(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 583 390 B9**

(12) **CORRECTED EUROPEAN PATENT SPECIFICATION**

(15) Correction information:
Corrected version no 1 (W1 B1)
Corrections, see
Description Paragraph(s) 41, 46, 100, 127, 140, 201
Claims EN 5

(48) Corrigendum issued on:
20.09.2017 Bulletin 2017/38

(45) Date of publication and mention of the grant of the patent:
07.06.2017 Bulletin 2017/23

(21) Application number: **05006378.3**

(22) Date of filing: **23.03.2005**

(51) Int Cl.:
H04Q 11/00 *(2006.01)*

(54) **Optical connection switching apparatus and management control unit thereof**

Anordnung für Vermittlung von optischen Verbindungen und Verwaltungssteuerungseinheit dafür

Appareil de commutation de connections optique et son unité de commande de gestion

(84) Designated Contracting States:
DE FR GB

(30) Priority: **30.03.2004 JP 2004100796**
27.01.2005 JP 2005020129

(43) Date of publication of application:
05.10.2005 Bulletin 2005/40

(73) Proprietor: **FUJITSU LIMITED**
Kawasaki-shi,
Kanagawa 211-8588 (JP)

(72) Inventors:
- **Amemiya, Kouichirou**
Kawasaki-shi,
Kanagawa 211-8588 (JP)
- **Naito, Takao**
Kawasaki-shi,
Kanagawa 211-8588 (JP)
- **Katagiri, Toru**
Kawasaki-shi,
Kanagawa 211-8588 (JP)
- **Tanaka, Toshiki**
Kawasaki-shi,
Kanagawa 211-8588 (JP)

(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(56) References cited:
WO-A1-01/33896 **WO-A1-97/24822**

EP 1 583 390 B9

Description

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on and hereby claims priority to Japanese Applications No. 2004-100796 filed on March 30, 2004 and document JP 4427463 B, the contents of which are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

[0002] The present invention relates to an optical connection. (wiring) switching apparatus and a management control unit thereof, for example, an optical connection switching apparatus and a management control unit thereof suitable for the connection management in in-datacenter or in-company optical network or the like.

(2) Description of the Related Art

[0003] Along with the recent speeding-up of transmission signals and wide-spreading of networks, an optical signal network is being constructed which employs, as a transmission medium, an optical fiber having a large-bandwidth property and a low-loss property.
Although the high-speed signal and the broadband transmission has been peculiar to the communications in the backbone networks so far, because of the appearance of various types of Ethernets (registered trademark), such as the Giga-bit Ethernet (GbE) and 10-Giga-bit Ethernet (10GbE), and a fiber channel (FC), the speeding-up of transmission signals and the wide-spreading of the networks are advancing even in Ethernets such as LAN (Local Area Network) and other networks.

[0004] Along with this situation, the construction of an optical network is advancing even in a LAN using an Ethernet, a SAN (Storage Area Network) using a fiber channel and others. In such an optical network, various types of information apparatus (IT equipment) such as personal computers and a layer-2/layer-3 electric switch are connected to each other through the use of an optical fiber on a one-to-one basis, and at the construction or change of a network, there is a need to employ a facility capable of switching the optical signal path when a trouble (disorder) occurs.

[0005] For example, as the network in which these LAN and SAN exist in a state mixed, there is an in-datacenter network. In general, the optical connection in the datacenter is under management through the use of a control panel, in which optical adapters are arranged, called a patch panel and, for example, the optical path switching is realized by manually inserting/drawing fiber connectors, and the connection management is made through the tag attachment to both the ends of a fiber and the connection state recording made by the manual inputting.

[0006] Thus, as an enterprise network such as an in-datacenter network, a network has been constructed through the use of a Giga-bit Ethernet, 10-Giga-bit Ethernet, fiber channel (FC) or the like, and the transmission rate of this network has been as high as 1.0 Gbps, 10 Gbps or more and, as represented by a service such as a wide-area Ethernet, the transmission distance has been lengthened. For this reason, as the transmission medium, there has been employed an optical fiber superior in large-bandwidth property and low-loss property.

[0007] So far, the connection between IT (Information Technology) equipment and layer-2/layer-3 electric switch has been made on a one-to-one basis and, hence, there is a need to install a large number of optical fibers. Moreover, the connection management for these optical fibers has been made in the present situation. In general, the construction and change of a network system or the change of the connection of optical fibers stemming from the occurrence of a trouble lead to complicated operations such as optical fiber connection device confirmation tagging, connection diagram renewal and connection confirmation.

[0008] Such a network environment management method creates a problem in that there is a need to take a large number of processes. Moreover, in most cases, the actual wiring operations and the network construction operations are conducted in a separate fashion and there is a need to share the information on connection devices even in remote sites.

[0009] In addition, since the signals flowing an optical fiber range widely in type, such as various Ethernets (Ethernet, FastEthernet, Giga-bitEthernet,10-Giga-bit Ethernet) and fiber channels, mainframe interfaces (OCLINK, ESCON/FICON), for the connection of equipment having these interfaces (protocol and bit rate) through an electric switch, the number of electric switches (Ethernet switch, fiber channel switch, and others) is required to be equal to the number of types of interfaces, which leads to an extremely high cost.

[0010] For this reason, as the route switching apparatus handling high-speed signals in the Giga-bit Ethernet, the fiber channel or the like, a hopeful view is taken on an optical connection switching apparatus. This optical switch was originally developed for use in a transmission apparatus of a trunk network (backbone network) and, since the route switching

can be made in a state of optical signal, the optical switch does not suffer from the delay occurring in an electric switch. Moreover, since there is no need to convert an optical signal into an electric signal, it also has a transparency in that it is possible to make the route switching on arbitrary protocols and arbitrary bit-rate signal.

[0011] In this connection, as a conventional technique on the fiber channel, there are techniques proposed, for example, in Japanese Patent Laid-open Nos. HEI 10-135952 and HEI 11-65980. The technique of Japanese Patent Laid-open No. HEI 10-135952 is for providing a fiber channel exchange which mutually connects a plurality of equipment to each other through node ports (N ports) related thereto, and the technique of Japanese Patent Laid-open No. HEI 11-65980 is for, in the connection configuration using fabrics in a fiber channel interface, speeding up the response of the fabrics.

[0012] In addition, as the conventional network interface apparatus, there are the techniques proposed in Japanese Patent Laid-Open Nos. 2000-341359 and 2000-209622. The technique of Japanese Patent Laid-Open No. 2000-341359 is for providing an apparatus capable of making the re-construction of ports in a communication network efficiently at a low cost, and includes a plurality of optical ports and a plurality of electronic circuits and an electronic switch disposed between the plurality of optical ports and the plurality of electronic circuits to re-construct the connection between one selected from the plurality of optical ports and one of the electronic circuits. The technique of Japanese Patent Laid-Open No. 2000-209622 relates to a serial transmission switching system capable of coping flexibly with the addition or change of the existing transmission-rate communication equipment and the addition of new transmission-rate communication equipment.

[0013] Still additionally, as the conventional techniques related to the fiber channel and the Giga-bit Ethernet, there is a technique proposed in Japanese Patent Laid-Open No. 2002-232409. This technique relates to a pattern detecting method and apparatus for monitoring a data stream in the fiber channel, Giga-bit Ethernet and others. That is, to most interfaces, as in the case of the fast fiber channel and Giga-bit Ethernet interface, it is useful to produce a special data stream with attention being paid to a given jitter in the interface and/or the equipment or other similar deterioration characteristics. Therefore, such a test apparatus is operated at a specified time of the data stream.

[0014] Meanwhile, for incorporating these network apparatus into a system, a redundant configuration is employed in most cases. In the case of routers acting as a network apparatus, information are interchanged between the routers in order to grasp states. Companies have presented diverse protocols for placing the routers into a redundant condition by interchanging the information.

[0015] For example, Cisco Systems Co., Ltd. has prepared HSRP (Hot Standby Routing Protocol) as the protocol for making the router redundant. That is, in a state where one IP (Internet Protocol) address is allocated to each router, one IP address is further allocated to all the routers multiplexed and, for making communications, a request is transmitted to the IP address for all the routers. The router to be used for common communication is one in number and, when the router which is in use comes to a stop, the other one router automatically makes communications in place of the router which has come to a stop. The time needed for the switching therefor is approximately one second.

[0016] In addition, although there is no interoperability (interchangeability), as a similar technique, there has been known VRRP (Virtual Router Redundancy protocol). A plurality of routers matching with the VRRP are grouped into one group and, usually, one of the routers takes care of communications, and when this router falls into a trouble, a router belonging to the same group automatically takes over the communications. Although the router which makes communications is limited to one in the same group, since one router can belong to a plurality of groups, it is also possible to realize the load distribution simultaneously according setting.

[0017] The foregoing techniques relate to a technique in which a routing table which is information on the layer 3 is interchanged among a plurality of routers and, when a router falls into a trouble, a path is set so as to bypass the router which has fallen into the trouble, thereby securing a communication route.

[0018] Moreover, as redundant arrangements of an optical switch, there are techniques proposed in Japanese patent Laid-Open Nos. 2002-95023 and 2003-289557, and others. In these techniques, power is monitored in each port of an optical switch set as a work system and, at the time of the detection of a power disconnection, switching is made to a port of an optical switch set as a spare (protection) system. In the arrangement, in addition to N x N optical switches which are a main switch, switches for the selection of the work system and the spare system are connected vertically, and a port relationship for placing an arrangement into a redundant condition is uniquely determined because of the physical connections. Still moreover, in the technique proposed in Japanese patent Laid-Open Nos. 2004-40726, when a trouble is detected on the work link side in a redundant input/output link of an optical switch, switching is made with reference to a protection table (port information) which specifies a portion to be restored at the detection of the trouble.

[0019] For the management of the optical connections (wiring) in a optical network such as an optical LAN (Local Area Network) constructed using an optical connection switching apparatus (optical switch) in a datacenter or in an enterprise, there is a need to capture what type (for example, protocol or bit rate) of equipment is connected to each port of the optical connection switching apparatus (information about the equipment). Although this requires monitoring the contents of an optical signal, it is impossible, for that the existing optical connection switching apparatus is not designed to analyze the contents of an optical signal while conducting the route switching in a state of the optical signal. This also applies to the aforesaid Japanese Patent Laid-Open Nos. HEI 10-135952, 2000-341359, HEI 11-65980, 2000-209622 and

2002-232409, and these documents does not disclose nor teach a technique of capturing which of ports of an optical switch is connected to what type of equipment for the connection management.

[0020] Furthermore, in the case of the employment of the above-mentioned optical connection switching apparatus, in a datacenter network, there is a need to construct a system for looking toward the nonstop for 365 days and 24 hours. For this reason, there is a need to enhance the reliability of the system by making this apparatus and power supply redundantly. The redundant optical connection switching apparatus requires a link redundancy for the switching to a spare link when a trouble occurs in a work link and requires a node redundancy for the switching to a spare apparatus (a plurality of collected ports) when a trouble occurs in a work apparatus .

[0021] Since the above-mentioned optical connection switching apparatus is designed to acquire the information on the apparatus having an optical communication interface to be connected optically for managing the connection between the apparatuses, in the work and spare systems, the same apparatus is not connected to the port with the same number, but the number of a port to be connected is optionally determined. Therefore, in the case of the conventional switching to a spare apparatus at the occurrence of a trouble, since the frequency of change of the apparatus to be connected is high, there is a high possibility that only the link switching cannot achieve the normal connection. Moreover, since the control in the physical layer is principally conduced instead of the control in the layer 3 such as a routing table, a redundancy protocol for a router cannot cope with it and, hence, a new switching procedure becomes necessary. Still moreover, in the case of the employment of a protection table (port information), an increase in the number of ports causes a complicated management and then leads to a low reliability.

[0022] Document WO 01/33896 A1 relates to a system for protecting connections between optical cross-connect switches and client equipment. According to the document, to minimize service interruption, a connection failure can detected, signaled, and a switch to a protection connection can be made by the client equipment and the optical cross-connect switch. An out-of-band channel or an in-band channel can be used to signal the connection failure.

[0023] Document WO 97/24822 A1 relates to a method and system for detecting optical signal degradation or loss within the optical domain of a fiber network. Optical cross-connect switches are provided at network nodes. Optical data traffic is conducted between nodes via a fiber link. The fiber link extends between respective ports of the optical cross-connect switches at each network node. Dedicated signals for detecting faults are introduced and removed within the optical domain of the fiber communication network.

SUMMARY OF THE INVENTION

[0024] The present invention has been developed with a view to eliminating the above-mentioned problems, and it is therefore an object of the invention to provide an optical connection switching apparatus and a management control unit therefor capable of acquiring the information on equipment having an optical communication interface to be optically connected, for carrying out the automatic connection management on this equipment. In addition, another object of the present invention is to improve the reliability in the case of the incorporation of these apparatus and unit into a network system.

[0025] For this purpose, in accordance with an aspect of the present invention, there is provided an optical connection switching apparatus to which a plurality of equipment each having an optical communication interface are connected and which is made to establish an optical connection therebetween, the apparatus comprising an optical connection switching facility having a plurality of an optical input/output ports each of which includes a pair of optical input port and an optical output port and is capable of making a connection between any one of the optical input ports and any one of the optical output ports, one or more optical transmitting/receiving units connected to a portion of the optical input/output ports, and a management control unit for controlling the optical connection switching facility to make a connection between the optical input/output port connected to the optical transmitting/receiving unit and the optical input/output port connected to the equipment for acquiring and managing information on the equipment by making a communication with the equipment through the use of the optical transmitting/receiving unit.

[0026] In this case, it is also appropriate that the management control unit includes an equipment information storing unit for storing identification information on the equipment, as information on the equipment acquired by the communication with the equipment in a state associated with information on the optical input/output port.

[0027] In addition, it is also appropriate that the management control unit includes an equipment state monitoring unit for monitoring connection, a disconnection or a communication state of the equipment by monitoring optical power information on the optical input/output port.

[0028] Still additionally, it is also appropriate that, in the optical connection switching apparatus, a light-receiving element is provided with respect to the optical input port of the optical connection switching facility, and the equipment state monitoring unit is constructed as an input port equipment state monitoring unit which handles, as the optical power information, a quantity of light reception by the light-receiving element to monitor the connection, disconnection or communication state of the equipment by monitoring a variation of the optical power information.

[0029] Furthermore, in accordance with a further aspect of the present invention, there is provided a management

control unit for an optical connection switching apparatus which includes an optical connection switching facility having a plurality of an optical input/output ports each of which is composed of a pair of optical input port and an optical output port and which is capable of making a connection between any one of the optical input ports and any one of the optical output ports, with each of a plurality of equipment each having an optical communication interface being connected to any one of the optical input/output ports to establish an optical connection between the equipment, the management control unit comprising one or more optical transmitting/receiving units connected to a portion of the optical input/output ports and a management control unit for controlling the optical connection switching facility to make a connection between the optical input/output port connected to the optical transmitting/receiving unit and the optical input/output port connected to the equipment for acquiring and managing information on the equipment by making a communication with the equipment through the use of the optical transmitting/receiving unit.

[0030] In addition, for the above-mentioned purpose, it is also appropriate that an optical connection switching apparatus according to the present invention further comprises a light source connected to one of the input ports of the optical connection switching facility and a light reception circuit connected to one of the output ports of the optical connection switching facility, and the management control unit further comprises a first trouble detecting unit designed to make the detection of a trouble of the optical connection switching facility by monitoring a light-reception state in the light reception circuit while switching a connection state between the input port connected to the light source and the output port connected to the light reception circuit.

[0031] Still additionally, in an optical connection switching apparatus according to the present invention, it is also appropriate that at least the optical connection switching facility and the management control unit are placed into a redundant condition (redundant configuration), and a first light source connected to one of the input ports of one optical connection switching facility and a second light source connected to one of the input ports of the other optical connection switching facility are provided so that an output port of the one optical connection switching facility which outputs light from the first light source is connected to an input port other than the input port connected to the second light source of the other optical connection switching facility and an output port of the other optical connection switching facility which outputs light from the second light source is connected to an input port other than the input port connected to the first, light source of the one optical connection switching facility, and the management control unit further includes a second trouble detecting unit designed to make the detection of a trouble of one of the optical connection switching facilities by monitoring an output light power from each of the output ports of one of the optical connection switching facilities.

[0032] Yet additionally, in the optical connection switching apparatus according to the present invention, it is also appropriate that, when one equipment is connected to two of the input/output ports to use one as a work port and the other as a spare port, the management control unit includes an equipment information storing unit for storing an equipment identification information table in which identification information on the equipment connected to the optical connection switching facility is associated with information on the work port and the spare port, and a work/spare switching control unit for, when an optical disconnection on the work port is detected, controlling the optical connection switching facility on the basis of the equipment identification information table in the equipment information storing unit to make the switching from the port used by the equipment to the spare port.

[0033] Moreover, in the optical connection switching apparatus according to the present invention, it is also appropriate that at least the optical connection switching facility and the management control unit are placed into a redundant condition, and each of the management control units includes an equipment information storing unit for storing a main equipment identification information table in which identification information on equipment connected to the work optical connection switching facility is associated with information on the input/output port of the work optical connection switching facility and a sub equipment identification information table in which identification information on the equipment connected to the spare optical connection switching facility is associated with information on the input/output port in the spare optical connection switching facility, a work/spare switching control unit for, when a trouble occurs in the input/output port of the work optical connection switching facility or the work optical connection switching facility itself, controlling each of the optical connection switching facilities on the basis of each of the tables on the optical connection switching facilities for switching the port used by the equipment to the input/output port of the spare optical connection switching facility, and a table synchronization updating unit for updating the contents of each of the tables in the management control unit, it pertains to, in synchronism with the contents of each of the tables in the other management control unit.

[0034] Still moreover, an optical connection switching apparatus according to the present invention comprises an optical connection switching facility connected to a plurality of equipment each having an optical communication interface for making an optical connection between the equipment, an optical receiver for receiving partial or full light to be transmitted/received between the equipment optically connected by the optical connection switching facility, and a management control unit for acquiring information on the equipment connected to the optical connection switching facility on the basis of the light received by the optical receiver to manage it.

[0035] According to the present invention, the optical connection switching facility is controlled to make the connection between the optical input/output port connected to the optical transmitting/receiving unit and the optical input/output port connected to the equipment so that the communication is made with the connected equipment through the use of the

optical transmitting/receiving unit to acquire and manage the information on the equipment, thus automating the connection management on the connected equipment to considerably shortening the time needed for this operation, which can considerably reduce the operation management cost as a result.

[0036] Moreover, the connection, disconnection or communication state of the equipment can be monitored by monitoring the optical power information on the optical input/output port of the optical connection switching facility, which can achieve the automation of the inter-port connection switching and which can also automate the connection switching at the re-construction of a network using this optical connection switching apparatus or at the occurrence of a trouble. This can considerably reduce the time needed for this operation and can cut the operation management cost of the network.

[0037] Still moreover, when an optical connection switching apparatus is placed into a redundant condition according to the present invention, the speeding-up of the detection of a trouble point based on a detection in a physical layer becomes feasible. In addition, since the switching becomes possible by making reference to identification information (for example, address information) on equipment, the switching to a spare system becomes easily and quickly achievable. Still additionally, the employment of the above-described technique can shorten the system-down time and the time needed for the switching to the spare system, which can shorten the suspension time of the system and enhance the reliability of the network system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038]

FIG. 1 is a block diagram showing a configuration of an optical connection automatic-switching apparatus (optical connection switching apparatus) according to an embodiment of the present invention;

FIG. 2 is a block diagram useful for explaining an IT equipment connection and disconnection automatic-recognition function (in a case in which an optical input port is equipped with a light-receiving element) of the optical connection automatic-switching apparatus shown in FIG. 1;

FIG. 3 is a block diagram useful for explaining an IT equipment connection and disconnection automatic-recognition function (in a case in which an optical output port is equipped with a light-receiving element) of the optical connection automatic-switching apparatus shown in FIG. 1;

FIG. 4 is a block diagram showing an example of the allocation of a monitor charge port in a case in which a plurality of optical power monitoring ports are provided in the optical connection automatic-switching apparatus shown in FIG. 1;

FIG. 5 is a flow chart useful for explaining an operation (control) at equipment connection by the optical connection automatic-switching apparatus (management control circuit) shown in FIG. 1;

FIG. 6 is a block diagram useful for explaining a redundant path switching function of the optical connection automatic-switching apparatus shown in FIG. 1;

FIG. 7 is a block diagram showing a modification of a redundant path switching function of the optical connection automatic-switching apparatus shown in FIG. 1;

FIG. 8 is a block diagram useful for explaining an IT equipment connection recognition function according to an input/output port direct-coupling method of the optical connection automatic-switching apparatus shown in FIG. 1;

FIG. 9 is a block diagram showing a connection example in an optical connection switching facility for explaining an IT equipment connection recognition function according to an adjacent input/output port direct-coupling method (quasi-fixing method) of the optical connection automatic-switching apparatus shown in FIG. 1;

FIG. 10(A) is a block diagram showing a connection example in an optical connection switching facility for explaining an IT equipment connection recognition function according to an adjacent input/output port direct-coupling method (quasi-fixing method) of the optical connection automatic-switching apparatus shown in FIG. 1;

FIG. 10(B) is an illustration of a registration example of an equipment information table in the connection example shown in FIG. 10(A);

FIG. 11 (A) is a block diagram showing a connection example in an optical connection switching facility for explaining an IT equipment connection recognition function according to an adjacent input/output port direct-coupling method (quasi-fixing method) of the optical connection automatic-switching apparatus shown in FIG. 1;

FIG. 11(B) is an illustration of a registration example of an equipment information table in the connection example shown in FIG. 11(A) ;

FIG. 12 (A) is a block diagram showing a connection example in an optical connection switching facility for explaining an IT equipment connection recognition function according to an adjacent input/output port direct-coupling method (quasi-fixing method) of the optical connection automatic-switching apparatus shown in FIG. 1;

FIG. 12 (B) is an illustration of a variation of the registration contents in an optical power information table in the connection example shown in FIG. 12(A);

FIG. 12 (C) is an illustration of a variation of the registration contents in an equipment information table in the connection example shown in FIG. 12(A);

FIG. 13 is a block diagram useful for explaining an IT equipment connection recognition function based on the association between equipment information and optical power information in the optical connection automatic-switching apparatus shown in FIG. 1;

FIG. 14 is a block diagram useful for explaining an IT equipment connection recognition function based on the association between equipment information and optical power information in the optical connection automatic-switching apparatus shown in FIG. 1;

FIG. 15 is a block diagram useful for explaining an IT equipment connection recognition function based on the association between equipment information and optical power information in the optical connection automatic-switching apparatus shown in FIG. 1;

