Intra-office devices **61**, **63**, and **65** are connected to the node devices **10**, **30**, and **50**, respectively, within the corresponding offices (stations). An NMS **71** controls the node devices **10**, **30**, and **50** and the like. Each of the node devices **10**, **30**, and **50** includes line interfaces **11** and **12**, an intra-office line interface **13**, an ADM unit **14**, and a test controller **15**. A control/response signal **601** interfaces between the NMS **71** and the node device **10**. Although FIG. **4** illustrates the connection between the NMS **71** and the node device **10** only, the NMS **71** is connected to either of the node devices **30** and **50** in the same manner as to the node device **10**.

[0052] As in the case of the ring network system illustrated in FIG. **1** or FIG. **8**, paths for the intra-office device **61** and the node device **63** are created between the node device **10** and the node device **30**. In the node device **10**, signals transmitted from the intra-office device **61** through the ADD line **301** are received at the intra-office line interface **13** and added to the working band **102** of the EAST line **101** in the ADM unit **14**, on the basis of ADM information defined according to information from the NMS **71**. Then, in the node device **30**, the signals are dropped from the working band **102** in the ADM unit **14**, on the basis of ADM information defined according to information from the NMS **71**, and output from the intra-office line interface **13** through the DROP line **302** to the node device **63**. Likewise, in the node device **30**, signals transmitted from the intra-office device **63** through the ADD line **401** are received at the intra-office line interface **13** and added to the working band **202** of the WEST line **201** in the ADM unit **14**, on the basis of ADM information defined according to information from the NMS **71**. Then, in the node device **10**, the signals are dropped from the working band **202** in the ADM unit **14**, on the basis of ADM information defined according to information from the NMS **71**, and output from the intra-office line interface **13** through the DROP line **402** to the node device **61**.

[0053] The node device **10** receives, from the NMS **71**, the control signal **601** for establishing a path for checking the communication quality of the protection band **203**. On the basis of the received control signal **601**, the node device **10** creates an "add" path in the ADM unit **14** such that test signals generated by the test signal generation unit **151** of the test controller **15** are transmitted over the protection band **203**. Then, the node device **10** assigns an ID value to the adjacent node device **50** such that the source node ID in the first to fourth bits of K2 byte in the WEST line **201** is the same as the destination node ID in the fifth to eighth bits of K1 byte (e.g., the destination node ID=0000 and the source node ID=0000).

[0054] The node device **50** terminates the WEST line **201** at the line interface **11** and detects K1 and K2 bytes. When the destination node ID and the source node ID are the same, the ADM unit **14** creates a through path that allows signals transmitted over the protection band **203** to pass through. Then, the node device **50** assigns an ID value to the adjacent node device **30** such that the source node ID in the first to fourth bits of K2 byte in the WEST line **201** is the same as the destination node ID in the fifth to eighth bits of K1 byte. Examples of possible combinations of node IDs are: the destination node ID=0000 and source node ID=0000 that are transmitted from the node device **10**; destination node ID=0100 and source node ID=0100; and destination node ID=0010 and source node ID=0010.

[0055] The node device **30** operates in the same manner as the node device **50**. The node device **30** terminates the WEST line **201** at the line interface **11** and detects K1 and K2 bytes. When the destination node ID and the source node ID are the same, the ADM unit **14** creates a through path that allows signals transmitted over the protection band **203** to pass through. Then, the node device **50** assigns an ID value to the adjacent node device **10** such that the source node ID in the first to fourth bits of K2 byte in the WEST line **201** is the same as the destination node ID in the fifth to eighth bits of K1 byte. For example, a destination node ID and a source node ID that are to be used may be those transmitted from the node device **30**, or those newly created.

[0056] The node device **50** terminates the WEST line **201** at the line interface **11** and detects K1 and K2 bytes. If the destination node ID and the source node ID are the same, the ADM unit **14** creates a "drop" path so that the evaluation of communication quality can be performed, in the test signal measurement unit **152** of the test controller **15**, on the signals transmitted over the protection band **203**.

[0057] The above-described operations of the node devices **10**, **30**, and **50** in the ring network create a path **300** that starts and ends at the node device **10** in the protection band **203** of the ring network system, and allow test signals generated by the test signal generation unit **151** to be transmitted over the path **300** and measured by the test signal measurement unit **152**. The communication quality of the protection band **203** can thus be evaluated.

[0058] Although only the protection band **203** of the WEST line **201** has been described above, the protection band **103** of the EAST line **101** can also be evaluated in the same manner as that described above.