FIG. 16 is a block diagram useful for explaining a redundant path switching function in a case in which a disconnection of an optical output port side optical link in the configuration shown in FIG. 6 or 7;

FIG. 17 is a block diagram showing an example of a configuration in a case in which an optical connection automatic-switching apparatus according to this embodiment is employed for a connection of equipment having a wavelength multiplexing (WDM) optical interface;

FIG. 18 is an illustration of one example of a table showing a port connection relationship in the configuration shown in FIG. 17;

FIG. 19 is a block diagram showing a configuration of an optical connection automatic-switching apparatus (optical connection switching apparatus) according to a further embodiment (first one) of the present invention;

FIG. 20 is a block diagram showing another configuration of the optical connection automatic-switching apparatus shown in FIG. 19;

FIG. 21 is a block diagram showing a further configuration of the optical connection automatic-switching apparatus shown in FIG. 19;

FIG. 22 is a block diagram showing a configuration of the management control circuit shown in FIG. 21;

FIG. 23 is a block diagram showing another configuration of the management control circuit shown in FIG. 21;

FIG. 24 is a block diagram showing a further configuration of the management control circuit shown in FIG. 21;

FIG. 25 is a block diagram showing a further configuration of the management control circuit shown in FIG. 21;

FIG. 26(A) is an illustration of one example of a frame structure of the Ethernet;

FIG. 26(B) is an illustration of one example of a frame structure of a fiber channel;

FIG. 27 is a block diagram showing a configuration of an optical connection automatic-switching apparatus for explaining a signal monitor which is in operation in the configuration shown in FIG. 21;

FIG. 28 is a block diagram showing a configuration of an optical connection automatic-switching apparatus (optical connection switching apparatus) according to a further embodiment (second one) of the present invention;

FIG. 29 is a flow chart for explaining a trouble detecting method in the optical connection automatic-switching apparatus shown in FIG. 28;

FIG. 30 is a block diagram showing a node redundant configuration based on the configuration shown in FIG. 28;

FIG. 31 is an illustration of one example of a trouble detecting table in the node redundant configuration shown in FIG. 30;

FIG. 32(A) is a block diagram showing an example of a link redundant configuration of an optical connection automatic-switching apparatus according to this embodiment;

FIG. 32(B) is an illustration of one example of an address table in the configuration shown in FIG. 32(A) ;

FIG. 32(C) is a flow chart for explaining a method of switching to a spare system in the link redundant configuration shown in FIGs. 32(A) and 32(B);

FIG. 33 is a block diagram showing an example of a node redundant configuration according to this embodiment;

FIGs. 34(A) and 34(B) are illustrations for explaining a method of updating an address table at the occurrence of a link trouble in the node redundant configuration shown in FIG. 33;

FIG. 35 is a block diagram showing an example of a node redundant configuration according to this embodiment;

FIGs. 36(A) and 36(B) are illustrations for explaining a method of updating an address table at the occurrence of a node trouble in the node redundant configuration shown in FIG. 35;

FIG. 37 is a block diagram showing a configuration in a case in which the control system is one in number in the node redundant configuration shown in FIG. 33 or 35;

FIG. 38 is an illustration for explaining a method of managing an address table in the control system shown in FIG. 37; and

FIG. 39 is an illustration for explaining a different method of managing an address table in the control system shown in FIG. 37.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[A] Description of Embodiment

[0039] FIG. 1 is a block diagram showing a configuration of an optical connection automatic-switching apparatus according to an embodiment of the present invention. In FIG. 1, the optical connection automatic-switching apparatus is made up of optical input ports 1_I, 2_I, ..., N-n_I and optical output ports 1_O, 2_O, ..., N-n_O serving as a plurality (N-n) of sets of IT equipment connection ports which come into connection with a plurality of IT equipment (information equipment) r1, r2, ..., rN-n ($N \geq 2$, $1 \leq n < N$) each having a desired optical communication interface (communication protocol and bit rate, optical input ports N-b+1_I, ..., N_1 and optical output ports N-n+1_O, ..., N_O serving as n sets of control ports corresponding to the number of types of handled interfaces of the IT equipment r1, r2, ..., rN-n, an optical connection switching facility (optical switch) 101 connected through optical wiring (optical fibers) to the n sets of ports 1_I, 2_I, ..., N_1 and 1_O, 2_O, ..., N_O in total, a light reception circuit 102, a management control circuit 103, storage media 104, 106, a drive circuit 105, and a plurality (n) of sets of optical transmitters t1_O, t2_O, ..., tn_O and optical receivers t1_I, t2_I, ..., tn_1 (which sometimes will collectively be referred to hereinafter as optical transmitting/receiving units t1, t2, ..., tn).

[0040] In addition, in this optical connection automatic-switching apparatus, each of the N (sets) ports in total is equipped with an optical branch circuit for taking a portion of input light and/or output light and a light-receiving element such as a PIN photodiode for measuring the optical intensity. In this configuration, there are a case in which the respective optical output ports (transmission ports) 1_O,2_O, N_O are equipped with these optical branch circuits and light-receiving elements as indicated by marks c1' , c2' , ..., cN' in FIG. 1, a case in which the respective optical input ports (reception ports) 1_I, 2_I, ..., N_I are equipped with these optical branch circuits and light-receiving elements as indicated by marks c1, c2, ..., cN in FIG. 1, and a case in which both the optical input ports 1_I, 2_I, ..., N_I and optical output ports 1_O, 2_O, ..., N_O are equipped therewith. In the following description, when the paired optical input ports i_I (i = 1 to N) and optical output ports i_O are discriminated from each other, they will be referred to collectively as optical input/output ports i_IO.

[0041] Still additionally, the n optical input ports (control ports) N-n+1_I, ..., N_I are connected to the n optical transmitters t1_O, t2_O, ..., tn_O on a one-to-one basis, and the n optical receivers t1_I, t2_I, ..., tn_I are respectively connected to the n optical output ports (control ports) N-n+1_O, ..., N_O, paired with the aforesaid optical input ports j_I (j = N-n to N), in one-to-one relation to each other, and in accordance with the inter-port connection switching in the optical connection switching facility, the communication can be made between any one of the IT equipment (which sometimes will hereinafter be referred to simply as "equipment") r1, r2, ..., rN-n and the management control circuit 103 through these control ports j_I and J_O.

[0042] Incidentally, in this embodiment, the control ports and optical transmitting/receiving units are n (≥ 1) in number, which corresponds to the number of types of handled optical communication interfaces (which sometimes will hereinafter be referred to simply as "interfaces") of the IT equipment r1, r2, ..., rN-n, and which depends upon the numbers of the handled protocols and bit rates of the IT equipment r1, r2, ..., rN-n. However, if multi-interface handling optical transmitting/receiving units t1, t2, ..., tn can be prepared which have a plurality of types of communication functions corresponding to a plurality of types of interfaces (multi-interface, multi-bit-rate) which can be provided in the IT equipment r1, r2, ..., rN-n, it is possible to decrease the number of control ports and number n of optical transmitting/receiving units up to n = 1 which is at a minimum, thus realizing the cost reduction of this optical connection automatic-switching apparatus.

[0043] In this configuration, the optical connection switching facility (optical switch) 101 is driven by the drive circuit 105 to switch the connection (optical link) between any ports 1_I, 2_I, ..., N_I and 1_O, 2_O, ..., N-O, thereby enabling the communication between any IT equipment r1, r2, ..., rN-n (if discriminated from each other, they will hereinafter be referred to as "IT equipment r") connected to this optical connection automatic-switching apparatus.

[0044] The light reception circuit 102, the management control circuit 103, the storage media 104, 106 and the drive circuit 105 constitute a management control unit which controls the optical connection switching facility 101 to make a connection between the control port (optical input/output port) j_IO connected to the optical transmitting/receiving unit tk (k = 1 to n) and the IT equipment connection port i-IO connected to the IT equipment r so that a communication with the IT equipment r is made through the use of this optical transmitting/receiving unit tk to acquire and manage information (equipment identifying information such as address information) on the equipment r.

[0045] That is, the light reception circuit 102 receives the optical power information obtained by the light-receiving elements c1, c2, ..., cN or c1', c2', ..., cN' and transmits it to the management control circuit 103, while the management control circuit (management control unit) 103 has a function to analyze a data frame obtained by making communication with an arbitrary IT equipment connected to the optical connection switching facility 101 through the use of any one of the optical transmitting/receiving units tk, a function (network automatic-construction function) to control the drive circuit 105 for controlling the inter-port connection switching in the optical connection switching facility 101, a function of storage control on the storage media 104 and 106, an IT equipment connection/disconnection automatic-recognition function,

an IT equipment interface automatic-recognition function, an inter-IT-equipment communication monitor function, a redundant path switching function, and others.

[0046] In this connection, when this management control circuit 103 itself, or together with the storage media 104, 106 and the drive circuit 105, is mounted as one function such as maintenance terminal remote from the optical connection switching facility 101, the remote control can also be made with respect to the optical connection switching facility 101. Moreover, each of the aforesaid optical transmitters t1_O, t2_O, ..., tn_O has an electrical/optical (E/O) conversion function while each of the optical receivers t1_I, t2_I, ..., tn_I has an optical/electrical (O/E) conversion function, and the communication is made between the management control circuit 103 and these optical transmitting/receiving units tk through electric signals.

[0047] The storage medium (equipment information storage unit) 104 is for storing the information (equipment information) about the IT equipment r connected to each of the ports 1_I, 2_I, ..., N-n_I and 1_O, 2_O, ..., N-n_O and, for example, retains address information [one of or both a physical address and logical address (attainable through the aforesaid data frame analysis)] serving as identification information on the IT equipment r and an IT equipment connection port number in a state associated with each other for specifying the IT equipment r (for example, see table 2 shown later). Another storage medium (optical power information storage unit) 106 is for retaining transmission optical power information (obtained through the light-receiving elements c1, c2, ..., cN or c1', c2', ..., cN' and the light reception circuit 102) from the IT equipment r in a state associated with the IT equipment connection port number.

[0048] Incidentally, as each of these storage media 104 and 106, a random access memory (RAM), a magnetic disk, an optical disk, a magneto optical disk or the like is employable. Moreover, these storage media 104 and 106 can also be realized by dividing a storage area of a single storage medium according to information to be stored.

[0049] With the above-described configuration, the user of this optical connection automatic-switching apparatus can realize the correct connections and communications without being aware of the optical communication interface (protocol and bitrate) used in that IT equipment r only by making a connection of the IT equipment r with any IT equipment connection port 1_I, 2_I, ..., N-n_I and 1_O, 2_O, ..., N-n_O. A more detailed description will be given hereinbelow.

(a) IT Equipment Connection and Disconnection Recognition Function

[0050] With the above-described configuration, the management control circuit 103 can automatically recognize the fact that IT equipment r is newly connected to the optical connection automatic-switching apparatus.

(a-1) Case in which a light-receiving element is provided in an optical input port of the optical connection automatic-switching apparatus (see FIG. 2)

[0051] In a case in which the light-receiving elements c1, c2, ..., cN are provided in the optical input ports 1_I, 2_I, ..., N_I of the optical connection automatic-switching apparatus as described above with reference to FIG. 1, the management control circuit 103 is set to monitor the optical power information, obtained from the light-receiving elements c1, c2, ..., cN through the light reception circuit 102, at all times. In FIG. 2, for convenience only, without making a discrimination between the optical input ports and the optical output ports, the number of all the ports (optical input/output ports) are set at 13 (ports h to t) as port number = h to t, and the IT equipment H to N are connectable to the ports h to n, respectively.

[0052] For example, in a case in which the IT equipment J having an optical communication interface [optical/electrical (O/E) conversion function] is connected to the IT equipment connection port j, light is incident from this IT equipment J on the port j and is received by the light-receiving element cj provided in the port j and transmitted through the light reception circuit 102 to the management control circuit 103.

[0053] Accordingly, the management control circuit 103 can recognize a variation of the light reception quantity (an increase in light reception quantity) about the port j, and it can automatically recognize the fact that the IT equipment J having the optical communication interface is connected to the port j.

[0054] Incidentally, although in FIGs. 1 and 2 all the optical input ports 1_I, 2_I, ..., N_I are respectively equipped with the light-receiving elements c1, c2, ..., cN, when the optical input ports (IT equipment connection ports) 1_1, 2_I, ..., N-n_I to which at least the IT equipment r is connectable are equipped therewith, the connection/disconnection automatic-recognition of the IT equipment r becomes feasible.

(a-2) Case in which a light-receiving element is provided in an optical output port of the optical connection automatic-switching apparatus (see FIG. 3)

[0055] In a case in which the respective optical output ports 1_O, 2_O, ..., N_O of the optical connection automatic-switching apparatus are equipped with the light-receiving elements c1', c2', ..., cN' (when the light-receiving elements c1, c2, ..., cN are not provided in the optical input ports 1_I, 2_I, ..., N_I), even if the IT equipment r is connected to this optical connection automatic-switching apparatus, the connection is not recognizable in this state. Therefore, in this

case, the port of port number = s is used as the control port (optical power monitoring port), and the management control circuit 103 controls the optical connection switching facility 101 through the use of the drive circuit 105 to successively (in a circulative manner) make connections of a plurality of IT equipment connection ports h to r with the optical power monitoring port s (no order required) so that the optical power monitor information obtained by the light-receiving element cs' provided in the optical output port of the optical power monitoring port s is transmitted to the management control circuit 103.

[0056] Thus, the management control circuit 103 can monitor the optical power information on the respective IT equipment connection ports h to r at all times and, in a case in which the IT equipment r having the optical communication interface is connected to any equipment connection port h to r, the optical power information is transferred to the management control circuit 103, thereby enabling the automatic recognition on the new connection of the IT equipment r. Therefore, in the case of this embodiment, if at least the control port (optical power monitoring port) s is equipped with the light-receiving element cs', the connection/disconnection automatic-recognition on the IT equipment becomes feasible.

[0057] That is, the functions of the aforesaid (a-1) and (a-2) signify that the management control circuit 103 has a function as an equipment state monitoring unit 131 (see FIG. 1) to monitor the connection, disconnection or communication state of the IT equipment r by monitoring the optical power information on the optical input/output port i_IO of the optical connection switching facility 101 and this equipment state monitoring unit 131 has the following functions (1) and (2) according to the light-receiving element location (port), with the function (2) including the following function (3). That is:

(1) a function as an input port equipment state monitoring unit 132 (see FIG. 1) to, in a case in which the optical input port i_I is equipped with the light-receiving element ci, monitor the connection, disconnection or communication state of the IT equipment r by monitoring a variation of the light reception quantity in the light-receiving element ci with the light reception quantity being handled as the optical power information;

(2) a function as an output port equipment state monitoring unit 133 to, in a case in which the optical output port i_O is equipped with the light-receiving element ci', control the optical connection switching facility 101 for making a connection between the optical input port which is connected to the IT equipment r and the optical output port (optical power monitoring port) s which is not connected to the IT equipment so that a variation of the light reception quantity in the light-receiving element cs' of this port s is monitored with the light reception quantity being handled as the optical power information, thereby monitoring the connection, disconnection or communication state of the IT equipment r; and

(3) a function as a port circulation (cyclic) connection control unit 134 to control the optical connection switching facility 101 for making the circulative connections between a plurality of optical input ports i_I connected to the IT equipment r and the optical output port j_O serving as the optical power monitoring port which is not connected to the IT equipment r.

[0058] Meanwhile, in the case of the employment of the aforesaid methods, since the IT equipment connection ports h to r are monitored in succession (in a circulating fashion), the time lag (delay) occurs in terms of the equipment connection recognition. Accordingly, for example, it is considered to employ a method in which not only the number of optical power monitoring ports is increased but also the number of equipment connection ports to be monitored through the optical power monitoring ports is decreased and even the circulation period is shortened. That is, for example, as shown in FIG. 4, each of the ports q, r and s is used as the optical power monitoring port so that these ports q, r and s share the IT equipment connection ports i_IO which are an object of monitor (in FIG. 4, the port q monitors the optical power information on the ports h, i, j, the port r monitors the optical power information on the ports k, 1, m, and the port s monitors the optical power information on the ports n, o, p).

[0059] This can reduce the number of equipment connection ports one optical power monitoring port takes charge of and shorten the circulation monitor period, which can achieve the fast monitor more efficiently. Incidentally, the maximum number of optical power monitoring ports to be used becomes equal to the number of equipment connection ports.

[0060] Moreover, in the case of both the above-mentioned (a-1) and (a-2), a decision as to whether the IT equipment r is connected or not is made according to the following method. That is, a given threshold is set with respect to the optical power monitor value and, when the optical power monitor value varies to exceed the threshold, a decision is made that the connection of the equipment r newly takes place. On the other hand, if the optical power monitor value varies to become a value below the threshold, a decision is made that the equipment r is connected or some trouble occurs.

(b) In-datacenter IT equipment automatic-recognition by the optical connection automatic-switching apparatus (single interface)

[0061] In a case in which the equipment r is newly connected to any one of the ports i_IO of this optical connection automatic-switching apparatus, as mentioned above, owing to the light-receiving element c1, c2, ..., cN provided in the

optical input port 1_I, 2_I, ..., N_1 of the optical connection automatic-switching apparatus or the light-receiving element c1', c2', ..., cN' provided in the optical output port 1_O, 2_O, ..., N_O thereof, the information indicative of the new connection of the equipment r is sent to the management control circuit 103. The management control circuit 103 controls the optical connection switching facility 101 through the use of the drive circuit 105 to make a connection of the optical input/output port i_IO connected to the equipment r with any optical input/output port (control port) j_IO connected to the optical transmitting/receiving unit tk connected to the management control circuit 103.

[0062] Moreover, the management control circuit 103 transmits a response request through the optical transmitting/receiving unit tk to the connected equipment r. Upon receipt of the response request, the equipment r transmits a data frame including the information on an address (logical or physical address) allocated to this equipment r to the transmission side address, and the management control circuit 103 receives the data frame through the optical transmitting/receiving unit tk in the form of an electric signal and acquires the transmission side address information stored in the data frame. Thus, the management control circuit 103 can make out a port-address correspondence table in which the acquired address information and the port (number) of the optical connection automatic-switching apparatus are associated with each other. This correspondence table is retained and managed in the storage medium 104.

(c) n-datacenter IT equipment automatic-recognition by the optical connection automatic-switching apparatus (multi-interface)

[0063] In a case in which the equipment r is newly connected to any one of the ports i_IO of this optical connection automatic-switching apparatus, also in this case, owing to the light-receiving element c1, c2, ..., cN provided in the optical input port 1_I, 2_I, ..., N_1 of the optical connection automatic-switching apparatus or the light-receiving element c1', c2', ..., cN' provided in the optical output port 1_O, 2_O, ..., N_O thereof, the information indicative of the connection of the equipment r is sent to the management control circuit 103. Upon receipt of this information, the management control circuit 103 carries out an interface decision process on the connected equipment r.

[0064] That is, as the optical transmitting/receiving unit tk to be connected to the management control circuit 103 of this optical connection automatic-switching apparatus, there is prepared the Ethernet, fiber channel or other data frame readable means. The management control circuit 103 performs the protocol and bit rate scanning on the equipment r connected to the equipment newly connected through the optical transmitting/receiving unit tk to obtain the type of the interface of this equipment r and the physical address and/or the logical address of the equipment r and further to preserve these information, for example, in the storage medium 104 or 106.

[0065] The following table 1 shows an example of the scanning items. Although this example includes the Ethernet and fiber channel, naturally, it is possible to handle the equipment r1, r2, ..., rN-n using other protocols as communication means by employing the optical transmitting/receiving unit tk capable of reading the other protocols.

Table 1

Example of Bit Rate/Protocol Scanning Items							
	100 Mbps	200 Mbps	400 Mbps	1 Gbps	2 Gbps	4 Gbps	10 Gbps
Ethernet	OK	---	---	OK	---	---	OK
FC*1	OK	OK	OK	OK	OK	OK	---
Others	*2	*2	*2	*2	*2	*2	*2

[0066] In this table 1, *1 represent FC : Fiber Channel, and *2 signifies depending on protocol to be used.

[0067] Secondly, referring to a flow chart of FIG. 5, a description will be given hereinbelow of a detailed procedure to be conducted from when the equipment r is connected to this optical connection automatic-switching apparatus until the communication is realized between the equipment r. In the following description, Although, as the order of the interface scanning, the protocol scanning is first conducted and the bit rate scanning is then done, the reverse order is also acceptable.

[0068] First of all, when the equipment r having an optical connection port is newly connected to any port i_IO of the optical connection automatic-switching apparatus (step S1), according to any one of the methods mentioned above in the item (a), the management control circuit 103 detects that the equipment r is connected to the port i_IO (step S2). Concretely, as mentioned above, a given threshold is set in conjunction with the light reception level and, when the light reception level exceeds this threshold, a decision is made as the connection of the equipment r.

[0069] Following this, the management control circuit (which will hereinafter be re ferred to simply as a "control circuit") 103 controls the optical connection switching facility 101 to make a connection between the port i_IO connected to the equipment r and the port j_IO connected to the optical transmitting/receiving unit tk corresponding to the protocol to be

scanned (steps S3 and S4). In this connection, if an optical transmitting/receiving unit tk is employed which handles the multi-interface (protocol), instead of this port switching by the optical connection switching facility 101, the selection/setting of the communication function (protocol) of the optical transmitting/receiving unit tk by the management control circuit 103 alone will avail.

[0070] Subsequently, for example, according to the aforesaid table 1, the control circuit 103 sets a bit rate of the optical transmitting/receiving unit tk (step S5), and transmits a response request through this optical transmitting/receiving unit tk to the connected equipment r. If there is a response (reception of a data frame) from that equipment r, the control circuit 103 analyzes the contents of the data frame and the specification of the equipment r reaches completion. Accordingly, the control circuit 103 stores, for example, in the storage medium 104, the information peculiar to the equipment r such as the information on one of or both the physical address and logical address of the equipment r (through Yes route of step S6 to step S7).

[0071] On the other hand, in the case of no response to the aforesaid response request, the control circuit 103 confirms whether or not the processing on all the bit rates which are an object of scanning reaches completion (through No route of step S6 to step S8). If it does not reach completion yet, the control circuit 103 changes the bit rate setting of the optical transmitting/receiving unit tk (through No route of step S8 to step S5). At this time, if the optical transmitting/receiving unit tk can handle the multi-bit-rate, also in this case, instead of the port switching by the optical connection switching facility 101, the bit rate setting on the optical transmitting/receiving unit tk by the management control circuit 103 will avail. If the optical transmitting/receiving unit tk cannot handle the multi-bit-rate, the optical transmitting/receiving unit tk is provided for each bit rate and the control circuit 103 controls the optical connection switching facility 101 to make a connection between the port j_IO connected to that optical transmitting/receiving unit tk and the port i_IO connected to the equipment r which is an object of scanning at present.