[0059] If the above-described condition "destination node ID=source node ID" is cancelled, the through path in the ADM unit **14** in each of the node devices **30** and **50** and the "drop" path in the ADM unit **14** of the node device **10** are also cancelled.

[0060] According to the present embodiment described above, it is possible to create, in node devices of a ring network, a path for transmitting test signals over a protection band of the ring network.

Third Embodiment

[0061] In the present embodiment based on the configuration illustrated in FIG. **4**, a destination node ID and a source node ID that satisfy "destination node ID=source node ID" in K1 and K2 bytes are transmitted, as a protection band control signal, from a node device to an adjacent node device so that a path for checking the communication quality of a protection band can be established. It is also possible to use one of 101, 100, and 011 in the sixth to eighth bits of K2 byte in FIG. **2** as the protection band control signal.

Fourth Embodiment

[0062] FIG. **5** is a diagram (**2**) illustrating exemplary operations of node devices. A ring network system illustrated in FIG. **5** has the same system configuration as that illustrated in FIG. **4**. In the present embodiment, signals coming from the intra-office device **61** through the ADD line **301** and transmitted from the node device **10** to the node device **30** are used as test signals. The communication quality of the protection band **203** of the WEST line **201** can thus be checked by the node device **10**, as in the case of the second embodiment.

[0063] The node device **10** receives, from the NMS **71**, the control signal **601** for establishing a path for checking the communication quality of the protection band **203**. On the basis of the received control signal **601**, the ADM unit **14** of the node device **10** adds signals from the ADD line **301** to the working band **102** of the EAST line **101** and, at the same time, to the protection band **203** of the WEST line **201**. This allows a path **300** that starts and ends at the node device **10** to be created in the protection band **203** of the ring network system, as in the case of the second embodiment.

[0064] Since the path **300** that starts and ends at the node device **10** is created in the protection band **203** of the ring network system, and signals on the ADD line **301** are transmitted over the path **300** and measured by the test signal measurement unit **152**, the communication quality of the protection band **203** can be evaluated.

Fifth Embodiment

[0065] FIG. **6** is a flowchart illustrating an exemplary operation of a first node device, which is equivalent to the node device **10** described with reference to FIGS. **1**, **3**, and **4**. The first node device serves as the start and end points for creating a round path to be used in testing a protection band.

[0066] Step **S01**: From the NMS, the first node device receives a user request, in the form of a line test control signal, for performing a line test on the protection band.

[0067] Step **S02**: The first node device determines whether the protection band is not in use in the ring network.

[0068] Step **S03**: The first node device sends out, to an adjacent second node device, a protection band control signal for establishing a path for checking the communication quality of the protection band. In the protection band control signal, a destination node ID in K1 byte and a source node ID in K2 byte may be the same, or the sixth to eighth bits of K2 byte may be defined as one of 101, 100, and 011.

[0069] Step S04: The first node device determines whether a protection band control signal has been received from the direction opposite the direction in which the protection band control signal was sent out in step S03.

[0070] Step S05: If it is determined in step S04 that the protection band control signal has not been received, the first node device determines in step S05 whether the amount of time that has elapsed from the time when the protection band control signal was sent out in step S03 exceeds a timeout period predefined according to the characteristics of the ring network system.

[0071] Step S06: If it is determined in step S02 that the protection band is in use, or if it is determined in step S05 that a timeout occurs, the first node device returns an "abnormal" response to the NMS in response to the user request received in step S01.

[0072] Step S07: If the first node device has received in step S04 the protection band control signal before a timeout occurs, in other words, if the protection band control signal sent out in step S01 has been transmitted around the entire ring network and a round path for testing the protection band has been created, the first node device returns a "normal" response to the NMS.

[0073] FIG. 7 is a flowchart illustrating an exemplary operation of a second node device, which is equivalent to either of the node devices 20, 30, 40, and 50 described with reference to FIGS. 1, 3, and 4. In the second node device, a protection band is placed in a pass-through state so that a round path for testing the protection band can be created.

[0074] Step S11: From an adjacent first node device or another second node device, the second node device receives a protection band control signal for establishing a path for checking the communication quality of the protection band. In the protection band control signal, a destination node ID in K1 byte and a source node ID in K2 byte may be the same, or the sixth to eighth bits of K2 byte may be defined as one of 101, 100, and 011.

[0075] Step S12: The second node device determines whether the protection band is not in use in the ring network.