[0072] In a case in which there is no response when the scanning on all the bit rates takes place (No in step S6 and Yes in step S8), for changing the interface, the control circuit 103 controls the optical connection switching facility 101 to make a connection between the port i_IO connected to the equipment r and the port k_IO connected to another optical transmitting/receiving unit tk (k = 1 to n, $k \neq i$) (through No route of step S9 to step S4). Also in this case, if the multi-protocol handling optical transmitting/receiving unit tk is provided, instead of the port switching by the optical connection switching facility 101, the setting by the control circuit 103 alone will avail.

[0073] Thereafter, the control circuit 103 repeatedly carries out the processing in the aforesaid steps S4, S5 and S6 (i.e., bit rate scanning and protocol scanning) until the corresponding interface is found by the reception of a response from the connected equipment r. If the corresponding interface is found, at this time, the information peculiar to this equipment r is stored, for example, in the storage medium 104 (step S7).

[0074] In a case in which, although the protocol scanning on all the protocols reaches completion, the corresponding interface is not found yet (Yes in step S9), the control circuit 103 makes a decision that it is impossible to handle the interface of this equipment r (step S10). In this case, a maintenance person or the like manually sets the peculiar information such as address information on this equipment r (step S11).

[0075] That is, in this case, the control circuit 103 has a function as an interface scanning unit 135 (see FIG. 1) to control the optical connection switching facility 101 for making circulating connections of the optical input/output ports j_IO connected to a plurality of optical transmitting/receiving units tk with the optical input/output port i_IO connected to the IT equipment r (no order necessary) so that the information on the IT equipment r is acquired through the use of the optical transmitting/receiving units tk, or to perform the circulating selection/setting of the communication function (protocol, bit rate and others) of the multi-interface handling optical transmitting/receiving unit tk so that the information on the IT equipment r is acquired through the use of the optical transmitting/receiving unit tk.

[0076] Moreover, the above-mentioned interface scanning processing is conducted with respect to all the newly connected equipment r, so a table in which the respective ports i_IO and the connected equipment r are associated with each other is produced in the storage medium 104. Still moreover, the control circuit 103 controls the optical connection switching facility 101 on the basis of the contents of this table to make the mutual connections among the equipment r (optical connection setting) (step S12). Thus, the connections among the equipment r come to an end. That is, the control circuit 103 functions as a inter-port connection control unit 136 to implement the inter-port connection control in the optical connection switching facility 101 on the basis of the equipment information in the storage medium 104.

[0077] Through the use of the above-described methods, the user of this optical connection automatic-switching apparatus can realize the correct inter-equipment connections only by making the connection to any port i_IO of this optical connection automatic-switching apparatus without paying attention to the type (protocol) of the optical communication interface of the equipment r to be connected, the bit rate and others.

[0078] Furthermore, a description will be given hereinbelow of a case in which this optical connection automatic-switching apparatus (optical connection switching apparatus) is employed for the connection of equipment having a wavelength multiplexing (WDM : Wavelength Division Multiplex) optical interface. This configuration is shown in FIG. 17. As shown in FIG. 17, to an optical connection switching facility 101, there are connected a switch 201 having a wavelength multiplexing optical interface and a wavelength multiplexing/demultiplexing unit 202. Reference numeral

140 denotes a wavelength-multiplexed signal light monitoring circuit, which is equivalent to a circuit including the above-mentioned light reception circuit 102, optical transmitting/receiving units t1, t2, ..., tn, light-receiving elements c1', c2', ..., cN' (c1, c2, ..., cN) and others. Incidentally, in FIG. 17, the above-mentioned storage mediums 104, 106, drive circuit 105 and others are omitted from the illustration.

[0079] The aforesaid wavelength,multiplexing optical interface is capable of introducing different wavelengths (for example, λ1, λ2, λ3, λ4) into each port, and the optical interface is replaceable. Moreover, as the optical interface of the switch 201, not until an appropriate wavelength is introduced into each port, a signal light passes when connected to the wavelength multiplexing/demultiplexing unit 202. Therefore, in a case in which an arbitrary optical interface is incorporated into each port of the switch 201, there is a need to make the matching between the wavelength and the port. For this reason, when an optical connection automatic-switching apparatus is employed like the above-described configuration, the matching between the wavelength and the port becomes feasible.

[0080] That is, when one port of the switch 201 is connected to the optical connection switching facility 101, the management control circuit. 103 recognizes the wavelength of that port and the port number in the switch 201. In the management control circuit 103, for example, as shown in FIG. 18, the information about the port of the optical connection switching facility connected to each port of the wavelength multiplexing/demultiplexing unit 202 is grasped as data or the like in the form of a table (for example, stored in the above-mentioned storage medium 104 or 106) in advance, and a decision is made on the port which should be connected to the previously recognized port, thus achieving the appropriate connection. At this time, if there are wavelengths duplicated or when a problem arises in the signal light power of this wavelength, the central wavelength information and others, error information or the like can be notified from the management control circuit 103 to the manager.

(d) In-datacenter Network Monitoring Function

[0081] Since the information flowing on an in-datacenter network is mission critical, the network monitoring function is significantly important. A description will be given hereinbelow of a network monitoring function using this optical connection automatic-switching apparatus.

[0082] For example, in FIG. 2 or 3, let it be assumed that, in a normal operation in which a work application is in action on a network, the IT equipment H, I, J and K in which applications are in action are connected to the ports h, i, j and k of the optical connection automatic-switching apparatus and the connection is made through the optical connection automatic-switching apparatus between the ports h-i and between the ports j-k. Moreover, to the different ports 1, m and n, there are connected the IT equipment L, M and N each of which is in a stand-by condition, while the other ports o, p, q and r are in a free condition. In this state, there is a need to implement the network monitor through the use of the ports h, i, j and k without affecting the applications which are in action. The procedure therefor is as follows.

(d-1) Case in which a light-receiving element is provided in an optical input port of an IT equipment connection port in the optical connection automatic-switching apparatus

[0083] When each light-receiving element ci is provided in each IT equipment connection port (optical input port) i_I of the optical connection automatic-switching apparatus as mentioned above with reference to FIG. 1, the optical power monitor can be made through the use of this light-receiving element ci without exerting influence on the application which is in operation (while continuing the operation). The monitor information is transmitted through the light reception circuit 102 to the control circuit 103 and is retained as the optical power monitor information, for example, in the storage medium 106.

(d-2) Case in which no light-receiving element is provided in an optical input port of the IT equipment connection port of the optical connection automatic-switching apparatus

[0084] In a case in which, as mentioned above with reference to FIG. 1, the light-receiving element ci' is provided in the IT equipment connection port (optical output port i_O) of the optical connection automatic-switching apparatus while no light-receiving element is provided in the paired IT equipment connection port (optical input port), also in this embodiment, for example, the port s is used as an optical power monitoring port for monitoring the optical power. This optical power monitoring port s and the other control port can be put in common use. Moreover, the number of optical power monitoring ports are increasable as far as the number of ports of the optical connection automatic-switching apparatus permits. However, the increase in number of optical power monitoring ports enhances the monitoring efficiency as mentioned above with reference to FIG. 4 but decreasing the number of ports connectable to the IT equipment r, which leads to the trade-off.

[0085] First, a description will be given hereinbelow of a procedure in the case of monitoring the ports o, p, q, r to which the IT equipment r is not connected and the ports 1, m, n which are not in connection with the IT equipment r but

in which an application is not in operation.

[0086] In this case, the management control circuit 103 controls the optical connection switching facility 101 to make connections of the respective ports 1 to r to the optical power monitoring port s in succession (in a circulating fashion) so that the optical power can be monitored by the light-receiving element cs' placed in the optical input port of the optical power monitoring port s. The optical power monitor information is transmitted from the light reception circuit 102 to the management control circuit 103 and is retained in the storage medium 106.

[0087] On the other hand, the procedure of monitoring the ports h, i, j and k in which the application is in action is as follows. In this case, let it be assumed that the connection is made through the optical connection switching facility 101 between the ports h-i and between the ports j-k.

[0088] In this case, difficulty is encountered in breaking the connection between the IT equipment r to make the connection thereof to the optical power monitoring port s for monitoring. For this reason, in this case, the input optical power from the equipment H connected to the port h is monitored by the light-receiving element ci' provided in the optical output port of the port i connected thereto. Likewise, the input optical power from the IT equipment I, the input optical power from the IT equipment J and the input optical power from the IT equipment K are monitored by the light-receiving elements ch', ck' and cj' of the ports h, k and j, respectively. Also in this case, each of the optical power monitor information is transmitted from the light reception circuit 102 to the management control circuit 103 and is retained in the storage medium 106.

[0089] Through the use of the above-mentioned procedures, the optical power monitor becomes feasible without cutting off the data on the application which is in operation on the network. Incidentally, in both the aforesaid cases of (d-1) and (d-2), a decision as to whether the IT equipment r is connected or not is made, for example, according to the following procedure. That is, also in this case, a given threshold set with respect to the optical power monitor value and, when the optical power monitor value varies to exceed the threshold, a decision is made as the new connection of the IT equipment r. On the other hand, when the optical power monitor value varies to be lower than the threshold, a decision is made that the IT equipment r is disconnected or that some trouble occurs.

(e) Switching Function to Redundant Path

[0090] Secondly, a description will be given hereinbelow of an example in which the function of the switching to a redundant path is realized through the use of the above-mentioned monitoring function.

[0091] For example, let it be assumed that, as shown in FIG. 6, each of the IT equipment ra and rb has two pairs of optical transmitting/receiving unit ports (four ports in total) as the input and output and the IT equipment r are connected through the optical transmitting/receiving unit ports to two sets of optical input/output ports of the optical connection switching facility 101 wherein one is used as a work port and the other is used as a spare (protection) port. However, in this case, it is not required that the IT equipment ra and rb themselves internally include the two pairs of ports, and for example, it is also considered that, as shown in FIG. 7, the IT equipment ra and rb internally include one pair of optical transmitting/receiving unit ports and units (signal branching units) sa and sb for splitting a signal are inserted thereinto separately so that the IT equipment ra and rb are apparently equipped substantially with two pairs of optical transmitting/receiving unit ports.

[0092] Moreover, in FIGs. 6 and 7, one pair of the two pairs of optical transmitting/receiving unit ports of the IT equipment ra are connected to optical input/output ports h_I and h_O and the other pair are connected to optical input/output ports i_I and I_O, while one pair of the two pairs of optical transmitting/receiving unit ports of the IT equipment rb are connected to optical input/output ports j_I and j_O and other pair are connected to optical input/output ports k_I and k_O. In this case, although the optical input/output ports with the same number are allocated to one pair of optical transmitting/receiving unit ports of the IT equipment ra, rb, the optical input port number and the optical output port number are sometimes different from each other.

[0093] In addition, as the following setting items, the ports h_I, h_O and the ports i_I, i_O are set to have a redundant configuration, and the ports j_I, j_O and the ports k_I, k_O are set to have a redundant configuration. In FIGs. 6 and 7, each of L_h, L_i, L_j and L_k represents an optical link.

[0094] Still additionally, in the service providing state, let it be assumed that in the optical connection automatic-switching apparatus, the connection is made between the optical input port h_I and the optical output port k_0 and between the optical input port k_I and the optical output port h_0, and the communication is established through the optical links L_h and L_k between the IT equipment ra and the IT equipment rb (see dotted-line paths 300 in FIGs. 6 and 7).

[0095] In this state, if a trouble occurs in the optical link L_h between the IT equipment ra and the optical input/output port h_IO, through the use of the light-receiving element ch or ch' provided in this optical input/output port h_IO, the control circuit 103 detects the optical power disconnection through the light reception circuit 102. This detection procedure is conducted as mentioned above in the item (c). When detecting the optical power disconnection, the control circuit 103 controls the optical connection switching facility 101 to connect the optical input/output port k_IO to a redundant path port (spare port) i_IO set in the optical input/output port h_IO in advance (see solid-line paths 200 in FIGs. 6 and

7). Thus, even if a trouble occurs in a path between the IT equipment ra and rb, the trouble is detectable through the optical power monitor to enable the automatic restoration from the trouble within a short time.

[0096] That is, in this case, in response to the detection of optical disconnection of the working port, the management control circuit 103 functions as a work/spare switching control unit 137 (see FIG. 1) to control the optical connection switching facility 101 for switching the using port for the IT equipment r to the aforesaid spare port.

(f) Network Automatic-Constructing Function

[0097] On the basis of the logical address and/or physical address of the IT equipment r, the IT equipment r are previously set which are to be mutually connected in constructing a network in a datacenter. According to the procedures mentioned above in the items (a), (b) and (c), a correspondence table (port-address correspondence table) between the logical addresses and/or physical addresses of the newly connected equipment r and the ports is produced in the storage medium 104 and preserved therein. Therefore, by making reference to both the port-address correspondence table and the connection setting between the logical addresses and/or physical addresses made in advance, it is possible to automatically realize the new equipment connection to the network construction (inter-port connections).

(g) Method of Confirming New IT equipment Connection in Non-connected (Free) Port of Optical Switch

[0098] In a case in which the monitor is made using the method mentioned above in the item (d-2), since the optical connection switching facility 101 is controlled so as to switch the inter-port connection one by one for the monitor, the extra time is taken. A description will be given hereinbelow of a method of recognizing the connection of the new equipment r without making the connection switching by the optical connection switching facility (optical switch) 101.

(g-1) Input/Output (Transmission/Reception) Port Direct-Coupling Method

[0099] FIG. 8 shows an example of connection in the case of the employment of this method. In this example, the light-receiving element ci' is provided in only the optical output port I_O of each of the optical input/output ports i_IO (h to t) . In FIG. 8, unless otherwise specified particularly, the same reference marks as those used above designate the same or corresponding parts.

[0100] Moreover, as shown in FIG. 8, in the ports (free ports) l, m, n, o, p, q and r to which the IT equipment r (= H, I, J, K) is not connected, the optical input port and the optical output port are set in a state directly coupled by the optical switch 101.

[0101] In this state, for example, as shown in FIG. 8, in a case in which the IT equipment L is newly connected to the port 1, light from this IT equipment L is inputted through the optical input port of the port 1 and is directly inputted to the light-receiving element of the optical output port of the port 1 by means of the turn-around connection in the optical connection switching facility 101. This enables the management control circuit 103 the optical power variation information through the light reception circuit 102, and the management control circuit 103 can recognize the new connection of the IT equipment L to the port 1 without performing the inter-port connection switching by the optical switch 101.

[0102] That is, in this case, in a state where the aforesaid equipment state monitoring unit 131 (see FIG. 1) controls the optical connection switching facility 101 to directly couple the optical input port i_I and the optical output port I_O, paired, as the optical input/output port i_IO to which the IT equipment is not connected, the control circuit 103 functions as a port turn-around connection equipment state monitoring unit 138 (see FIG. 1) which, with the light reception quantity in the light-receiving element ci' of the optical output port i_0 being handled as the light power information, monitors a variation thereof for monitoring the connection, disconnection or communication state of the IT equipment r.

[0103] Following this, as well as the above-described example, the management control circuit 103 controls the optical connection switching facility 101 to establish the connection between the optical transmitting/receiving unit tk and the newly connected equipment L so that the communication is made with this IT equipment L to acquire the necessary information such as the address information for produce a port-address correspondence table, thereby controlling the optical switch 101 on the basis of this correspondence table to establish the connection between the IT equipment L and another IT equipment r which is the other communication party.

(g-2) Quasi-Fixing Method

[0104] In a case in which the IT equipment r is connected to the optical switch 101 according to the method mentioned above in the item (g-1), the light outputted from the IT equipment L is returned through the optical switch 101 to the receiving port of the IT equipment r. For example, if the connected IT equipment r is a layer-2 switch, due to this connection, disorder occurs in the MAC (Media Access Control) address table retained in the equipment r so that the communication abnormality occurs.

[0105] Accordingly, another method is taken. That is, in the optical switch 101, with respect to the free ports, instead of the direct coupling between the optical input and output of the same free port, for example, as shown in FIG. 9, the optical input port (In) and the optical output port (Out) of the free ports adjacent to each other (in this case, the eight ports with numbers 1 to 8 in total) are set in a state directly coupled (turn-around-connected) to each other to, when the IT equipment r is newly connected to the free port of the optical switch 101, prevent the output light of this IT equipment from returning directly to the IT equipment.

[0106] In addition, for example, when, as shown in FIG. 10(A), the equipment r is connected to the free port of port number = 2 (however, in a service non-providing condition) and the equipment r, which mutually make communication with each other, are connected to the free port of the port number = 5 and the free port of port number = 6 and the service is in a providing condition, the optical switch 101 takes a connection set condition in which the optical input port of the port number = 5 and the optical output port of the port number = 6 are connected to each other, the optical output port of the port number = 5 and the optical input port of the port number = 6 are connected to each other, and the other free ports are directly coupled to each other. The optical switch 101 shown in FIG. 10(A) is additionally equipped with a spare port (port number = 9) and a control port (port number = 10).

[0107] In this case, for example, as shown in FIG. 10(B), the control circuit 103 retains and manages, in the storage medium 104 or 106, the information for each port (number) of the optical switch 101, such as the occurrence or non-occurrence of equipment connection, whether -this equipment r is in operation (in service) and the optical input port connection party (monitor position) (= port number), as data in the form of a table (equipment information management table 107). In this example, the ports (in FIG. 10A, port numbers = 2, 5 and 6) connected to the IT equipment are not put to use for the optical power monitor. Moreover, the management control circuit 103 does not monitor these ports connected to the IT equipment r at all times and, at the occurrence of an instruction on the inter-equipment connection or the like, controls the optical switch 101 as needed to make the connection with the control port (optical power monitoring port) (in FIG. 10, port number = 10) for monitoring them.

[0108] FIG. 11 (A) shows a connection state in the optical switch 101 when the It equipment (in a service non-providing condition) is further connected to the optical input/output port of the port number = 1 in the state shown in FIG. 10(A), and FIG. 11(B) shows a concrete example of the aforesaid equipment information management table 107 in this state. As shown in FIG. 11 (B), in this example, the occurrence and non-occurrence of the equipment connection are designated at "1" (occurrence) and "0" (non-occurrence), and each of the other connection party to the equipment and the other connection party to the optical input port is expressed by a port number.

[0109] For example, in FIG. 11(B), the entry ("1", "0", "--") for the port number = 1, 2 signifies that, although the equipment r are connected to the ports corresponding to the port number = 1, 2 ("1"), since the service is in a non-providing condition, the other connection party does not exist ("0") and there is no need for the monitor. Moreover, the entry ("0", "0", "4"/ "7") for the port number = 3, 4 signifies that the ports corresponding to the port number = 3, 4 are free and the optical input ports thereof are connected (directly coupled) to the free ports (optical output ports) corresponding to the port number = 4, 7.

[0110] Moreover, the entry ("1", "6", "6") for the port number = 5 signifies that the equipment r is connected to the port of the port number = 5 and the other connection party (communication party) therefor is the equipment r connected to the port of the port number = 6 and the communication is monitored by the optical output port of the port number = 6. Likewise, the entry ("1", "5", "5") for the port number = 6 signifies that the equipment r is connected to the port of the port number = 6 and the other connection party (communication party) therefor is the aforesaid equipment r connected to the port of the port number = 5 and the communication is monitored by the optical output port of the port number = 5.

[0111] Still moreover, the entry ("0", "0", "8") for the port number = 7 signifies that the port of the port number = 7 is free and the optical input port thereof is connected (directly coupled) to the optical output port of the port number = 8 so that the optical power monitor is made through the use of this optical output port, and the entry ("0", "0", "9") for the port number = 8 signifies that the port of the port number = 8 is free and the optical input port thereof is connected (directly coupled) to the optical output port (spare port) of the port number = 9 so that the optical power monitor is made through the use of this spare port.

[0112] In this state, for example, as shown in FIG. 12(A), when the equipment r is newly connected to the free port (port number = 3) of the optical switch 101, the output light from this equipment r is incident on the light-receiving element c4' provided in the optical output port of the port number = 4 and is transmitted through the light reception circuit 102 to the control circuit 103. Therefore, for example, as shown in FIG. 12(B), the control circuit 103 updates that entry contents of the optical power information (optical power information management table 108) for each port retained and managed in the storage medium 106. FIG. 12 (B) shows a state in which the optical power before the connection of the equipment r is "-40 dBm" and it is updated to "-8 dBm" through the connection of the equipment r.

[0113] In addition, the management control circuit 103 controls the optical switch 101 to cancel the connection (direct coupling) between the optical input port of the port number = 3 and the optical output port of the port number = 4 and, for example, as shown in FIG. 12(C), updates the entry contents of the equipment information management table 107. That is, with respect to the entry of the port number = 3; the "equipment connection" is set at "1" (occurrence) and the

re-allocation is made in terms of the monitor position. In FIG. 12(C), although the monitor position (port) is in a non-allocated condition since the newly connected equipment r is in a service non-providing condition, the allocation of the monitor position is determined afterwards when the equipment r is determined as the other communication party and the mutual connection is established therebetween. Following this, the control circuit 103 carries out the optical power monitor at this monitor position.

[0114] That is, in this case, the management control circuit 103 functions as an adjacent port connection equipment state monitoring unit 139 which, in a state where the aforesaid equipment state monitoring unit 131 (see FIG. 1) controls the optical connection switching facility 101 to directly couple the optical input port i_I and the optical output port I_O of the adjacent optical input/output port (free port) i_IO to which the equipment r is not connected and the light reception quantity in the light-receiving element ci' of the optical output port i_I0 is handled or employed as the optical information, port i-I0 is handled or employed as the optical information, monitors a variation thereof.

(h) IT Equipment Connection Automatic-Recognition Based on Cooperation between Connected Equipment Information and Optical Power Information

[0115] As FIG. 13 shows, let it be assumed that the IT equipment r1, r2, ri, ···, rN-n are connected to this optical connection automatic-switching apparatus (state h1) and, in this state, the IT equipment r1, which has been connected to the port 1_IO, is disconnected from this optical connection automatic-switching apparatus as shown in FIG. 15 (state h2) and, thereafter, the IT equipment r1_1 is newly connected to the same port 1_IO as shown in FIG. 15 (state h3).

[0116] In this case, according to only the information in the optical power information retaining storage medium 106, even if the equipment connection state varies such that the state h1 → the state h2 → the state h3, the management control circuit 103 observes only the optical power variation of rise (up) → fall (down) → rise (up) for the port 1_IO, and difficulty is encountered in distinguishing between the state h1 and the state h3.

[0117] In this case, the additional use of the information in the equipment information retaining storage medium 104 enables finer state management.

[0118] First, in the case of the state h1 (see FIG. 13), for example, the equipment information in the storage medium 104 and the optical power information in the storage medium 106 are as shown in the following tables 2 and 3.

Table 2

Information in Storage Medium 104	
Port No.	Equipment
1	r1
2	r2
...	...
H	rh
I	ri
...	...
N-n	-

Table 3

Information in Storage Medium 106	
Port No.	Optical Power [dBm]
1	-6
2	-8
...	...
H	-9
I	-7
...	...

(continued)

Information in Storage Medium 106	
Port No.	Optical Power [dBm]
N-n	-40

[0119] In the case of shifting to the aforesaid state h2, for example, the equipment information in the storage medium 104 and the optical power information in the storage medium 106 become as shown in the following tables 4 and 5, and due to the cutoff of the optical power and the disappearance of the connected equipment information, the control circuit 103 can recognize that the IT equipment r1, which has been connected to the port 1_IO of the port number = 1, is disconnected therefrom.

Table 4

Information in Storage Medium 104	
Port No.	Equipment
1	
2	r2
...	...
H	rh
I	ri
...	...
N-n	-

Table 5

Information in Storage Medium 106

Port No.	Optical Power [dBm]
1	-40
2	-8
...	...
H	-9
I	-7
...	...
N-n	-40

[0120] Moreover, when the IT equipment r1_1 is connected to the port 1_I0 and the shifting to the aforesaid state h3 occurs, the equipment information in the storage medium 104 and the optical power information in the storage medium 106 become as shown in the following tables 6 and 7.

Table 6

Information in Storage Medium 104

Port No.	Equipment
1	r1_1
2	r2
...	...
H	rh
I	ri
...	...
N-n	—

Table 7

Information in Storage Medium 106

Port No.	Optical Power [dBm]
1	-6
2	-8
...	...
H	-9
I	-7
...	...
N-n	-40

[0121] In this case, although difficulty is experienced in distinguishing from the state 1 on the basis of only the optical power information, by making reference to the connected equipment information in the storage medium 104, the control circuit 103 can recognize that the IT equipment r1_1 different from that in the state 1 is newly connected thereto.

(i) Trouble Detection at Disconnection of Output Side Fiber

[0122] In the redundant configuration (see FIGs. 6 and 7) described above in the item (e), if a trouble (disorder) occurs in the optical link L_h connected to the optical output port h_O of this optical connection automatic-switching apparatus, the light-receiving element ch or ch' provided in this connection automatic-switching apparatus cannot detect that trouble. For this reason, the trouble is detected through the use of a separate line network 109 shown in FIG. 16. This network will be referred to hereinafter as a control network 109. This control network 109 is a network connected so that the

management control circuit 103 and each IT equipment r are communicable with each other.

[0123] Accordingly, an interface is provided in each of the IT equipment r and the management control circuit 103 of this optical connection automatic-switching apparatus for the connection to this control network 109. Moreover, in a case in which a trouble occurs in the optical link L_h connected to the optical output port h_O of this optical connection automatic-switching apparatus, the communication is cut off between the equipment rh and the equipment ri. The equipment rh or ri detects this information on the communication cutoff and notifies the trouble information through the control network 109 to the management control circuit 103 of the optical connection automatic-switching apparatus. Therefore, the optical connection automatic-switching apparatus (management control circuit 103) can recognize the trouble and can perform the switching to the redundant path as mentioned above.

[0124] As described above in detail, according to this embodiment, the optical network connection switching can be automated at the equipment connection management, the optical network re-construction and the occurrence of a trouble and, hence, the time needed for that operation is considerably reducible up to approximately 1 hour, as compared with the conventional technique depending on the manual operation and requiring several days to several weeks for the operation. Therefore, the maintenance/operation/management cost of an optical network constructed through the use of this optical connection automatic-switching apparatus is considerably reducible.

[0125] In addition, since one optical connection automatic-switching apparatus (body of equipment) can cope with diverse types of optical communication interfaces, the number of connection switching apparatus to be used for the connections is considerably reducible, thus lowering the initial introduction cost at the optical network construction.

[0126] Still additionally, when the management control circuit 103 or this circuit 103 and the storage media 104 and 106 is mounted as one function of a remote maintenance terminal or the like, the aforesaid connection management or the connection switching is remotely controllable from the terminal, which enables the operations such as the connection management and the connection switching in the optical connection switching facility 101 to be conducted more efficiently.

[B] Description of Further Embodiment (First One)

(B1) Different Configuration 1

[0127] FIG. 19 is a block diagram showing a configuration of an optical connection automatic-switching apparatus (optical connection switching apparatus) according to a further embodiment (first one) of the present invention. As well as the configuration described above, the optical connection automatic-switching apparatus shown in FIG. 19 is made up of N sets of optical input/output ports 1_I, 2_I, ···, N-n_I and 1_0, 2_O, ···, N-n_O in total, optical input ports M-n+1_I, ···, N_I and optical output ports N-n+1_O serving as n sets of control ports corresponding to the number of corresponding types of interfaces of IT equipment r1, r2, ···, rN-n, an optical connection switching facility (optical switch) 101 connected through optical wiring (optical fibers) to the n sets of ports 1_I, ···, N_1 and 1_O, ···, N_O in total, a management control circuit 103, storage mediums 104, 106, a drive circuit 105, and a plurality of (n) sets of optical transmitters t1_O, t2_O, ···, tn_O or optical receivers t1_I, t2_I, ···, tn_I or both (which will sometimes be referred to generally as optical transmitting/receiving units t1, t2, ···, tn). In the following description, the same reference numerals as those used above designate the same or similar parts unless otherwise specified particularly.

[0128] Each of the total of N (sets) ports of this optical connection automatic-switching apparatus is equipped with an optical branch circuit whereby a portion of inputted light and/or outputted light branches. These optical branching circuits can be provided in the optical output ports (transmission ports) 1_O, 2_O ···, N-O as indicated by reference numerals c1' , c2' , ···, cN' in FIG. 19, in the optical input ports (reception ports). 1_I, 2_I, ···, N-I as indicated by reference numerals c1, c2, ···, cN in FIG. 19, or in both the optical input ports 1_I, 2_1, ···, N-I and the optical output ports 1_O, 2_O, ···, N-O.

[0129] Moreover, two branched signal lights from each of the optical branch circuits c1, c2, ···, cN, c1' , c2' ···, cN' are led through optical wiring (optical fibers) to the optical connection switching facility (optical switch) 101. In detail, since one of the branched lights is used as a main signal and used for the connection between the IT equipment (see thick solid lines in FIG. 19) while the other branched light is used as a monitor control signal, they are connected to monitor control ports cs1, cs2, ···, csN, cs1' , cs2' , ···, csN' provided in the optical connection switching facility 101, respectively.

(B1-1) IT equipment connection and disconnection automatic-recognition

[0130] The management control circuit 103 controls the optical connection switching facility 101 through the drive circuit 105 and connects the monitor control ports cs1, cs2, ···, csN, cs1', cs2', ···, csN' to the control ports connected to the optical transmitting/receiving units t1, t2, ···, tn. At this time, in a case in which the number of optical transmitting/receiving units t1, t2, ···, tn is smaller than the number of monitor control ports cs1, cs2, ···, csN, cos1' , cs2' , ···, csN', a plurality of monitor control ports are successively (in a circulative manner) connected to the control ports connected to some optical transmitting/receiving units t1, t2, ···, tn (no order required).

[0131] Thus, a portion of main signal light between the optical connection switching facility 101 and the IT equipment,

connected, is sectioned by the branch circuits c1, c2, ···, cN, c1' , c2' , ···, cN' to be transmitted through the monitor control ports cs1, cs2, ···, csN, cs1' , cs2' , ···, csN' , the optical connection switching facility 101 and the optical transmitting/receiving units t1, t2, ···, tn to the management control circuit 103.

[0132] Accordingly, the optical power information on the respective ports 1_IO to N_IO can be monitored in the management control circuit 103 without using the above-mentioned light reception circuit 102 (for example, see FIG. 1) and, in a case in which the IT equipment r having an optical communication interface is connected to any one of the ports 1_IO to N_IO (or disconnected from any one of the ports 1_IO to N_IO), the optical power fluctuation information is sent to the management control circuit 103, which enables the automatic recognition on the fact that the IT equipment r is newly connected (or the IT equipment r is removed. Moreover, the management control circuit 103 can read (analyze) the contents of the signal.

[0133] In this connection, for example, as shown in FIG. 20, in the case of the employment of an arrangement in which each of optical branch circuits made to further divide (diverge) each of the branched lights (monitor control lights) from the aforesaid optical branch circuits c1, c2, ···, cN, c1' , c2' ···, cN' is additionally provided so that one of the divided lights from each of these optical branch circuits cc1, cc2, ···, ccN, cc1', cc2' ···, ccN' is coupled to the optical connection switching facility 101 (monitor control ports cs1, cs2, ···, csN, cs1' , cs2', ···, csN') while the other is coupled to a light reception circuit 102, the management control circuit 103 can monitor the optical power fluctuation of the ports 1_IO to N_IO (connection/disconnection of equipment) at all times by way of the light reception circuit 102.

(B1-2) IT Equipment Automatic-Recognition

(Multi-Interface)

[0134] In a case in which an equipment r is newly connected to one port i_IO of this optical connection automatic-switching apparatus, the information on the new connection of the equipment r is fed to the management control circuit 103 as mentioned above. The management control circuit 103 controls the optical connection switching facility 101 through the drive circuit 105 to connect the optical input/output port i_IO connected to the equipment r to one optical input/output port (control port) j_IO connected to the optical transmitting/receiving unit tk connected to the management control circuit 103.

[0135] In addition, the management control circuit 103 waits for a signal from the equipment r connected thereto. When the equipment r carries out some communication and transmits a data frame, the management control circuit 103 acquires, as identification information on the equipment r, the transmitting-side address information put in the data frame. Thus, the management control circuit 103 can make out a port-address correspondence table in which the acquired address information and the port (number) of the optical connection automatic-switching apparatus are associated with each other. For example, this correspondence table is retained and kept in the storage medium 104.

[0136] That is, in the aforesaid optical connection automatic-switching apparatus, the optical branch circuits c1, c2, ···, cN, c1' , c2' ···, cN' are provided with respect to one of or both the input port and output port of the optical connection switching facility 101, and one of the outputs from each of the optical branch circuits c1, c2, ···, cN, c1' , c2' ···, cN' is fed as a main signal light to the optical connection switching facility 101 while the other is fed as a monitor control light thereto, and the management control circuit 103 controls the optical connection switching facility 101 to make connections between the optical input/output ports connected to the optical transmitting/receiving units t1, t2, ···, tn and the optical input/output ports coupled to the monitor control lights for, through the use of the optical transmitting/receiving units t1, t2, ···, tn, acquiring the information on the equipment r (equipment identification information such as address information) from the aforesaid monitor control light and managing it and further for monitoring the optical power information on the optical input/output ports.

(B1-3) IT Equipment Automatic-Recognition

(Multi-Interface)

[0137] In a case in which the equipment r is newly connected to one port i_IO of this optical connection automatic-switching apparatus, the information on the new connection of the equipment r is sent to the management control circuit 103. Upon receipt of this information, the management control circuit 103 carries out an interface decision process.

[0138] That is, the Ethernet, a fiber channel or means capable of reading a data frame is prepared as the optical transmitting/receiving unit tk to be connected to the management control circuit 103 of this optical connection automatic-switching apparatus, and the management control circuit 103 scans the protocol and the bit rate with respect to the newly connected equipment r through this optical transmitting/receiving unit tk to acquire the type of the interface of this equipment r and the address information (information on one of or both the physical address and logical address) on this equipment r and preserve this address information in, for example, the storage medium 104 or 106 in a state

associated with the port information (number) or the like.

[0139] Incidentally, the scanning items in the aforesaid protocol and bit rate scanning processing are the same as those shown in the above-mentioned table 1, and the detailed procedure from the connection of the equipment r to this optical connection automatic-switching apparatus to the realization of the communication between equipment r is the same as the above-described procedure in the flow chart (steps S1 to S12) of FIG. 5.

(B) Different Configuration 2

[0140] FIG. 21 is a block diagram showing a different configuration of the optical connection automatic-switching apparatus (optical connection switching apparatus) according to a further embodiment (second one) of the present invention. As well as the configuration described above, the optical connection automatic-switching apparatus shown in FIG. 21 is made up of N sets of optical input/output ports 1_I, 2_I, ···, N_I and 1_0, 2_O, ···, N_O in total, an optical connection switching facility (optical switch) 101, a management control circuit 103, storage mediums 104, 106 and a drive circuit 105.

[0141] In addition, each of the total of N (sets) ports of this optical connection automatic-switching apparatus is equipped with an optical branch circuit whereby a portion of inputted light and/or outputted light branches. These optical branching circuits can also be provided in the optical output ports (transmission ports) 1_O, 2_O, ···, N-O as indicated by reference numerals c1', c2' , ···, cN' in FIG. 21, in the optical input ports (reception ports) 1_I, 2_I, ···, N-I as indicated by reference numerals c1, c2, ···, cN in FIG. 21, or in both the optical input ports 1_I, 2_I, ···, N-I and the optical output ports 1_O, 2_O, ···, N-O.

[0142] Moreover, one of the signals from the optical branch circuits c1, c2, ···, cN, c1', c2' ···, cN' is led through an optical wiring (optical fiber) to the optical connection switching facility (optical switch) 101, while the other is coupled through an optical wiring (optical fiber) to the corresponding one of optical receivers indicated by the reference numerals rc1, rc2, ···, rcN, rc1' , rc2', ···, rcN' in FIG. 21 on a one-to-one basis. Each of these optical receivers rc1, rc2, ···, rcN, rc1' , rc2' , ···, rcN' is connected to the management control circuit 103 and has a function to convert an inputted optical signal into an electric signal and a function to transmit this electric signal to the management control circuit 103.

[0143] Thus, an optical signal from each IT equipment is partially divided and received by the corresponding optical receiver rc1, rc2, ···, rcN, rc1' , rc2', ···, rcN' to be converted into an electric signal and sent to the management control circuit 103, thereby allowing the optical power fluctuations of the input/output ports 1_I, 2_I, ···, N-n_I and 1_O, 2_O, ···, N-n_O to be monitored in the management control circuit 103 without exerting influence such as suspension of communication even if the IT equipment are in communication to each other, and enabling reading (analyzing) the contents of the signal, for example, acquiring the information on the equipment r (equipment identification information such as address information).

[0144] Incidentally, a reception port (optical reception function) of an optical transmitting/receiving unit such as an optical transceiver can also be used as the optical receivers rc1, rc2, ···, rcN, rc1' , rc2', ···, rcN' .

(B2-1) IT equipment Connection and Disconnection Automatic-recognition

[0145] For example, in a case in which an IT equipment r having an optical communication interface is connected to one port, light emitted from this IT equipment is incident on the port and a portion of the light diverges by one optical branch circuit c1, c2, ···, cN provided in the port and transmitted through the corresponding one optical receiver rc1, rc2, ···, rcN to the management control circuit 103.

[0146] Thus, the management control circuit 103 can recognize a fluctuation of the light reception quantity (increase in light reception quantity) on the aforesaid port and can automatically recognize the fact that the IT equipment r having an optical communication interface has been connected to the port.

(B2-2) IT Equipment Automatic-Recognition (Single Interface)

[0147] In a case in which an IT equipment is newly connected to one port i_IO of this optical connection automatic-switching apparatus, as mentioned above, the information on the new connection of the IT equipment r is sent to the management control circuit 103 by way of the optical branch circuits c1, c2, ···, cN provided in the optical input ports 1_I, 2_I, ···, N_I of the optical connection automatic-switching apparatus and the optical receivers rc1, rc2, ···, rcN, or the optical branch circuits c1', c2', ···, cN' provided in the optical output ports 1_O, 2_O, ···, N_O and the optical receivers rc1' , rc2', ···, rcN' .

[0148] The management control circuit 103 analyzes the contents of a data frame accommodating information on source and destination addresses (logical or physical addresses), sent from the IT equipment r, and acquires the source address information. Therefore, the management control circuit 103 can produce a port-address correspondence table [address (equipment identification information) table] in which the acquired address information and the information on

the port of the optical connection automatic-switching apparatus are associated with each other. This address table is retained and managed , for example, in the storage medium 104.

(B2-3) IT Equipment Automatic-Recognition

(Multi-Interface)

[0149] In the configuration shown in FIG. 21, for realizing the IT equipment automatic-recognition handling the multi-interface, the processing using an electric circuit becomes necessary. The Ethernet and a fiber channel are taken as an example. FIG. 22 shows an example of a configuration of the management control circuit 103 in this case. In FIG. 22, reference mark rci represents any one of the optical receivers rc1, rc2, ···, rcN in FIG. 21. Moreover, as shown in FIG. 22, as the optical receiver rci, it is also possible to prepare a reception-dedicated optical receiver, or to employ a reception port (reception function) of a general-purpose optical transceiver.

[0150] The management control circuit 103 includes an electric signal path switching switch 141m an Ethernet frame analysis circuit 142 and a fiber channel frame analysis circuit 143.

[0151] For example, as well as the case shown in FIG. 2, in a case in which an IT equipment J having an optical communication interface is connected to one port j, according to the above-described procedure, the management control circuit 103 automatically recognizes the connection of the IT equipment J and, thereafter, implements an analysis process on an inputted optical signal.

[0152] That is, the management control circuit 103 first connects the internal switch 141 to one (for example, Ethernet frame analysis circuit 142) of the analysis circuits 142 and 143 and, hence, a signal is inputted to the Ethernet frame analysis circuit 142, and the Ethernet frame analysis circuit 142 analyzes the contents of the inputted signal (frame). When, as a result, the signal contents can correctly read, the Ethernet frame analysis circuit 142 makes a decision that this inputted signal is an Ethernet frame and then reads a source address (one of or both logical address and physical address) from this frame. Accordingly, the management control circuit 103 can produce a port-address correspondence table in which the acquired address information and the port (number) of the optical connection automatic-switching apparatus are associated with each other. This correspondence table is retained and managed, for example, in the storage medium 104.

[0153] On the other hand, in a case in which the Ethernet frame analysis circuit 142 cannot correctly read the frame, the switch 141 is operated so that the signal path is connected to the fiber channel frame analysis circuit 143. Moreover, if the fiber channel frame analysis circuit 143 can correctly read the frame, the fiber channel frame analysis circuit 143 reads the source address (source ID) from this frame and, likewise, makes out a port-address correspondence table which in turn is preserved, for example, in the storage medium 104.

[0154] FIG. 26(A) shows an example of an Ethernet frame structure and FIG. 26(B) shows an example of a fiber channel frame structure. For example, in the case of the Ethernet frame, since, as shown in FIG. 26(A), preamble (7 bytes) + start of frame delimiter (SFD) (1 byte) always appear at the head of the frame, if the Ethernet frame analysis circuit 142 cannot read the data corresponding to the leading 8 bytes, a decision can be made that this frame does not pertain to the Ethernet (it pertains to the fiber channel). Also in the case of handling the other frames (protocols), a discrimination on various types of protocols becomes feasible by grasping a characteristic point of the frame to make a collation.

[0155] Although this configuration handles the two types of interfaces of the Ethernet and the fiber channel, when the switch 141 is changed to a 1 x n switch and a frame analysis circuit for a protocol which is to be an object of operation is properly added to the management control circuit 103, it can handle a greater variety of interfaces.

(Different Configuration 1 of Management Control Circuit 103)

[0156] FIG. 23 is an illustration of a different configuration 1 of the management control circuit 103. The management control circuit 103 shown in FIG. 23 differs from the above-mentioned circuit shown in FIG. 22 in that a protocol analysis circuit 144 and a buffer memory 145 are additionally provided therein.

[0157] In this case, the buffer memory 145 is for temporarily storing an inputted signal (data frame) from the optical receiver rci, and the protocol analysis circuit 144 is for making a decision as to the protocol on the inputted signal from an optical receiver rcj on the basis of the difference in frame structure mentioned above with reference to FIGs. 26 (A) and 26 (B) and, according to this decision result, changing the switch 141 to the frame analysis circuit 142 or 142 side which has an appropriate protocol.

[0158] In the management control circuit 103 configured as described above, the signal sent from the optical receiver rcj is divided so that one is inputted to the protocol analysis circuit 144 and the other is inputted to the buffer memory 145. Moreover, the protocol analysis circuit 144 makes a decision the protocol of the inputted signal on the basis of the difference in frame shown in FIGs. 26(A) and 26(B) and, according to the decision result, changes the switch 141 to the

frame analysis circuit 142 or 143 which has a proper protocol.

[0159] After this change, the data frame accumulated in the buffer memory 145 is inputted to one the frame analysis circuits 142 and 143 so that this frame analysis circuit 142, 143 carries out the frame analysis, thereby specifying the source address (source ID), with this address information being preserved , for example, in the storage medium 104 in a state associated with the port number (in the form of a port-address correspondence table).

(Different Configuration 2 of Management Control Circuit 103)

[0160] In the configuration of the management control circuit 103 shown in FIGs. 22 and 23, since the frame analysis circuits 142, 143, the protocol analysis circuit 144 and the buffer memory 145 become necessary with respect to each of the optical receivers rci, when these are all mounted for each of the receivers rci, an increase in apparatus scale and cost is unavoidable. For this reason, for example, as shown in FIGs. 24 and 25, a switch device 111 is provided between the plurality of optical receivers rci, rci+1, ··· and the management control circuit 103 in the configuration shown in FIGs. 22 and 23.

[0161] Through the use of this switch device 111, the signals outputted from the plurality of optical receivers rci, rci+1, ··· are successively fed to the management control circuit 103 in a time-division manner (no order required) to carry out the above-mentioned protocol decision process. Accordingly, even if the number of optical receivers rci, rci+1, ··· increases, the simplification of the management control circuit 103 is realizable without depending upon it.

(B2-4) Signal Monitor in Operation

[0162] In the case of employing a configuration in which, as described above with reference to FIGs. 19, 20 and 21, the diverged lights by the optical branch circuits c1, c2, ···, cN, c1' , c2', ···, cN' are connected to the optical connection switching facility 101 to be fed to the optical transmitting/receiving units by way of the optical connection switching facility 101, as mentioned above, it is possible to analyze a signal from the equipment r which is in operation (communication).