[0076] Step S13: If it is determined in step S12 that the protection band is not in use, the second node device keeps the protection band in a through state.

[0077] Step S14: The second node device sends out a protection band control signal to the adjacent first or second node devices in the same direction as the flow of the protection band control signal received in step S11. The protection band control signal to be sent out is a control signal defined in the same manner as in step S11.

[0078] In the protection band of a SONET ring composed of the first node device and the plurality of second node devices, a round path starting and ending at the first node device and passing through the second node devices can thus be created and allow the communication quality of the protection band to be tested.

What is claimed is:

1. A ring network system comprising:

a first node device;

a plurality of second node devices; and

a transmission line for connecting the first node device and the plurality of second node devices in a ring configuration,

wherein each of the first node device and the second node devices combines a working band used as a normal band for transmitting signals and a protection band used as an alternative band for diverting signals to form a redundant transmission band pair;

the first node device comprises means for sending out a protection band control signal for controlling one of the second node devices so as to allow signals transmitted over the protection band to pass through the second node device;

each of the second node devices comprises means for receiving the protection band control signal sent out from one of the first node device and another second node device, means for controlling the signals transmitted over the protection band to pass through the second node device while receiving the protection band control signal, and means for transferring the protection band control signal to one of the first node device and the adjacent second node device while receiving the protection band control signal;

the first node device further comprises means for receiving the protection band control signal transferred from the adjacent second node device; and

a ring path that starts at the first node device, passes through the plurality of second node devices, and ends at the first node device is set up in the protection band, and is used to evaluate a communication quality of the protection band.

2. The ring network system according to claim 1,

wherein the protection band control signal is valid, while a destination address in K1 byte and a source address in K2 byte have the same value in the section overhead of a frame used by a transmission device.

3. The ring network system according to claim 1,

wherein an unused portion of K2 byte is used as the protection band control signal.

4. The ring network system according to claim 1,

wherein the communication quality of the protection band is evaluated by transmitting test signals over the protection band from the first node device through the plurality of second node devices to the first node device.

5. A node device for connecting to a transmission line to form a ring network with other node devices, the node device comprising:

a ring line interface circuit for receiving and transmitting a multiframe signal having a working band used as a normal band for transmitting signals and a protection band used as an alternative band for diverting signals;

a setting circuit for dropping or adding the multiframe signal received by the ring line interface circuit on the basis of a received control signal; and

a test controller for controlling the dropping or adding the multiframe signal,

wherein the ring line interface circuit detects and generates a protection band control signal for testing a path in the protection band;

the setting circuit sets the path in the protection band into a pass-through state on the basis of the protection band control signal; and

the test controller controls the execution of a path test for the protection band, generates test signals for the path test, and performs measurements for the path test.

6. The node device according to claim **5**,
wherein the protection band control signal is valid while a destination address in K1 byte and a source address in K2 byte have the same value in the section overhead of a SONET/SDH frame.

7. The node device according to claim **5**,
wherein an unused portion of K2 byte is used in the protection band control signal.

8. The node device according to claim **5**,
wherein the communication quality of the protection band is evaluated by transmitting test signals over the protection band from the first node device through the plurality of second node devices to the first node device.

9. A protection band testing method for a ring network system in which a first node device and a plurality of second node devices are connected in a ring configuration, and a working band and a protection band combine to form a redundant transmission band pair, the protection band testing method comprising the steps of:
sending out, from the first node device, a control signal for controlling one of the second node devices so as to allow signals transmitted over the protection band to pass through the second node device;
at one of the second node devices,
receiving the control signal sent out from one of the first node device and another second node device;
controlling the signals transmitted over the protection band to pass through the second node device while receiving the control signal;
transferring the control signal to one of the first node device and the adjacent second node device while receiving the control signal; and
receiving, at the first node device, the control signal transferred from the adjacent second node device,
wherein a ring path that starts at the first node device, passes through the plurality of second node devices, and ends at the first node device is created in the protection band, and is used to evaluate the communication quality of the protection band.

10. The protection band testing method according to claim **9**,
wherein the control signal is valid, while a destination address in K1 byte and a source address in K2 byte have the same value in the section overhead of a frame used by a transmission device.

11. The protection band testing method according to claim **9**,
wherein an unused portion of K2 byte is used in the control signal.

12. The protection band testing method according to claim **9**,
wherein the communication quality of the protection band is evaluated by transmitting test signals over the protection band from the first node device through the plurality of second node devices to the first node device.

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