[0163] For example, in the configuration shown in FIG. 21, in a case in which an IT equipment r1 and an IT equipment ri are connected through this optical connection automatic-switching apparatus (optical connection switching facility 101) to each other as shown in FIG. 27, the signal outputted from the IT equipment r1 and inputted to the port 1_I of the optical connection automatic-switching apparatus is divided by the optical branch circuit c1 and fed through the optical receiver rc1 to the management control circuit 102 at all times.

[0164] Therefore, the management control circuit 103 can not only monitor the presence or absence of a signal but also analyze the contents of the signal to monitor the connection state. A firmer monitoring system can be constructed in cooperation with a management control software which operates in an upper layer.

[C] Description of Further Embodiment (Second One)

[0165] The following description relates to an embodiment about an apparatus redundancy in the optical connection automatic-switching apparatus. Concretely, it relates to a trouble detecting method and a shift to a spare system after the trouble detection.

(C1) Trouble Detecting Method

[0166] First, a description will be given of an embodiment about a trouble detecting method. As mentioned above with reference to FIGs. 6 and 7, a physical path trouble such as an optical fiber disconnection can be monitored through the use of the light reception circuit provided in the optical connection automatic-switching apparatus. However, difficulty is encountered in monitoring a trouble (node trouble) which can originate principally from two troubles: a trouble of a control system such as a control firm (the management control circuit 103 and the drive circuit 105) and a power supply trouble.

[0167] For this reason, with reference to FIG. 28, a description will be given hereinbelow of a method of fast detecting a trouble of a control system causing a node trouble. As shown in FIG. 28, in the optical connection automatic-switching apparatus (optical connection switching facility 101), one or more management (node trouble confirmation) input/output ports (each of which will hereinafter be referred to equally as a "management port" or "monitor port") are prepared (set) in addition to the input/output ports (each of which will hereinafter be referred to equally as a "customer port") for the IT equipment such as servers, and a light source is connected to an input port of the management port while a light reception circuit is connected to an output port of the management port. In FIG. 28, two ports are prepared as the management port and light sources 110-1 and 110-2 are connected to the input ports (A-101 IN, A-102 IN) thereof, respectively, while light reception circuits 102-1 and 102-2 are connected to the output ports (A-101 OUT, A-102 OUT), respectively, thereby placing the light sources and the light reception circuits into a redundant condition (redundant configuration).

[0168] However, the aforesaid monitor port can also be used as the aforesaid control port. That is, if some of the

aforesaid optical transmitters t1_O, t2_O, ···, tn_O (see FIG. 1) are used in place of the light sources 110-1 and 110-2 to make a change between the functions as the monitor port and the control port in a time-division manner, there is no need to individually set the aforesaid dedicated monitor ports. Moreover, in the case of carrying out only the monitoring of optical power without depending upon a layer of an optical signal, the light reception circuits 102-1 and 102-2 can have the same function and configuration, and for the analysis of the contents (protocol) of a signal, circuits with a signal analysis function on protocols different in type can be employed therefor.

[0169] In addition, the aforesaid light sources 110-1, 110-2 and the light reception circuits 102-1, 102-2 are connected to a control managing unit 400 and the control managing unit 400 is made to confirm the optical outputs of the light sources 110-1 and 110-2 and the light reception powers in the light reception circuits 102-1 and 102-2. The control managing unit 400 is equivalent to means including the above-mentioned management control circuit 103, drive circuit 105 and storage mediums 104 and 106. In addition, the control managing unit 40 is designed to control the optical connection switching facility (optical switch) 101 through the aforesaid drive circuit 105 (omitted in FIG. 28) for periodically changing the output destination of light to be inputted from the aforesaid light sources 110-1 and 110-2 between the aforesaid output ports (A-101 OUT, A-102 OUT) connected the light reception circuits 102-1 and 102-2.

[0170] Referring to FIG. 29, a description will be given hereinbelow of a concrete control procedure (node trouble detecting method) in the control managing unit 400.

(1) The control managing unit 400 controls a mirror (optical deflection means), provided to correspond to the aforesaid monitor port in the optical switch 101, through the drive circuit 105 to periodically repeat the connection (switching) of input/output of each monitor port. At this time, the control managing unit 400 supplies a control signal to the drive circuit 105 so as to take one of two states of three states of through/cross/no setting in the optical switch 101 (see step S21). The "through" state signifies a connection state in which light from the light source 110-1 (or 110-2) is inputted to the light reception circuit 102-1 (or 102-2), and the "cross" state signifies a connection state in which light from the light source 110-1 (or 110-2) is inputted to the light reception circuit 102-2 (or 102-1) .

(2) In this periodic connection switching state, the control managing unit 400 confirms the optical outputs of the light sources 110-1 and 110-2 and monitors each of the light reception powers of the light reception circuits 102-1 and 102-2 (step S22).

(3) If the result of the aforesaid monitor shows that the light to the monitor port is repeatedly turned on and off according to the control based on the aforesaid control signal, the control managing unit 400 makes a decision that the optical switch control system (for example, the optical switch 101 and the drive circuit 105) is in a normally operating condition. On the other hand, if the monitor result does not show the operation according to the aforesaid control, it makes a decision that a trouble occurs in the aforesaid optical switch control system (for example, one of or both the optical switches 101 and the drive circuit 105) (step S23).

[0171] That is, in this embodiment, the control managing unit 400 functions as a first trouble detecting unit to perform the detection of a trouble of the optical switch 101 by monitoring the light reception states in the light reception circuits 102-1 and 102-2 while switching the connection states between the input ports connected to the light sources 110-1, 110-2 and the output ports connected to the light reception circuits 102-1, 102-2.

[0172] In comparison with the method in which, for example, a signal for the confirmation of ping or the like is sent to an optical switch control system to monitor the response state thereto, the employment of the above-described method enables the right of the control to be directly and quickly detected, for that there is no need to wait for the response.

(C2) Trouble Notifying Method

[0173] Secondly, a description will be given hereinbelow of a method of quickly notifying trouble information automatically to a spare system when all the links of the optical connection automatic-switching apparatus fall into a disconnection state due to a break of a power supply or the like. The employment of this method enables the spare system itself to detect the shutdown of a work system. This trouble detecting method will be described hereinbelow with reference to FIG. 30.

[0174] In FIG. 30, a main signal light is divided into two by an optical coupler161 and then multiplexed (coupled) by an optical coupler 162 and, in the respective systems, optical connection automatic-switching apparatuses (optical switch 101A and 101B) are put as a work system and a spare system. In more detail, one of branch lights from the former-stage optical coupler 161 is fed to a customer port of the work-system optical switch 101A while the other is fed to a customer port of the spare-system optical switch 101B. Moreover, two or more node trouble confirmation management ports (in this case, four ports A-101 IN/OUT, A-102 IN/OUT, A-103 IN/OUT, A-104 IN/OUT) are prepared (set) for the work-system optical switch 101A, and two or more node trouble confirmation management ports (in this case, four ports B-101 IN/OUT, B-102 IN/OUT, B-103 IN/OUT, B-104 IN/OUT) are also prepared (set) for the spare-system optical switch 101B.

[0175] In addition, the light sources (first light sources) 110-1 and 110-2 are connected to the management ports (input ports: in this case, two ports A-101 IN and A-102 IN) of the work-system optical switch 101A, and the corresponding output ports are connected to the management ports (input ports: in this case, two ports B-101 IN and B-102 IN) of the spare-system optical switch 101B. Still additionally, the remaining management ports (input ports: in this case, two ports B-103 IN and B-104 IN) of the spare-system optical switch 101B are connected to the light sources (second light sources) 110-3 and 110-4, and the corresponding output ports (in this case, two ports B-103 OUT and B-104 OUT) are connected to the remaining management ports (in this case, two ports A-103 IN and A-104 IN) of the work-system optical switch 101A.

[0176] Moreover, the output optical powers of the output ports of the respective optical switches 101A and 101B are made to be monitored by the control managing units 400, provided in the optical switches 101A and 101B, by way of light reception circuits (not shown) or the like.

[0177] That is, this can provide an arrangement in which the optical outputs from the light source 110-1 and 110-2 (or 110-3 and 110-4) of one optical switch 101A (or 101B) are inputted to the other optical switch 101B (or 101A) in a cascaded state to be monitored by one of the control managing units 400 by way of the aforesaid light reception circuit.

[0178] Therefore, the main signal lights are transferred in parallel through the customer ports in the optical switches (each of which will hereinafter be referred to equally as a "node") 101A and 101B constituting a redundant configuration, while the lights outputted from the four trouble detection light sources 110-1, 110-2, 110-3 and 110-4 are transferred through the management ports in the optical switches 101A and 101B in a cascaded state, and a trouble occurring in one of the nodes 101A and 101B exerts influence on the other node 101B, 101A constituting a redundant system.

[0179] Therefore, each of the control managing units 400 can monitor, through the aforesaid light reception circuit, the optical powers outputted from the two light sources 110-1 and 110-2 or 110-3 and 110-4 to the node 101A, 101B to make a decision on an abnormal equipment by making an inquiry using a trouble detection table 500, for example, shown in FIG. 31. That is, in this embodiment, the control managing unit 400 functions as a second trouble detecting unit to monitor the output optical power (monitor optical power by the light source 110-1, 110-2, 110-3, 110-4) from each output port of one of the nodes 101A and 101B for detecting a trouble of one of the nodes 101A and 101B. For example, the trouble detection table 500 is preserved in the aforesaid storage medium 104 or 106 each of the control managing units 400 can gain access to.

[0180] An inquiry method based on the trouble detection table 500 in the management control circuit 103 is as follows.

(1) When no trouble occurs, as indicated by "Case 1" and "Case 3" in the trouble detection table 500, the light reception power in the light reception circuit does not drop with respect to both the nodes 101A and 101B.
(2) When a trouble occurs in the node 101A, as indicated by "Case 2", after passing through the node 101A, a power drop occurs in only the ports (B-101 OUT and B102 OUT) connected to the node 101B, and no power drop occurs in the ports (B-103 OUT and B-104 OUT) going through only the node 101B.
(3) When a trouble occurs in the node 101B, as indicated by "Case 4", after passing through the node 101B, a power drop occurs in only the ports (A-103 OUT and A-104 OUT) connected to the node 101A, and no power drop occurs in the ports (A-101 OUT and A-102 OUT) going through only the node 101A.

[0181] Since the other node can singly monitor/detect a trouble of one node on the basis of the above-mentioned criteria for decision, the speeding-up of the switching from the work system to the spare system becomes feasible.

[0182] In addition, a combination of the two methods described in the items (C1) and (C2) can achieve more effective trouble detection and classification of the factors thereof.

[0183] Incidentally, it is also acceptable that the aforesaid node trouble confirmation ports are also used as the control ports to be connected to the control managing unit 400 as mentioned above. Moreover, although in the above-described configuration two light sources are used for each of the nodes 101A and 101B, the present invention is not limited to this number, and it depends upon a rate of trouble per link port.

(C3) Method of Shifting to Spare System in Link redundancy Configuration

[0184] Furthermore, a description will be hereinbelow of a method for shifting to a spare system in a link redundant configuration described above with reference to FIG. 6 or 7, particularly, of a method of setting a state of a redundant configuration with respect to an equipment information management table (address table) preserved in the aforesaid storage medium 104 or 106 which serves as an equipment information storing unit and a method for shifting thereto.

[0185] FIG. 32 (A) shows an example of a configuration with link redundancy. As shown in FIG. 32 (A), to the optical connection automatic-switching apparatus (optical switch 101), an IT equipment (address = α) (which will hereinafter be referred to as "IT equipment α") is connected through the use of two ports with port numbers = 1 and 2, and an IT equipment (address = β) (which will hereinafter be referred to as "IT equipment β") is connected through the use of two ports with port numbers = 3 and 4. Incidentally, the "address" of the IT equipment can be used as identification information on this IT equipment and is a physical address (or logical address, alternatively both the physical and logical addresses)

of an arbitrary protocol. Moreover, a twin fiber having one optical fiber is connected to each of the input/output ports for each transmission/reception.

[0186] In this case, the link redundancy setting is made by (1) producing an address (equipment identification information) table (correspondence table between port number of the-optical switch 101 and addresses of the IT equipment α and P) in the control managing unit 400 of the optical connection automatic-switching apparatus and (2) selecting the numbers of ports to be connected to the IT equipment α and P so as to set one as a work system and the other as a spare system. At this time, in the case of a work system being put into operation, the spare system is placed into a non-connection condition.

[0187] For example, in FIG. 32(A), the port number = 1 connected to the IT equipment α is set as "work" while the port number = 2 is set as "spare", and the port number = 3 connected to the IT equipment β is set as "work" while the port number = 4 is set as "spare". Moreover, the connection destination of the port number = 1 connected to the IT equipment α in the normal operation is set, for example, as port number = 3 connected to the IT equipment β, and the connection destination of the port number = 3 connected to the IT equipment β in the normal operation is set, for example, as port number = 1 connected to the IT equipment α.

[0188] On the other hand, the connection destination of the port number = 2 connected to the IT equipment α at the occurrence of abnormality such as a trouble is set, for example, as port number = 4 connected to the IT equipment β, and the connection destination of the port number = 4 connected to the IT equipment P at the occurrence of abnormality is set, for example, as port number = 2 connected to the IT equipment α. However, an optical signal is outputted from each of the IT equipment α and β in a state placed into a redundant condition and then incident on each port of the optical switch 101. The configuration in this example is only one example, and the number of ports and others are not limited to the above.

[0189] The above-mentioned set contents are preserved as an equipment information management table [address (equipment identification information) table] 600 shown in FIG. 32 (B) in the storage medium 104 or 106 which serves as an equipment information storing unit of the control managing unit 400. Accordingly, in the normal operation, the IT equipment α and the IT equipment β make communications through the use of a link (work-system optical path) passing through the port numbers = 1 and 3, and when the work path falls into abnormality, they make communications through the use of a link (spare-system optical path) passing through the port numbers = 2 and 4.

[0190] Referring to FIG. 32 (C), a description will be given hereinbelow of a switching method at the occurrence of a trouble.

[0191] First, the control managing unit 400 always monitors optical signal power transmitted through the work-system optical path through the use of, for example, the above-mentioned light reception circuit 102 (see FIGs. 6 and 7) and, when this power monitor detects an optical power disconnection stemming from the occurrence of a trouble of the work-system optical path (steps S31 and S32), the control managing unit 400 refers to the aforesaid address table 600 (step S33) for changing the connection to a spare-system optical path set in advance (step S34), thereby updating (replacing) the address table 600 (see step S35 and arrow 700 in FIG. 32 (B)). That is, in this example, the control managing unit 400 functions as a work/spare switching control unit to, in response to the detection of an optical disconnection of the work port, control the optical switch 101 on the basis of the aforesaid address table 600 for switching the port of the apparatus, which is in use, to a spare port.

[0192] In this case, in the aforesaid address table 600, the association of the connection destination in the working state and the connection destination after the switching to the spare system is made as mentioned above, thus realizing the speeding-up of the switching control. Therefore, even if a link trouble occurs, the quick switching to the spare system becomes feasible to shorten the suspension time of the system.

(C4) Method of Shifting to Spare System in Node Redundant Configuration

[0193] Meanwhile, in the case of the link redundant configuration mentioned above, because of the redundancy in one optical connection automatic-switching apparatus (node), although possible to cope with a physical path trouble such as optical fiber disconnection, it is impossible to cope with a case in which a trouble occurs in the power supply and the node itself. A description will be given hereinbelow of a means for realizing a node redundant configuration capable of switching a node when a trouble occurs in the node.

[0194] FIG. 33 shows one example of a node redundant configuration. This redundant configuration uses two optical switches 101A and 101B. To the nodes (optical switches 101A and 101B), there are connected four IT equipment α, β, γ and κ. The "IT equipment α", "IT equipment β", "IT equipment γ" and "IT equipment κ" signify an IT equipment with an address = α, an IT equipment with an address = β, an IT equipment with an address = γ and an IT equipment with an address = κ, respectively. The "address" is used as identification information on the IT equipment and is a physical address of an arbitrary protocol.

[0195] In addition, control managing units 400A and 400B respectively related to the optical switches 101A and 101B are also provided so that the one control managing unit 400A is connected through a hub 401A to the optical switch

101A and the other control managing unit 400B to be communicable thereto and the other control managing unit 400B is connected through a hub 401B to the optical switch 101B and the one control managing unit 400A to be communicable thereto. That is, the control managing units 400A and 400B are connected to each other to be communicable thereto.

[0196] In this case, for the link redundancy setting, (1) address (equipment identification information) tables (correspondence tables between the port numbers of the optical switches 101 and the addresses of the IT equipments α, β, γ and κ) 600A and 600B are produced in each of the control managing units 400A and 400B, and (2), after the numbers of the ports to be connected to the same IT equipments α, β, γ and κ are selected, one is set as a work system while the other is set as a spare system. At this time, in a case in which the work system is put into operation, the spare-system link is set in a non-connected state. That is, 600A represents an address table for use in the optical switch 101A and 600B denotes an address table for use in the optical switch 101B, and in the control managing unit 400A, the address table 600A is a work (main) table, while in the control managing unit 400B, the address table 600B is a work (main) table. In the following description, the port numbers = 1, 2, 3 and 4 of the optical switch 101A are expressed as A-1, A-2, A-3 and A-4, respectively, and the port numbers = 7, 8, 9 and 10 of the optical switch 101B are expressed as B-7, B-8, B-9 and B-10, respectively.

[0197] That is, the one (work) control managing unit 400A makes reference to the address tables 600A and 600B under management to make an inquiry about ports which can accept a redundant system with respect to the IT equipments α, β, γ and κ. In the case shown in FIG. 33, the port numbers = A-1 and B-7, the port numbers = A-2 and B-8, the port numbers = A-3 and B-9 and the port numbers A-4 and B-10 are set for a redundant configuration in the control managing unit 400A (in this case, the redundancy setting is updated also in the other control managing unit 400B in a synchronized manner).

[0198] In more detail, for example, in FIG. 33, the IT equipment α is connected to the port number = A-1 of the optical switch 101A and the port number = B-7 of the optical switch 101B, the IT equipment β to the port number = A-3 of the optical switch 101A and the port number = B-9 of the optical switch 101B, the IT equipment γ to the port number = A-2 of the optical switch 101A and the port number = B-8 of the optical switch 101B, and the IT equipment κ to the port number = A-4 of the optical switch 101A and the port number = B-10 of the optical switch 101B.

[0199] Moreover, the port number A-1 connected to the IT equipment α is set as "work" while the port number = B-7 connected thereto is set as "spare", the port number A-3 connected to the IT equipment β as "work" while the port number = B-9 connected thereto as "spare", the port number A-2 connected to the IT equipment γ as "work" while the port number = B-8 connected thereto as "spare", and the port number A-4 connected to the IT equipment κ as "work" while the port number = B-10 connected thereto as "spare" .

[0200] In a case in which communications are made between the IT equipments α and β and between the IT equipments γ and κ, the connection destination of the port number = A-1 connected to the IT equipment α in the normal operation is set at, for example, the port number = A-3 connected to the IT equipment β which is the communication partner, the connection destination of the port number = A-3 connected to the IT equipment β in the normal operation at, for example, the port number = A-1 connected to the IT equipment α which is the communication partner, the connection destination of the port number = A-2 connected to the IT equipment γ in the normal operation at, for example, the port number = A-4 connected to the IT equipment κ which is the communication partner, and the connection destination of the port number = A-4 connected to the IT equipment κ in the normal operation at, for example, the port number = A-2 connected to the IT equipment γ which is the communication partner.

[0201] On the other hand, the connection destination of the port number = B-7 connected to the IT equipment α at the occurrence of abnormality such as trouble is set at, for example, the port number = B-9 connected to the IT equipment β, and the connection destination of the port number = B-9 connected to the IT equipment β at the occurrence of abnormality at, for example, the port number = B-7 connected to the IT equipment α. Moreover, the connection destination of the port number = B-8 connected to the IT equipment γ at the occurrence of abnormality at, for example, the port number = B-10 connected to the IT equipment κ, and the connection destination of the port number = B-10 connected to the IT equipment κ at the occurrence of abnormality at, for example, the port number = B-8 connected to the IT equipment γ. However, an optical signal after placed into a redundant condition is outputted from each of the IT equipments α, β, γ and κ and is incident on each port of the optical switches 101A and 101B. The configuration shown here is one example, and the number of ports and others are not limited to the above description.

[0202] The above-described contents are preserved in the storage medium 104 or 106 serving as an equipment information storing unit of each of the control managing units (each of which will be referred to hereinafter as a "control system") in the form of the equipment information management tables (address tables) 600A and 600B, for example, as shown in FIG. 34(A). To the work control system 400A, the address table 600A is a main address table and the address table 600B is a sub address table while, to the spare control system 400B, the address table 600B is a main address table and the address table 600A is a sub address table.

[0203] As described above, one control system (management controlling unit 400A or 400B) manages the address tables 600A and 600B of each of the plurality of optical switches 101A and 101B, and the connection relationship of addresses written in the address tables 600A and 600B is managed in a state associated between the plurality of address

tables 600A and 600B. For example, the connection relationship among the IT equipments α, β, γ and κ which exists in the one address table 600A is retrieved on the basis of the other address table 600B, and the association on the work/spare port switching is managed in a state converted into the addresses of the IT equipments α, β, γ and κ.

[0204] Thus, in comparison with the case in which the switching between the work system and the spare system is made on the basis of the port information (number), (1) the port can arbitrarily be selected and (2) the management is made on the basis of the address, which provide the advantages of making easy the management irrespective of an increase in number of ports without depending upon the number of ports and of enabling the employment of devices different in characteristic such as the number of ports of the plurality of optical switches realizing the redundant configuration. Moreover, since the control systems for managing the plurality of address tables 600A and 600B are placed into a redundant configuration (the control managing units 400A and 400B are prepared), the periodic mutual updating of the address tables 600A and 600B of the plurality of control systems 400A and 400B further enables coping with troubles of the control systems 400A and 400B themselves.

[0205] A description will be given hereinbelow of a switching method at the occurrence of a trouble in the node redundant configuration.

[0206] First, for example, the one control system 400A grasps the address table 600A as the work-system address table (work table) and also seizes the address table 400B as the spare-system address table (spare table), thereby providing for detection of a trouble. Moreover, the control system 400B is prepared as a spare system for the occurrence of a trouble in the control system 400A. In this case, for providing for the occurrence of a trouble in the control system 400A itself, the spare-system control system 400B makes a communication with the control system 400A and updates its own address tables 600A and 600B at any time to make the synchronization with the address tables 600A and 600B on the work control system 400A side.

[0207] Moreover, when the information on a link trouble or a node trouble is notified to the control system 400A according to the trouble detecting methods mentioned above in the items [A] and [B], or the like, the control system 400A selects a switching method according to each trouble.

[0208] That is, for example, in a case in which a trouble occurs in a link between the port numbers = A-1 and A-3 of the optical switch 101A (when a trouble occurs on an input/output port in the work optical switch), as shown in FIGs. 34 (A) and 34 (B), the control system 400A grasping the address tables 600A and 600B makes comparison and reference to the address tables 600A and 600B to switch only a portion of ports, where the trouble has occurred, to a spare system. That is, the IT equipment α and β, which have made communications through the work optical path running between the port numbers = A-1 and A-3, newly make communications through the use of, as a work optical path, the spare-system path running between the port numbers B-7 and B-9.

[0209] On the other hand, for example, in a case in which a node trouble occurs in the node 101A itself as shown in FIG. 35, as shown in FIGs. 36 (A) and 36(B), the control system 400A, which has grasped the address tables 600A and 600B, makes comparison and reference to the address tables 600A and 600B to collectively switch all the ports of the optical switch 101A, in which the trouble has occurred, to all the connection ports of the spare optical switch 101B.

[0210] That is, in this example, control system 400A (400B) functions as a work/spare switching control unit to, when a trouble (link trouble or node trouble) occurs in an input/output port of the work optical switch 101A or in the work optical switch 101A itself, control each of the optical switches 101A and 101B on the basis of the aforesaid tables 600A and 600B for switching the port, which is in use in the equipment, to an input/output port of the spare optical switch 101B.

[0211] At this time, since the retransmission history log becomes large, in addition to the implementation of the switching, this fact (information) is notified to a management server or a manager of each user connected for executing the control of indicating that the retransmission is not a trouble or of masking the retransmission history.

[0212] As mentioned above, in the case of a node redundant configuration, in response to the detection of a trouble (link trouble or node trouble), the control system 400A makes reference to the address tables 600A and 600B of each of the work/spare nodes 101A and 101B in a state associated with each other to carry out the port switching and updates the contents of each of the address tables 600A and 600B. At this time, the main table it grasps (the table 600A in the case of the control system 400A, and the table 600B to the control system 400B) is also updated. Moreover, when the control system is also placed into a redundant condition as mentioned above, at the updating of the work address tables 600A and 600B, both the work and spare main tables 600A and 600B are updated in a synchronized condition.

[0213] That is, in this example, the control system 400A (400B) also functions as a table synchronization updating unit to update the contents of its own tables 600A and 600B in synchronism with the contents of the table 600A and 600B in the other control system 400B (400A).

[0214] Through the use of the above-described procedure, even if a trouble occurs in a power supply or a node itself, the quick switching to the spare system becomes feasible, thus shortening the suspension time of the system.

[0215] As described above, when the optical connection automatic-switching apparatus is placed into a redundant condition, the speeding-up of detection of a trouble point based on the detection in a physical layer becomes feasible. Moreover, since the switching can be made by making reference to the equipment address, the easy and quick switching to the spare system becomes possible. Still moreover, since the employment of the above-described technique can

shorten the time of the system shutdown or the time needed for the switching to the spare system, it is possible to shorten the time of the suspension of the system, thus improving the reliability of the network system employing the optical connection automatic-switching apparatus.

[0216] Although in the above-described examples a control system also has a redundant configuration for providing for a trouble of the control system itself, for example, as shown in FIG. 37, it is also acceptable that a single control system 400 manages the address tables 600A and 600B. That is, in this case, the control system 400 is connected through the hub 401 to the optical switches 101A and 101B. Also in this configuration, in the control system 400, the connection relationship between the addresses written in the address tables 600A and 600B is managed in a state associated between the plurality of address tables 600A and 600B.

[0217] In this case, for example, as shown in FIG. 38, the management can also be made through different address tables 600A and 600B and, for example, as shown in FIG. 39, the management can also be made through a single address table 600 in a manner such that the two optical switches 101A and 101B are virtually handled as an input/output port (common port) of one optical switch.

[0218] As described above in detail, the optical connection switching apparatus according to the present invention can automatically achieve the equipment connection management and the connection switching of an optical network at the reconstruction of the optical network and at the occurrence of a trouble and, hence, these works are considerably reducible, and the maintenance, operation and management costs for an optical network such as an optical LAN, constructed using this optical connection automatic-switching apparatus, are considerably reducible. Therefore, it can be considered as being extremely useful in the technical fields of optical communications.

Claims

1. A management control unit for an optical connection switching apparatus which includes an optical connection switching facility (101) having a plurality of optical input/output ports each of which is composed of a pair of optical input port (1_I, 2_I, ···, N_I) and an optical output port (1_O, 2_O, ···, N_O) and adapted to make a connection between any one of said optical input ports (1_I, 2_I, ···, N_I) and any one of said optical output ports (1_O, 2_O, ···, N_O), with each of a plurality of equipment (r1, r2, ···, rN-n) each having an optical communication-interface being connected to any one of said optical input/output ports (1_I, 2_I, ···, N_I, 1_O, 2_O, ···, N_O), the optical connection switching apparatus being adapted to establish an optical connection between said equipment (r1, r2, ···, rN-n) and being **characterized by further comprising:**

one or more optical transmitting/receiving units (t1_O, t2_O, ···, tn_O, t1_I, t2_I, ···, tn_I) connected to a portion of said optical input/output ports; and

a management control section (103) adapted to control said optical connection switching facility (101) to make a connection between said optical input/output port (1_I, 2_I, ···, N_I, 1_O, 2_O, ···, N_O) connected to said optical transmitting/receiving unit (t1_O, t2_O, ···, tn_O, t1_I, t2_I, ···, tn_I) and said optical input/output port connected to said equipment (r1, r2, ···, rN-n) for acquiring and managing information on said equipment (r1, r2, ···, rN-n) through a communication with said equipment (r1, r2, ···, rN-n) through the use of said optical transmitting/receiving unit (t1_O, t2_O, ···, tn_O, t1_I, t2_I, ···, tn_I), wherein

said management control section (103) includes an interface scanning unit (135) adapted to control said optical connection switching facility (101) to make connections between said optical input/output ports (1_I, 2_I, ···, N_I, 1_O, 2_O, ···, N_O) connected to said plurality of optical transmitting/receiving units (t1_O, t2_O, ···, tn_O, t1_I, t2_I, ···, tn_I) and the optical input/output port (1_I, 2_I, ···, N_I, 1_O, 2_O, ···, N_O) connected to said equipment (r1, r2, ···, rN-n) in a circulating fashion for acquiring the information on said equipment (r1, r2, ···, rN-n) through the use of said optical transmitting/receiving units (t1_O, t2_O, ···, tn_O, t1_I, t2_I, ···, tn_I).

2. An optical connection switching apparatus to which a plurality of equipment (r1, r2, ..., rN-n) each having an optical communication interface are connected, comprising:

an optical connection switching facility (101) having a plurality of optical input/output ports each of which is composed of a pair of optical input port (1_I, 2_I, ..., N_I) and an optical output port (1_O, 2_O, ..., N_O) and adapted to make a connection between any one of said optical input ports (1_I, 2_I, ..., N_I) and any one of said optical output ports (1_O, 2_O, ..., N_O), with each of a plurality of equipment (r1, r2, ..., rN-n) each having an optical communication interface being connected to any one of said optical input/output ports (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O), the optical connections switching apparatus being adapted to establish an optical connection between said equipment (r1, r2, ..., rN-n); and

a management control unit according to claim 1.

3. The optical connection switching apparatus according to claim 2, **characterized in that** said management control unit (103) includes an equipment information storing unit (104) adapted to store identification information on said equipment (r1, r2, ···, rN-n) as equipment information, which is information on said equipment (r1, r2, ···, rN-n) acquired by the communication with said equipment (r1, r2, ···, rN-n), in a state associated with information on said optical input/output port (1_I, 2_I, ···, N_I, 1_O, 2_O, ···, N_O).

4. The optical connection switching apparatus according to claim 2, **characterized in that** said management control unit (103) includes an equipment state monitoring unit (131) adapted to monitor a connection, disconnection or communication state of said equipment (r1, r2, ···, rN-n) by monitoring optical power information on said optical input/output port (1_I, 2_I, ···, N_I, 1_O, 2_O, ···, N_O).

5. The optical connection switching apparatus according to claim 2, **characterized in that** said management control unit (103) includes:

equipment information storage unit (104) adapted to store identification information on said equipment (r1, r2, ···, rN-n) as equipment information, which is information on said equipment (r1, r2, ···, rN-n) acquired by the communication with said equipment (r1, r2, ···, rN-n), in a state associated with information on said optical input/output port (1_I, 2_I, ···, N_I, 1_O, 2_O, ···, N_O) ;
an optical power information storage unit (106) adapted to store optical power information on said optical input/output port (1_I, 2_I, ···, N_I, 1_O, 2_O, ···, N_O) ; and
an equipment state monitoring unit (131) adapted to monitor connection, disconnection or communication state of said equipment (r1, r2, ···, rN-n) on the basis of said equipment information in said equipment information storage unit (104) and said optical power information in said optical power information storage unit (106).

6. The optical connection switching apparatus according to claim 2 or 5, **characterized in that** said management control unit (103) includes an inter-port connection control unit (136) adapted to carry out inter-port connection control in said optical connection switching facility (101) on the basis of said equipment information in said equipment information storage unit (104).

7. The optical connection switching apparatus according to claim 4 or 5, **characterized in that** a light-receiving element (c1, c2, ···, cN) is provided in said optical input port (1_I, 2_I, ···, N_I) of said optical connection switching facility (101), and
said equipment state monitoring unit (131) is constructed as an input port equipment state monitoring unit (132), when a quantity of light reception by said light-receiving element (c1, c2, ···, cN) is employed as said optical power information, adapted to monitor the connection, disconnection or communication state of said equipment (r1, r2, ···, rN-n) by monitoring a variation of said optical power information.

8. The optical connection switching apparatus according to claim 4 or 5, **characterized in that** a light-receiving element (c1, c2, ···, cN) is provided in said optical output port (1_O, 2_O, ···, N_O) of said optical connection switching facility (101), and
said equipment state monitoring unit (131) is constructed as an output port equipment state monitoring unit (133) adapted to control said optical connection switching facility (101) to make a connection between said optical input port which is connected to said equipment (r1, r2, ···, rN-n) and said optical output port which is not connected to said equipment (r1, r2, ···, rN-n) so that, when a quantity of light reception by said light-receiving element (c1, c2, ···, cN) of said optical output port is employed as said optical power information, the connection, disconnection or communication state of said equipment (r1, r2, ···, rN-n) is monitored by monitoring a variation of said optical power information.

9. The optical connection switching apparatus according to claim 5, **characterized in that** said output port equipment state monitoring unit (133) includes a port circulation connection control unit (134) adapted to control said optical connection switching facility (101) to make connections of said plurality of optical input ports (1_I, 2_I, ···, N_I) connected to said equipment (r1, r2, ···, rN-n) with said optical output port, nonconnected to said equipment (r1, r2, ···, rN-n) and serving as an optical power monitoring port, in a circulating fashion.

10. The optical connection switching apparatus according to claim 9, **characterized in that** a plurality of optical power monitoring ports (q, r, s) each corresponding to said optical power monitoring port are provided to monitor the optical power information on said optical input/output ports (1_I, 2_I, ···, N_I, 1_O, 2_O, ···, N_O) in said optical connection switching facility (101) in a sharing fashion.

11. The optical connection switching apparatus according to claim 4 or 5, **characterized in that** a light-receiving element is provided in said optical output port (1_O, 2_O, ···, N_O) of said optical connection switching facility (101), and said equipment state monitoring unit (131) is constructed as a port turn-around connection equipment state monitoring unit (138) adapted to control said optical connection switching facility (101) to make direct coupling between said optical input port and said optical output port of said optical input/output port which is not connected to said equipment (r1, r2, ···, rN-n) so that, when a quantity of light reception by said light-receiving element (c1', c2', ···, cN') of said optical output port is employed as said optical power information, the connection, disconnection or communication state of said equipment is monitored by monitoring a variation of said optical power information.

12. The optical connection switching apparatus according to claim 4 or 5, **characterized in that** a light-receiving element (c1', c2', ···, cN') is provided in said optical output port (1_O, 2_O, ···, N_O) of said optical connection switching facility (101), and
said equipment state monitoring unit (131) is constructed as an adjacent port connection equipment state monitoring unit (139) adapted to control said optical connection switching facility (101) to make direct coupling between said optical input port and said optical output port of said optical input/output ports which are adjacent to each other and which are not connected to said equipment (r1, r2, ···, rN-n) so that, when a quantity of light reception by said light-receiving element (c1', c2', ···, cN') of said optical output port is employed as said optical power information, the connection, disconnection or communication state of said equipment is monitored by monitoring a variation of said optical power information.

13. The optical connection switching apparatus according to claim 4 or 5, **characterized in that**, when one of said equipment is connected to two of said input/output ports so that one is used as a work port and the other is used as a spare port, said management control unit (103) includes a work/spare switching control unit (137), when said equipment state monitoring unit (131) detects an optical disconnection on said working port, adapted to control said optical connection switching facility (101) to switch a port to be used for said equipment to said spare port.

14. The optical connection switching apparatus according to claim 2, **characterized in that** the plurality of optical transmitting/receiving units (t1_O, t2_O, ···, tn_O, t1_I, t2_I, ···, tn_I) are connected to said optical input/output ports so as to correspond to a plurality of types of optical communication interfaces to be provided in said equipment (r1, r2, ···, rN-n), and
said interface scanning unit (135) is adapted to control said optical connection switching facility (101) to make connections between said optical input/output ports connected to said plurality of optical transmitting/receiving units (t1_O, t2_O, ···, tn_O, t1_I, t2_I, ···, tn_I) and the optical input/output port connected to said equipment (r1, r2, ···, rN-n) in a circulating fashion for acquiring the information on said equipment (r1, r2, ···, rN-n) through the use of said optical transmitting/receiving units (t1_O, t2_O, ···, tn_O, t1_I, t2_I, ···, tn_I).

15. The optical connection switching apparatus according to claim 2, **characterized in that** said optical transmitting/receiving unit (t1_O, t2_O, ···, tn_O, t1_I, t2_I, ···, tn_I) is constructed as a multi-interface handling optical transmitting/receiving unit having a plurality of types of communication functions corresponding to a plurality of types of optical communication interfaces to be provided in said equipment (r1, r2, ···, rN-n), and
said interface scanning unit (135) is adapted to select and set said communication functions of said optical transmitting/receiving unit (t1_O, t2_O, ···, tn_O, t1_I, t2_I, ···, tn_I) in a circulating fashion to acquire the information on said equipment (r1, r2, ···, rN-n), through the use of said optical transmitting/receiving unit (t1_O, t2_O, ···, tn_O, t1_I, t2_I, ···, tn_I).

16. The optical connection switching apparatus according to claim 2, **characterized in that** an optical branch circuit (c1, c2, ···, cN, c1', c2', ···, cN') is provided with respect to one of or both said optical input port (1_I, 2_I, ···, N_I) and said output port (1_O, 2_O, ···, N_O) in said optical connection switching facility (101), and one of outputs of said optical branch circuit (c1, c2, ···, cN, c1', c2', ···, cN') is connected as main signal light to said optical connection switching facility (101) while the other is connected as monitor control light thereto, and
said management control unit (103) is adapted to control said optical connection switching facility (101) to make a connection between an optical input/output port connected to said optical transmitting/receiving unit (t1_O, t2_O, ···, tn_O, t1_I, t2_I, ···, tn_I) and an optical input/output port connected to said monitor control light for acquiring information on said equipment (r1, r2, ···, rN-n) from said monitor control light through the use of said optical transmitting/receiving unit (t1_O, t2_O, ···, tn_O, t1_I, t2_I, ···, tn_I) and managing it, and further monitor information on optical power of said optical input/output port (1_I, 2_I, ···, N_I, 1_O, 2_O, ···, N_O).

17. The optical connection switching apparatus according to claim 16, **characterized in that** a monitor control optical

branch circuit (cc1, cc2, ···, ccN, cc1', cc2' ···, ccN') adapted to divide said monitor control light is provided and one of outputs of said monitor control optical branch circuit (cc1, cc2, ···, ccN, cc1', cc2' ···, ccN') is connected to said optical connection switching facility (101), and
said management control unit (103) is adapted to monitor the other output of said monitor control optical branch circuit (cc1, cc2, ···, ccN, cc1', cc2' ···, ccN') for monitoring information on optical power of said input/output port (1_I, 2_I, ···, N_I, 1_O, 2_O, ···, N_O).

18. The optical connection switching apparatus according to claim 2, **characterized by** further comprising:

a light source (110-1, 110-2) connected to one of said input ports of said optical connection switching facility (101); and
a light reception circuit (102-1, 102-2) connected to one of said output ports of said optical connection switching facility (101),
said management control unit (400) further comprising a first trouble detecting unit adapted to make detection of a trouble of said optical connection switching facility (101) by monitoring a light reception state in said light reception circuit (102-1, 102-2) while switching a connection state between said input port connected to said light source (110-1, 110-2) and said output port connected to said light reception circuit (102-1, 102-2).

19. The optical connection switching apparatus according to claim 2, **characterized in that** at least said optical connection switching facility (101) and said management control unit (400) are placed into a redundant condition, and a first light source (110-1, 110-2) connected to one of said input ports of one optical connection switching facility (101A) and a second light source (110-3, 110-4) connected to one of said input ports of the other optical connection switching facility (101B) are provided so that an output port of said one optical connection switching facility (101A) adapted to output light from said first light source (110-1, 110-2) is connected to an input port other than said input port connected to said second light source (110-3, 110-4) of the other optical connection switching facility (101B) and an output port of the other optical connection switching facility (101B) adapted to output light from said second light source (110-3, 110-4) is connected to an input port other than said input port connected to said first light source (110-1, 110-2) of said one optical connection switching facility (101A), and said management control unit (400A, 400B) further includes a second trouble detecting unit adapted to make detection of a trouble of one of said optical connection switching facilities (101A, 101B) by monitoring an output light power from each of said output ports of said optical connection switching facility (101A, 101B).

20. The optical connection switching apparatus according to claim 2, **characterized in that**, when one equipment is connected to two of said input/output ports to use one as a work port and the other as a spare port, said management control unit (103) includes:

an equipment information storing unit (104) adapted to store an equipment identification information table (600) in which identification information on said equipment connected to said optical connection switching facility (101) is associated with information on said work port and said spare port; and
a work/spare switching control unit, when an optical disconnection on said work port is detected, adapted to control said optical connection switching facility (101) on the basis of said equipment identification information table (600) in said equipment information storing unit (104) to make the switching from the port used by the equipment to said spare port.

21. The optical connection switching apparatus according to claim 2, **characterized in that** at least said optical connection switching facility (101) and said management control unit (400) are placed into a redundant condition, and said management control unit (400A, 400B) includes:

an equipment information storing unit (104) adapted to store a main equipment identification information table (600A) in which identification information on equipment connected to a work optical connection switching facility (101A) is associated with information on an input/output port of said work optical connection switching facility (101A) and a sub equipment identification information table (600B) in which identification information on equipment connected to a spare optical connection switching facility (101B) is associated with information on an input/output port of said spare optical connection switching facility (101B); a work/spare switching control unit, when a trouble occurs in said input/output port of said work optical connection switching facility (101A) or said work optical connection switching facility (101A) itself, adapted to control each of said optical connection switching facilities (101A, 101B) on the basis of each of said tables (600A, 600B) on said optical connection switching facility (101A) for switching the port used by said equipment to said input/output port of said spare optical

connection switching facility (101B); and
a table synchronization updating unit adapted to update the contents of each of said tables (600A, 600B) in said management control unit (400A, 400B), it pertains to, in synchronism with the contents of each of said tables (600A, 600B) in the other management control unit (400A, 400B).

22. The optical connection switching apparatus according to claim 2, **characterized in that** at least said optical connection switching facility (101) is placed into a redundant condition, and
said management control unit (103) includes:

an equipment information storing unit (104) adapted to store a main equipment identification information table (600A) in which identification information on equipment connected to a work optical connection switching facility (101A) is associated with information on an input/output port of said work optical connection switching facility (101A) and a sub equipment identification information table (600B) in which identification information on equipment connected to a spare optical connection switching facility (101B) is associated with information on an input/output port of said spare optical connection switching facility (101B); and
a work/spare switching control unit, when a trouble occurs in said input/output port of said work optical connection switching facility (101A) or said work optical connection switching facility (101A) itself, adapted to control each of said optical connection switching facilities (101A, 101B) on the basis of each of said tables (600A, 600B) on said optical connection switching facility (101A) for switching the port used by said equipment to said input/output port of said spare optical connection switching facility (101B).

23. The optical connection switching apparatus according to claim 22, **characterized in that** said input/output ports of said optical connection switching facilities (101A, 101B) are virtually handled as a common port of one optical connection facility to manage the contents of said tables (600A, 600B) as one table (600) in said equipment information storing unit (104).

Patentansprüche

1. Verwaltungssteuerungseinheit für eine Anordnung zur Schaltung von optischen Verbindungen, die eine Vorrichtung zur Schaltung von optischen Verbindungen (101) enthält, die eine Vielzahl von optischen Eingangs-/Ausgangsanschlüssen aufweist, von denen jeder aus einem Paar von optischem Eingangsanschluss (1_I, 2_I, ..., N_I) und einem optischen Ausgangsanschluss (1_O, 2_O, ..., N_O) besteht, und dazu beschaffen ist, eine Verbindung zwischen einem beliebigen der optischen Eingangsanschlüsse (1_I, 2_I, ..., N_I) und einem beliebigen der optischen Ausgangsanschlüsse (1_O, 2_O, ..., N_O) herzustellen mit jedem aus einer Vielzahl von Equipment (r1, r2, ..., rN-n), von denen jedes eine optische Kommunikationsschnittstelle aufweist, die mit einem beliebigen der optischen Eingangs-/Ausgangsanschlüsse (1_I, 2_I, ..., N_I, 1_O, 2_O,..., N_O) verbunden ist, wobei die Anordnung zur Schaltung von optischen Verbindungen dazu beschaffen ist, eine optische Verbindung zwischen dem Equipment (r1, r2, ..., rN-n) aufzubauen, und **dadurch gekennzeichnet ist, dass sie des Weiteren Folgendes umfasst:**

eine oder mehrere optische Sende-/Empfangseinheiten (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I), die mit einem Teil der optischen Eingangs-/Ausgangsanschlüsse verbunden sind; und
einen Verwaltungssteuerungsbereich (103), der dazu beschaffen ist, die Vorrichtung zur Schaltung von optischen Verbindungen (101) dazu zu steuern, eine Verbindung zwischen dem optischen Eingangs-/Ausgangsanschluss (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O), der mit der optischen Sende-/Empfangseinheit (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) verbunden ist, und dem optischen Eingangs-/Ausgangsanschluss, der mit dem Equipment (r1, r2, ..., rN-n) verbunden ist, herzustellen zum Beziehen und Verwalten von Informationen zu dem Equipment (r1, r2, ..., rN-n) durch eine Kommunikation mit dem Equipment (r1, r2, ..., rN-n) durch Verwenden der optischen Sende-/Empfangseinheit (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I), wobei
der Verwaltungssteuerungsbereich (103) eine Schnittstellenabtasteinheit (135) enthält, die dazu beschaffen ist, die Vorrichtung zur Schaltung von optischen Verbindungen (101) dazu zu steuern, Verbindungen zwischen den optischen Eingangs-/Ausgangsanschlüssen (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O), die mit der Vielzahl von optischen Sende-/Empfangseinheiten (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) verbunden sind, und dem optischen Eingangs-/Ausgangsanschluss (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O), der mit dem Equipment (r1, r2, ..., rN-n) verbunden ist, in einer zirkulierenden Weise herzustellen zum Beziehen der Informationen zu dem Equipment (r1, r2, ..., rN-n) durch Verwenden der optischen Sende-/Empfangseinheiten (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I).

2. Anordnung zur Schaltung von optischen Verbindungen, mit der eine Vielzahl von Equipment (r1, r2, ..., rN-n), von denen jedes eine optische Kommunikationsschnittstelle aufweist, verbunden ist, umfassend:

eine Vorrichtung zur Schaltung von optischen Verbindungen (101), die eine Vielzahl von optischen Eingangs-/Ausgangsanschlüssen aufweist, von denen jeder aus einem Paar von optischem Eingangsanschluss (1_I, 2_I, ..., N_I) und einem optischen Ausgangsanschluss (1_O, 2_O,..., N_O) besteht und dazu beschaffen ist, eine Verbindung zwischen einem beliebigen der optischen Eingangsanschlüsse (1_I, 2_I, ..., N_I) und einem beliebigen der optischen Ausgangsanschlüsse (1_O, 2_O, ..., N_O) herzustellen mit jedem aus einer Vielzahl von Equipment (r1, r2, ..., rN-n), von denen jedes eine optische Kommunikationsschnittstelle aufweist, die mit einem beliebigen der optischen Eingangs-/Ausgangsanschlüsse (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O) verbunden ist, wobei die Anordnung zur Schaltung von optischen Verbindungen dazu beschaffen ist, eine optische Verbindung zwischen dem Equipment (r1, r2, ..., rN-n) aufzubauen; und
eine Verwaltungssteuerungseinheit nach Anspruch 1.

3. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 2, **dadurch gekennzeichnet, dass** die Verwaltungssteuerungseinheit (103) eine Equipmentinformationen-Speichereinheit (104) enthält, die dazu beschaffen ist, Identifikationsinformationen zu dem Equipment (r1, r2, ..., rN-n) als Equipmentinformationen, das heißt Informationen zu dem Equipment (r1, r2, ..., rN-n), die durch die Kommunikation mit dem Equipment (r1, r2, ..., rN-n) bezogen wurden, in einem Zustand mit Informationen zu dem optischen Eingangs-/Ausgangsanschluss (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O) assoziiert zu speichern.

4. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 2, **dadurch gekennzeichnet, dass** die Verwaltungssteuerungseinheit (103) eine Equipmentzustands-Überwachungseinheit (131) enthält, die dazu beschaffen ist, einen Verbindungs-, Trennungs- oder Kommunikationszustand des Equipments (r1, r2, ..., rN-n) durch Überwachen von optischen Leistungsinformationen an dem optischen Eingangs-/Ausgangsanschluss (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O) zu überwachen.

5. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 2, **dadurch gekennzeichnet, dass** die Verwaltungssteuerungseinheit (103) Folgendes enthält:

eine Equipmentinformationen-Speichereinheit (104), die dazu beschaffen ist, Identifikationsinformationen zu dem Equipment (r1, r2, ..., rN-n) als Equipmentinformationen, das heißt Informationen zu dem Equipment (r1, r2, ..., rN-n), die durch die Kommunikation mit dem Equipment (r1, r2, ..., rN-n) bezogen wurden, in einem Zustand mit Informationen zu dem optischen Eingangs-/Ausgangsanschluss (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O) assoziiert zu speichern;
eine Optische-Leistungsinformationen-Speichereinheit (106), die dazu beschaffen ist, Informationen zur optischen Leistung an dem Eingangs-/Ausgangsanschluss (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O) zu speichern; und
eine Equipmentzustands-Überwachungseinheit (131), die dazu beschaffen ist, den Verbindungs-, Trennungs- oder Kommunikationszustand des Equipments (r1, r2, ..., rNn) auf Basis der Equipmentinformationen in der Equipmentinformationen-Speichereinheit (104) und der optischen Leistungsinformationen in der Optische-Leistungsinformationen-Speichereinheit (106) zu überwachen.

6. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 2 oder 5, **dadurch gekennzeichnet, dass** die Verwaltungssteuerungseinheit (103) eine Steuerungseinheit für Verbindungen zwischen Anschlüssen (136) enthält, die dazu beschaffen ist, die Steuerung von Verbindungen zwischen Anschlüssen in der Vorrichtung zur Schaltung von optischen Verbindungen (101) auf Basis der Equipmentinformationen in der Equipmentinformationen-Speichereinheit (104) auszuführen.

7. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 4 oder 5, **dadurch gekennzeichnet, dass** in dem optischen Eingangsanschluss (1_I, 2_I, ..., N_I) der Vorrichtung zur Schaltung von optischen Verbindungen (101) ein Licht empfangendes Element (c1, c2, ..., cN) bereitgestellt ist, und
wenn eine Menge von Lichtempfang durch das Licht empfangende Element (c1, c2, ..., cN) als die optische Leistungsinformation verwendet wird, die Equipmentzustands-Überwachungseinheit (131) als eine Equipmentzustands-Überwachungseinheit am Eingangsanschluss (132) ausgeführt ist, dazu beschaffen, den Verbindungs-, Trennungs- oder Kommunikationszustand des Equipments (r1, r2, ..., rNn) durch Überwachen einer Veränderung der optischen Leistungsinformationen zu überwachen.

8. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 4 oder 5, **dadurch gekennzeichnet, dass**

in dem optischen Ausgangsanschluss (1_O, 2_O, ..., N_O) der Vorrichtung zur Schaltung von optischen Verbindungen (101) ein Licht empfangendes Element (c1, c2, ..., cN) bereitgestellt ist, und
die Equipmentzustands-Überwachungseinheit (131) als eine Equipmentzustands-Überwachungseinheit am Ausgangsanschluss (133) ausgeführt ist, dazu beschaffen, die Vorrichtung zur Schaltung von optischen Verbindungen (101) dazu zu steuern, eine Verbindung zwischen dem optischen Eingangsanschluss, der mit dem Equipment (r1, r2, ..., rN-n) verbunden ist, und dem optischen Ausgangsanschluss, der nicht mit dem Equipment (r1, r2, ..., rN-n) verbunden ist, herzustellen, so dass, wenn eine Menge von Lichtempfang durch das Licht empfangende Element (c1, c2, ..., cN) des optischen Ausgangsanschlusses als die optische Leistungsinformation verwendet wird, der Verbindungs-, Trennungs- oder Kommunikationszustand des Equipments (r1, r2, ..., rNn) durch Überwachen einer Veränderung der optischen Leistungsinformationen überwacht wird.

9. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 5, **dadurch gekennzeichnet, dass** die Equipmentzustands-Überwachungseinheit am Ausgangsanschluss (133) eine Verbindungssteuerungseinheit mit Zirkulation der Anschlüsse (134) enthält, dazu beschaffen, die Vorrichtung zur Schaltung von optischen Verbindungen (101) dazu zu steuern, Verbindungen der Vielzahl von optischen Eingangsanschlüssen (1_I, 2_I, ..., N_I), die mit dem Equipment (r1, r2, ..., rN-n) verbunden sind, mit dem optischen Ausgangsanschluss, der nicht mit dem Equipment (r1, r2, ..., rN-n) verbunden ist und als ein optischer Leistungsüberwachungsanschluss dient, in einer zirkulierenden Weise herzustellen.

10. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 9, **dadurch gekennzeichnet, dass** eine Vielzahl von optischen Leistungsüberwachungsanschlüssen (q, r, s), von denen jeder dem optischen Leistungsüberwachungsanschluss entspricht, bereitgestellt sind, um die optischen Leistungsinformationen an den optischen Eingangs-/Ausgangsanschlüssen (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O) in der Vorrichtung zur Schaltung von optischen Verbindungen (101) in einer teilenden Weise zu überwachen.

11. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 4 oder 5, **dadurch gekennzeichnet, dass** in dem optischen Ausgangsanschluss (1_O, 2_O, ..., N_O) der Vorrichtung zur Schaltung von optischen Verbindungen (101) ein Licht empfangendes Element bereitgestellt ist, und
die Equipmentzustands-Überwachungseinheit (131) als eine Equipmentzustands-Überwachungseinheit von Anschlussumkehrverbindungen (138) aufgebaut ist, dazu beschaffen, die Vorrichtung zur Schaltung von optischen Verbindungen (101) dazu zu steuern, eine direkte Kopplung zwischen dem optischen Eingangsanschluss und dem optischen Ausgangsanschluss des optischen Eingangs-/Ausgangsanschlusses, der nicht mit dem Equipment (r1, r2, ..., rN-n) verbunden ist, herzustellen, so dass, wenn eine Menge von Lichtempfang durch das Licht empfangende Element (c1', c2', ..., cN') des optischen Ausgangsanschlusses als die optische Leistungsinformation verwendet wird, der Verbindungs-, Trennungs- oder Kommunikationszustand des Equipments durch Überwachen einer Veränderung der optischen Leistungsinformationen überwacht wird.

12. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 4 oder 5, **dadurch gekennzeichnet, dass** in dem optischen Ausgangsanschluss (1_O, 2_O, ..., N_O) der Vorrichtung zur Schaltung von optischen Verbindungen (101) ein Licht empfangendes Element (c1', c2', ..., cN') bereitgestellt ist, und
die Equipmentzustands-Überwachungseinheit (131) als eine Equipmentzustands-Überwachungseinheit von benachbarten Anschlussverbindungen (139) aufgebaut ist, dazu beschaffen, die Vorrichtung zur Schaltung von optischen Verbindungen (101) dazu zu steuern, eine direkte Kopplung zwischen dem optischen Eingangsanschluss und dem optischen Ausgangsanschluss der optischen Eingangs-/Ausgangsanschlüsse, die zueinander benachbart sind und die nicht mit dem Equipment (r1, r2, ..., rN-n) verbunden sind, herzustellen, so dass, wenn eine Menge von Lichtempfang durch das Licht empfangende Element (c1', c2', ..., cN') des optischen Ausgangsanschlusses als die optische Leistungsinformation verwendet wird, der Verbindungs-, Trennungs- oder Kommunikationszustand des Equipments durch Überwachen einer Veränderung der optischen Leistungsinformationen überwacht wird.

13. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 4 oder 5, **dadurch gekennzeichnet, dass**, wenn eines des Equipments mit zwei der Eingangs-/Ausgangsanschlüsse verbunden ist, so dass einer als ein Arbeitsanschluss und der andere als ein Ersatzanschluss verwendet wird, die Verwaltungssteuerungseinheit (103) eine Arbeits-/Ersatz-Schaltungssteuerungseinheit (137) enthält, die dazu beschaffen ist, die Vorrichtung zur Schaltung von optischen Verbindungen (101) dazu zu steuern, einen für das Equipment zu verwendenden Anschluss auf den Ersatzanschluss zu schalten, wenn die Equipmentzustands-Überwachungseinheit (131) eine optische Trennung an dem Arbeitsanschluss erkennt.

14. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 2, **dadurch gekennzeichnet, dass** die

Vielzahl von optischen Sende-/Empfangseinheiten (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) mit den optischen Eingangs-/Ausgangsanschlüssen verbunden sind, so dass einer Vielzahl von Arten von in dem Equipment (r1, r2, ..., rN-n) bereitzustellenden optischen Kommunikationsschnittstellen entsprochen wird, und
die Schnittstellenabtasteinheit (135) dazu beschaffen ist, die Vorrichtung zur Schaltung von optischen Verbindungen (101) dazu zu steuern, Verbindungen zwischen den optischen Eingangs-/Ausgangsanschlüssen, die mit der Vielzahl von optischen Sende-/Empfangseinheiten (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) verbunden sind, und dem optischen Eingangs-Ausgangsanschluss, der mit dem Equipment (r1, r2, ..., rN-n) verbunden ist, in einer zirkulierenden Weise herzustellen zum Beziehen der Informationen zu dem Equipment (r1, r2, ..., rN-n) durch Verwenden der optischen Sende-/Empfangseinheiten (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I).

15. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 2, **dadurch gekennzeichnet, dass** die optische Sende-/Empfangseinheit (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) als eine mehrere Schnittstellen handhabende optische Sende-/Empfangseinheit aufgebaut ist, die eine Vielzahl von Arten von Kommunikationsfunktionen aufweist, die einer Vielzahl von Arten von in dem Equipment (r1, r2, ..., rN-n) bereitzustellenden optischen Kommunikationsschnittstellen entsprechen, und
die Schnittstellenabtasteinheit (135) dazu beschaffen ist, die Kommunikationsfunktionen der optischen Sende-/Empfangseinheit (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) in einer zirkulierenden Weise auszuwählen und festzulegen, um die Informationen zu dem Equipment (r1, r2, ..., rN-n) durch Verwenden der optischen Sende-/Empfangseinheiten (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) zu beziehen.

16. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 2, **dadurch gekennzeichnet, dass** eine optische Verzweigungsschaltung (c1, c2, ..., cN, c1', c2', ..., cN') in Bezug auf einen aus oder beide des optischen Eingangsanschlusses (1_I, 2_I, ..., N_I) und des Ausgangsanschlusses (1_O, 2_O, ..., N_O) in der Vorrichtung zur Schaltung von optischen Verbindungen (101) bereitgestellt ist, und einer der Ausgänge der optischen Verzweigungsschaltung (c1, c2, ..., cN, c1', c2', ..., cN') als Hauptsignallicht mit der Vorrichtung zur Schaltung von optischen Verbindungen (101) verbunden ist, während der andere als Überwachungssteuerungslicht damit verbunden ist, und die Verwaltungssteuerungseinheit (103) dazu beschaffen ist, die Vorrichtung zur Schaltung von optischen Verbindungen (101) dazu zu steuern, eine Verbindung zwischen einem optischen Eingangs-/Ausgangsanschluss, der mit der optischen Sende-/Empfangseinheit (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) verbunden ist, und einem optischen Eingangs-/Ausgangsanschluss, der mit dem Überwachungssteuerungslicht verbunden ist, herzustellen, um Informationen zu dem Equipment (r1, r2, ..., rN-n) aus dem Überwachungssteuerungslicht durch Verwenden der optischen Sende-/Empfangseinheit (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) zu beziehen und sie zu verwalten, und des Weiteren Informationen zur optischen Leistung des optischen Eingangs-/Ausgangsanschlusses (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O) zu überwachen.

17. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 16, **dadurch gekennzeichnet, dass** eine optische Überwachungssteuerungs-Verzweigungsschaltung (cc1, cc2, ..., ccN, cc1', cc2', ..., ccN') bereitgestellt ist, die dazu beschaffen ist, das Überwachungssteuerungslicht zu dividieren, und einer der Ausgänge der optischen Überwachungssteuerungs-Verzweigungsschaltung (cc1, cc2, ..., ccN, cc1', cc2', ..., ccN') mit der Vorrichtung zur Schaltung von optischen Verbindungen (101) verbunden ist, und
die Verwaltungssteuerungseinheit (103) dazu beschaffen ist, den anderen Ausgang der optischen Überwachungssteuerungs-Verzweigungsschaltung (cc1, cc2, ..., ccN, cc1', cc2', ..., ccN') zum Überwachen von Informationen zur optischen Leistung des Eingangs-/Ausgangsanschlusses (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O) zu überwachen.

18. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 2, **dadurch gekennzeichnet, dass** sie des Weiteren Folgendes umfasst:

eine Lichtquelle (110-1, 110-2), die mit einem der Eingangsanschlüsse der Vorrichtung zur Schaltung von optischen Verbindungen (101) verbunden ist; und
eine Lichtempfangsschaltung (102-1, 102-2), die mit einem der Ausgangsanschlüsse der Vorrichtung zur Schaltung von optischen Verbindungen (101) verbunden ist,
wobei die Verwaltungssteuerungseinheit (400) des Weiteren eine erste Störungserkennungseinheit umfasst, die dazu beschaffen ist, eine Störung der Vorrichtung zur Schaltung von optischen Verbindungen (101) zu erkennen durch Überwachen eines Lichtempfangszustands in der Lichtempfangsschaltung (102-1, 102-2) während Schaltung eines Verbindungszustand zwischen dem Eingangsanschluss, der mit der Lichtquelle (110-1, 110-2) verbunden ist, und dem Ausgangsanschluss, der mit der Lichtempfangsschaltung (102-1, 102-2) verbunden ist.

19. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 2, **dadurch gekennzeichnet, dass** mindestens die Vorrichtung zur Schaltung von optischen Verbindungen (101) und die Verwaltungssteuerungseinheit (400) in eine redundante Bedingung gesetzt sind, und eine erste Lichtquelle (110-1, 110-2), die mit einem der Eingangsanschlüsse von einer Vorrichtung zur Schaltung von optischen Verbindungen (101A) verbunden ist, und eine zweite Lichtquelle (110-3, 110-4), die mit einem der Eingangsanschlüsse der anderen Vorrichtung zur Schaltung von optischen Verbindungen (101B) verbunden ist, bereitgestellt sind, so dass ein Ausgangsanschluss der einen Vorrichtung zur Schaltung von optischen Verbindungen (101A), der dazu beschaffen ist, Licht von der ersten Lichtquelle (110-1, 110,2) auszugeben, mit einem anderen Eingangsanschluss verbunden ist als dem Eingangsanschluss, der mit der zweiten Lichtquelle (110-3, 110-4) der anderen Vorrichtung zur Schaltung von optischen Verbindungen (101B) verbunden ist, und ein Ausgangsanschluss der anderen Vorrichtung zur Schaltung von optischen Verbindungen (101B), der dazu beschaffen ist, Licht von der zweiten Lichtquelle (110-3, 110-4) auszugeben, mit einem anderen Eingangsanschluss verbunden ist als dem Eingangsanschluss, der mit der ersten Lichtquelle (110-1, 110-2) der einen Vorrichtung zur Schaltung von optischen Verbindungen (101A) verbunden ist, und die Verwaltungssteuerungseinheit (400A, 400B) des Weiteren eine zweite Störungserkennungseinheit enthält, die dazu beschaffen ist, eine Störung von einer der Vorrichtungen zur Schaltung von optischen Verbindungen (101A, 101B) zu erkennen durch Überwachen einer Ausgangslichtleistung von jedem der Ausgangsanschlüsse der Vorrichtung zur Schaltung von optischen Verbindungen (101A, 101B).

20. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 2, **dadurch gekennzeichnet, dass** wenn ein Equipment mit zwei der Eingangs-/Ausgangsanschlüsse verbunden ist, um einen als einen Arbeitsanschluss und den anderen als einen Ersatzanschluss zu verwenden, die Verwaltungssteuerungseinheit (103) Folgendes enthält:

eine Equipmentinformationen-Speichereinheit (104), die dazu beschaffen ist, eine Equipment-Identifikationsinformationen-Tabelle (600) zu speichern, in der Identifikationsinformationen zu dem Equipment, das mit der Vorrichtung zur Schaltung von optischen Verbindungen (101) verbunden ist, mit Informationen zu dem Arbeitsanschluss und dem Ersatzanschluss assoziiert sind; und
eine Arbeits-/Ersatz-Schaltungssteuerungseinheit, die dazu beschaffen ist, wenn eine optische Trennung an dem Arbeitsanschluss erkannt wird, die Vorrichtung zur Schaltung von optischen Verbindungen (101) auf Basis der Equipment-Identifikationsinformationen-Tabelle (600) in der Equipmentinformationen-Speichereinheit (104) dazu zu steuern, die Schaltung von dem von dem Equipment verwendeten Anschluss auf den Ersatzanschluss herzustellen.

21. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 2, **dadurch gekennzeichnet, dass** mindestens die Vorrichtung zur Schaltung von optischen Verbindungen (101) und die Verwaltungssteuerungseinheit (400) in eine redundante Bedingung gesetzt sind, und
die Verwaltungssteuerungseinheit (400A, 400B) Folgendes enthält:

eine Equipmentinformationen-Speichereinheit (104), die dazu beschaffen ist, eine Equipment-Identifikationsinformationen-Haupttabelle (600A) zu speichern, in der Identifikationsinformationen zu Equipment, das mit einer Arbeitsvorrichtung zur Schaltung von optischen Verbindungen (101A) verbunden ist, mit Informationen zu einem Eingangs-/Ausgangsanschluss der Arbeitsvorrichtung zur Schaltung von optischen Verbindungen (101A) assoziiert sind, und eine Equipment-Identifikationsinformationen-Untertabelle (600B,) in der Identifikationsinformationen zu Equipment, das mit einer Ersatzvorrichtung zur Schaltung von optischen Verbindungen (101B) verbunden ist, mit Informationen zu einem Eingangs-/Ausgangsanschluss der Ersatzvorrichtung zur Schaltung von optischen Verbindungen (101B) assoziiert sind;
eine Arbeits-/Ersatz-Schaltungssteuerungseinheit, die dazu beschaffen ist, wenn eine Störung in dem Eingangs-/Ausgangsanschluss der Arbeitsvorrichtung zur Schaltung von optischen Verbindungen (101A) oder der Arbeitsvorrichtung zur Schaltung von optischen Verbindungen (101A) selbst auftritt, jede der Vorrichtungen zur Schaltung von optischen Verbindungen (101A, 101B) auf Basis jeder der Tabellen (600A, 600B) zu der Vorrichtung zur Schaltung von optischen Verbindungen (101A) dazu zu steuern, den von dem Equipment verwendeten Anschluss auf den Eingangs-/Ausgangsanschluss der Ersatzvorrichtung zur Schaltung von optischen Verbindungen (101B) zu schalten; und
eine Tabellen-Synchronisierungs-Aktualisierungs-Einheit, die dazu beschaffen ist, die Inhalte jeder der Tabellen (600A, 600B) in der Verwaltungssteuerungseinheit (400A, 400B), zu der sie gehört, in Synchronismus mit den Inhalten jeder der Tabellen (600A, 600B) in der anderen Verwaltungssteuerungseinheit (400A, 400B) zu aktualisieren.

22. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 2, **dadurch gekennzeichnet, dass** mindestens die Vorrichtung zur Schaltung von optischen Verbindungen (101) in eine redundante Bedingung gesetzt ist, und
die Verwaltungssteuerungseinheit (103) Folgendes enthält:

eine Equipmentinformationen-Speichereinheit (104), die dazu beschaffen ist, eine Equipment-Identifikationsinformationen-Haupttabelle (600A) zu speichern, in der Identifikationsinformationen zu Equipment, das mit einer Arbeitsvorrichtung zur Schaltung von optischen Verbindungen (101A) verbunden ist, mit Informationen zu einem Eingangs-/Ausgangsanschluss der Arbeitsvorrichtung zur Schaltung von optischen Verbindungen (101A) assoziiert sind, und eine Equipment-Identifikationsinformationen-Untertabelle (600B), in der Identifikationsinformationen zu Equipment, das mit einer Ersatzvorrichtung zur Schaltung von optischen Verbindungen (101B) verbunden ist, mit Informationen zu einem Eingangs-/Ausgangsanschluss der Ersatzvorrichtung zur Schaltung von optischen Verbindungen (101B) assoziiert sind; und
eine Arbeits-/Ersatz-Schaltungssteuerungseinheit, die dazu beschaffen ist, wenn eine Störung in dem Eingangs-/Ausgangsanschluss der Arbeitsvorrichtung zur Schaltung von optischen Verbindungen (101A) oder der Arbeitsvorrichtung zur Schaltung von optischen Verbindungen (101A) selbst auftritt, jede der Vorrichtungen zur Schaltung von optischen Verbindungen (101A, 101B) auf Basis jeder der Tabellen (600A, 600B) zu der Vorrichtung zur Schaltung von optischen Verbindungen (101A) dazu zu steuern, den von dem Equipment verwendeten Anschluss auf den Eingangs-/Ausgangsanschluss der Ersatzvorrichtung zur Schaltung von optischen Verbindungen (101B) zu schalten.

23. Anordnung zur Schaltung von optischen Verbindungen nach Anspruch 22, **dadurch gekennzeichnet, dass** die Eingangs-/Ausgangsanschlüsse der Vorrichtungen zur Schaltung von optischen Verbindungen (101A, 101B) virtuell als ein gemeinsamer Anschluss von einer optischen Verbindungsvorrichtung gehandhabt werden, um die Inhalte der Tabellen (600A, 600B) als eine Tabelle (600) in der Equipmentinformationen-Speichereinheit (104) zu verwalten.

Revendications

1. Unité de commande de gestion pour un appareil de commutation de connexion optique qui inclut un équipement de commutation de connexion optique (101) ayant une pluralité de ports d'entrée / sortie optiques, chacun d'eux étant composé d'un couple d'un port d'entrée optique (1_I, 2_I, ..., N_I) et d'un port de sortie optique (1_O, 2_O, ..., N_O) et adapté pour établir une connexion entre l'un quelconque desdits ports d'entrée optiques (1-I, 2_I, ..., N_I) et l'un quelconque desdits ports de sortie optiques (1_O, 2_O, ..., N_O), avec chacun d'une pluralité d'équipements (r1, r2, ..., rN-n) ayant chacun une interface de communication optique reliée à l'un quelconque desdits ports d'entrée / sortie optiques (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O), l'appareil de commutation de connexion optique étant adapté pour établir une connexion optique entre ledit équipement (r1, r2, ..., rN-n) et étant **caractérisé comme comprenant en outre** :

une ou plusieurs unités d'émission / réception optiques (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) reliées à une partie desdits ports d'entrée / sortie optiques ; et
une section de commande de gestion (103) adaptée pour commander ledit équipement de commutation de connexion optique (101) pour établir une connexion entre ledit port d'entrée / sortie optique (1_I, 2_I, ..., N_I, 1_O, 2_O,..., N_O) relié à ladite unité d'émission / réception optique (t1_O, t2_O, tn_O, t1_I, t2_I, ..., tn_I) et ledit port d'entrée / sortie optique relié audit équipement (r1, r2, ..., rN-n) pour acquérir et gérer des informations sur ledit équipement (r1, r2, ..., rN-n) par l'intermédiaire d'une communication avec ledit équipement (r1, r2, ..., rN-n) à l'aide de ladite unité d'émission / réception optique (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I), dans laquelle ladite section de commande de gestion (103) inclut une unité de balayage d'interface (135) adaptée pour commander ledit équipement de commutation de connexion optique (101) pour établir des connexions entre lesdits ports d'entrée / sortie optiques (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O) reliés à ladite pluralité d'unités d'émission / réception optiques (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) et le port d'entrée / sortie optique (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O) relié audit équipement (r1, r2, ..., rN-n) d'une façon circulante pour acquérir les informations sur ledit équipement (r1, r2, ..., rN-n) à l'aide desdites unités d'émission / réception optiques (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I).

2. Appareil de commutation de connexion optique auquel une pluralité d'équipements (r1, r2, ..., rN-n) ayant chacun une interface de communication optique sont reliés, comprenant :

un équipement de commutation de connexion optique (101) ayant une pluralité de ports d'entrée / sortie optiques, chacun d'eux étant composé d'un couple d'un port d'entrée optique (1_I, 2_I, ..., N_I) et d'un port de sortie optique (1_O, 2_O, ..., N_O) et adapté pour établir une connexion entre l'un quelconque desdits ports d'entrée optiques (1_I, 2_I, ..., N_I) et l'un quelconque desdits ports de sortie optiques (1_O, 2_O, ..., N_O), chacun d'une pluralité d'équipements (r1, r2, ..., rN-n) ayant chacun une interface de communication optique reliée à l'un quelconque desdits ports d'entrée / sortie optiques (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O), l'appareil de commutation de connexion optique étant adapté pour établir une connexion optique entre ledit équipement (r1, r2, ..., rN-n) ; et
une unité de commande de gestion selon la revendication 1.

3. Appareil de commutation de connexion optique selon la revendication 2, **caractérisé en ce que** ladite unité de commande de gestion (103) inclut une unité de stockage d'informations d'équipement (104) adaptée pour stocker des informations d'identification sur ledit équipement (r1, r2, ..., rN-n) en tant qu'informations d'équipement, qui sont des informations sur ledit équipement (r1, r2, ..., rN-n) acquises par la communication avec ledit équipement (r1, r2, ..., rN-n), dans un état associé à des informations sur ledit port d'entrée / sortie optique (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O).

4. Appareil de commutation de connexion optique selon la revendication 2, **caractérisé en ce que** ladite unité de commande de gestion (103) inclut une unité de contrôle d'état d'équipement (131) adaptée pour contrôler un état de connexion, déconnexion ou communication dudit équipement (r1, r2, ..., rN-n) en contrôlant des informations de puissance optique sur ledit port d'entrée / sortie optique (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O).

5. Appareil de commutation de connexion optique selon la revendication 2, **caractérisé en ce que** ladite unité de commande de gestion (103) inclut :

une unité de stockage d'informations d'équipement (104) adaptée pour stocker des informations d'identification sur ledit équipement (r1, r2, ..., rN-n) en tant qu'informations d'équipement, qui sont des informations sur ledit équipement (r1, r2, ..., rN-n) acquises par la communication avec ledit équipement (r1, r2, ..., rN-n), dans un état associé à des informations sur ledit port d'entrée / sortie optique (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O) ;
une unité de stockage d'informations de puissance optique (106) adaptée pour stocker des informations de puissance optique sur ledit port d'entrée / sortie optique (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O) ; et
une unité de contrôle d'état d'équipement (131) adaptée pour contrôler un état de connexion, déconnexion ou communication dudit équipement (r1, r2, ..., rN-n) sur la base desdites informations d'équipement dans ladite unité de stockage d'informations d'équipement (104) et desdites informations de puissance optique dans ladite unité de stockage d'informations de puissance optique (106).

6. Appareil de commutation de connexion optique selon la revendication 2 ou 5, **caractérisé en ce que** ladite unité de commande de gestion (103) inclut une unité de commande de connexion entre ports (136) adaptée pour effectuer une commande de connexion entre ports dans ledit équipement de commutation de connexion optique (101) sur la base desdites informations d'équipement dans ladite unité de stockage d'informations d'équipement (104).

7. Appareil de commutation de connexion optique selon la revendication 4 ou 5, **caractérisé en ce qu'**un élément de réception de lumière (c1, c2, ..., cN) est prévu dans ledit port d'entrée optique (1_I, 2_I, ..., N_I) dudit équipement de commutation de connexion optique (101), et
ladite unité de contrôle d'état d'équipement (131) est construite comme une unité de contrôle d'état d'équipement de port d'entrée (132), quand une quantité de réception de lumière par ledit élément de réception de lumière (c1, c2, ..., cN) est employée en tant que lesdites informations de puissance optique, adaptée pour contrôler l'état de connexion, déconnexion ou communication dudit équipement (r1, r2, ..., rN-n) en contrôlant une variation desdites informations de puissance optique.

8. Appareil de commutation de connexion optique selon la revendication 4 ou 5, **caractérisé en ce qu'**un élément de réception de lumière (c1, c2, ..., cN) est prévu dans ledit port de sortie optique (1_O, 2_O, ..., N_O) dudit équipement de commutation de connexion optique (101), et
ladite unité de contrôle d'état d'équipement (131) est construite comme une unité de contrôle d'état d'équipement de port de sortie (133) adaptée pour commander ledit équipement de commutation de connexion optique (101) pour établir une connexion entre ledit port d'entrée optique qui est relié audit équipement (r1, r2, ..., rN-n) et ledit port de sortie optique qui n'est pas relié audit équipement (r1, r2, ..., rN-n) de sorte que, quand une quantité de réception de lumière par ledit élément de réception de lumière (c1, c2, ..., cN) dudit port de sortie optique est employée en

tant que lesdites informations de puissance optique, l'état de connexion, déconnexion ou communication dudit équipement (r1, r2, ..., rN-n) est contrôlé en contrôlant une variation desdites informations de puissance optique.

9. Appareil de commutation de connexion optique selon la revendication 5, **caractérisé en ce que** ladite unité de contrôle d'état d'équipement de port de sortie (133) inclut une unité de commande de connexion de circulation de port (134) adaptée pour commander ledit équipement de commutation de connexion optique (101) pour établir des connexions de ladite pluralité de ports d'entrée optiques (1_I, 2_I, ..., N_I) reliés audit équipement (r1, r2, ..., rN-n) avec ledit port de sortie optique, non relié audit équipement (r1, r2, ..., rN-n) et servant de port de contrôle de puissance optique, d'une façon circulante.

10. Appareil de commutation de connexion optique selon la revendication 9, **caractérisé en ce qu'**une pluralité de ports de contrôle de puissance optique (q, r, s) correspondant chacun audit port de contrôle de puissance optique sont prévus pour contrôler les informations de puissance optique sur lesdits ports d'entrée / sortie optiques (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O) dans ledit équipement de commutation de connexion optique (101) d'une façon en partage.

11. Appareil de commutation de connexion optique selon la revendication 4 ou 5, **caractérisé en ce qu'**un élément de réception de lumière est prévu dans ledit port de sortie optique (1_O, 2_O, ..., N_O) dudit équipement de commutation de connexion optique (101), et
ladite unité de contrôle d'état d'équipement (131) est construite comme une unité de contrôle d'état d'équipement de connexion de renversement de port (138) adaptée pour commander ledit équipement de commutation de connexion optique (101) pour établir un couplage direct entre ledit port d'entrée optique et ledit port de sortie optique dudit port d'entrée / sortie optique qui n'est pas relié audit équipement (r1, r2, ..., rN-n) de sorte que, lorsqu'une quantité de réception de lumière par ledit élément de réception de lumière (c1', c2', ..., cN') dudit port de sortie optique est employée en tant que lesdites informations de puissance optique, l'état de connexion, déconnexion ou communication dudit équipement est contrôlé en contrôlant une variation desdites informations de puissance optique.

12. Appareil de commutation de connexion optique selon la revendication 4 ou 5, **caractérisé en ce qu'**un élément de réception de lumière (c1', c2', ..., cN') est prévu dans ledit port de sortie optique (1_O, 2_O, ..., N_O) dudit équipement de commutation de connexion optique (101), et
ladite unité de contrôle d'état d'équipement (131) est construite comme une unité de contrôle d'état d'équipement de connexion de port (139) adaptée pour commander ledit équipement de commutation de connexion optique (101) pour établir un couplage direct entre ledit port d'entrée optique et ledit port de sortie optique desdits ports d'entrée / sortie optiques qui sont adjacents l'un à l'autre et qui ne sont pas reliés audit équipement (r1, r2, ..., rN-n) de sorte que, lorsqu'une quantité de réception de lumière par ledit élément de réception de lumière (c1', c2', ..., cN') dudit port de sortie optique est employée en tant que lesdites informations de puissance optique, l'état de connexion, déconnexion ou communication dudit équipement est contrôlé en contrôlant une variation desdites informations de puissance optique.

13. Appareil de commutation de connexion optique selon la revendication 4 ou 5, **caractérisé en ce que**, lorsqu'un desdits équipements est relié à deux desdits ports d'entrée / sortie de sorte qu'un est utilisé comme un port actif et l'autre est utilisé comme un port de rechange, ladite unité de commande de gestion (103) inclut une unité de commande de commutation actif / de rechange (137), lorsque ladite unité de contrôle d'état d'équipement (131) détecte une déconnexion optique sur ledit port actif, adaptée pour commander ledit équipement de commutation de connexion optique (101) pour commuter un port à utiliser pour ledit équipement audit port de rechange.

14. Appareil de commutation de connexion optique selon la revendication 2, **caractérisé en ce que** la pluralité d'unités d'émission / réception optiques (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) est reliée auxdits ports d'entrée / sortie optiques afin de correspondre à une pluralité de types d'interfaces de communication optique à fournir dans ledit équipement (r1, r2,..., rN-n), et
ladite unité de balayage d'interface (135) est adaptée pour commander ledit équipement de commutation de connexion optique (101) pour établir des connexions entre lesdits ports d'entrée / sortie optiques reliés à ladite pluralité d'unités d'émission / réception optiques (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) et le port d'entrée / sortie optique relié audit équipement (r1, r2, ..., rN-n) d'une façon circulante pour acquérir les informations sur ledit équipement (r1, r2, ..., rN-n) à l'aide desdites unités d'émission / réception optiques (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I).

15. Appareil de commutation de connexion optique selon la revendication 2, **caractérisé en ce que** ladite unité d'émission / réception optique (t1-O, t2_O, ..., tn_O, t1_I, t2_I, tn_I) est construite comme une unité d'émission / réception

optique traitant de multiples interfaces ayant une pluralité de types de fonctions de communication correspondant à une pluralité de types d'interfaces de communication optique à fournir dans ledit équipement (r1, r2, ..., rN-n), et ladite unité de balayage d'interface (135) est adaptée pour sélectionner et fixer lesdites fonctions de communication de ladite unité d'émission / réception optique (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) d'une façon circulante pour acquérir les informations sur ledit équipement (r1, r2, ..., rN-n), à l'aide de ladite unité d'émission / réception optique (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I).

16. Appareil de commutation de connexion optique selon la revendication 2, **caractérisé en ce qu'**un circuit de dérivation optique (c1, c2, ..., cN, c1', c2 ', ..., cN') est prévu en ce qui concerne l'un de ou les deux dudit port d'entrée optique (1_I, 2_I, ..., N_I) et dudit port de sortie (1_O, 2_O, ..., N_O) dans ledit équipement de commutation de connexion optique (101), et l'une des sorties dudit circuit de dérivation optique (c1, c2, ..., cN, c1', c2', ..., cN') est reliée en tant que lumière de signal principale audit équipement de commutation de connexion optique (101) tandis que l'autre est reliée en tant que lumière de commande de contrôle à celui-ci, et
ladite unité de commande de gestion (103) est adaptée pour commander ledit équipement de commutation de connexion optique (101) pour établir une connexion entre un port d'entrée / sortie optique relié à ladite unité d'émission / réception optique (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) et un port d'entrée / sortie optique relié à ladite lumière de commande de contrôle pour acquérir des informations sur ledit équipement (r1, r2, ..., rN-n) à partir de ladite lumière de commande de contrôle à l'aide de ladite unité d'émission / réception optique (t1_O, t2_O, ..., tn_O, t1_I, t2_I, ..., tn_I) et les gérer, et en outre contrôler des informations sur la puissance optique dudit port d'entrée / sortie optique (1_I, 2_I, ..., N_I, 1_O, 2_O, ..., N_O).

17. Appareil de commutation de connexion optique selon la revendication 16, **caractérisé en ce qu'**un circuit de dérivation optique de commande de contrôle (cc1, cc2, ..., ccN, cc1', cc2', ..., ccN') adapté pour diviser ladite lumière de commande de contrôle est prévu et une des sorties dudit circuit de dérivation optique de commande de contrôle (cc1, cc2, ..., ccN, cc1', cc2', ..., ccN') est reliée audit équipement de commutation de connexion optique (101), et ladite unité de commande de gestion (103) est adaptée pour contrôler l'autre sortie dudit circuit de dérivation optique de commande de contrôle (cc1, cc2, ..., ccN, cc1', cc2', ..., ccN') pour contrôler des informations sur la puissance optique dudit port d'entrée / sortie (1_I, 2_I, ..., N_I, 1_O, 2_O,..., N_O).

18. Appareil de commutation de connexion optique selon la revendication 2, caractérisé comme comprenant en outre :

une source de lumière (110-1, 110-2) reliée à l'un desdits ports d'entrée dudit équipement de commutation de connexion optique (101) ; et
un circuit de réception de lumière (102-1, 102-2) relié à l'un desdits ports de sortie dudit équipement de commutation de connexion optique (101),
ladite unité de commande de gestion (400) comprenant en outre une première unité de détection de trouble adaptée pour effectuer une détection d'un trouble dudit équipement de commutation de connexion optique (101) en contrôlant un état de réception de lumière dans ledit circuit de réception de lumière (102-1, 102-2) tout en commutant un état de connexion entre ledit port d'entrée relié à ladite source de lumière (110-1, 110-2) et ledit port de sortie relié audit circuit de réception de lumière (102-1, 102-2).

19. Appareil de commutation de connexion optique selon la revendication 2, **caractérisé en ce qu'**au moins ledit équipement de commutation de connexion optique (101) et ladite unité de commande de gestion (400) sont placés dans un état redondant, et une première source de lumière (110-1, 110-2) reliée à un desdits ports d'entrée d'un premier équipement de commutation de connexion optique (101A) et une seconde source de lumière (110-3, 110-4) reliée à un desdits ports d'entrée de l'autre équipement de commutation de connexion optique (101B) sont prévues de sorte qu'un port de sortie dudit premier équipement de commutation de connexion optique (101A) adapté pour sortir de la lumière à partir de ladite première source de lumière (110-1, 110-2) est relié à un port d'entrée autre que ledit port d'entrée relié à ladite seconde source de lumière (110-3, 110-4) de l'autre équipement de commutation de connexion optique (101B), et un port de sortie de l'autre équipement de commutation de connexion optique (101B) adapté pour sortir de la lumière à partir de ladite seconde source de lumière (110-3, 110-4) est relié à un port d'entrée autre que ledit port d'entrée relié à ladite première source de lumière (110-1, 110-2) dudit premier équipement de commutation de connexion optique (101A), et ladite unité de commande de gestion (400A, 400B) inclut en outre une seconde unité de détection de trouble adaptée pour effectuer la détection d'un trouble d'un desdits équipements de commutation de connexion optique (101A, 101B) en contrôlant une puissance de lumière de sortie provenant de chacun desdits ports de sortie dudit équipement de commutation de connexion optique (101A, 101B).

20. Appareil de commutation de connexion optique selon la revendication 2, **caractérisé en ce que**, quand un premier équipement est relié à deux desdits ports d'entrée / sortie pour en utiliser un comme port actif et l'autre comme port de rechange, ladite unité de commande de gestion (103) inclut :

une unité de stockage d'informations d'équipement (104) adaptée pour stocker une table d'informations d'identification d'équipement (600) dans laquelle des informations d'identification sur ledit équipement relié audit équipement de commutation de connexion optique (101) sont associées à des informations sur ledit port actif et ledit port de rechange ; et
une unité de commande de commutation actif/de rechange, quand une déconnexion optique sur ledit port actif est détectée, adaptée pour commander ledit équipement de commutation de connexion optique (101) sur la base de ladite table d'informations d'identification d'équipement (600) dans ladite unité de stockage d'informations d'équipement (104) pour effectuer la commutation depuis le port utilisé par l'équipement vers ledit port de rechange.

21. Appareil de commutation de connexion optique selon la revendication 2, **caractérisé en ce qu'**au moins ledit équipement de commutation de connexion optique (101) et ladite unité de commande de gestion (400) sont placés dans un état redondant, et
ladite unité de commande de gestion (400A, 400B) inclut :

une unité de stockage d'informations d'équipement (104) adaptée pour stocker une table d'informations d'identification d'équipement principale (600A) dans laquelle des informations d'identification sur un équipement relié à un équipement de commutation de connexion optique actif (101A) sont associées à des informations sur un port d'entrée / sortie dudit équipement de commutation de connexion optique actif (101A) et une table d'informations d'identification d'équipement secondaire (600B) dans laquelle des informations d'identification sur un équipement relié à un équipement de commutation de connexion optique de rechange (101B) sont associées à des informations sur un port d'entrée / sortie dudit équipement de commutation de connexion optique de rechange (101B) ; une unité de commande de commutation actif / de rechange, quand un trouble se produit dans ledit port d'entrée / sortie dudit équipement de commutation de connexion optique actif (101A) ou ledit équipement de commutation de connexion optique de travail (101A) lui-même, adaptée pour commander chacun des équipements de commutation de connexion optique (101A, 101B) sur la base de chacune desdites tables (600A, 600B) sur ledit équipement de commutation de connexion optique (101A) pour commuter le port utilisé par ledit équipement vers ledit port d'entrée / sortie dudit équipement de commutation de connexion optique de rechange (101B) ; et
une unité de mise à jour de synchronisation de table adaptée pour mettre à jour le contenu de chacune desdites tables (600A, 600B) dans ladite unité de commande de gestion (400A, 400B), à laquelle elle appartient, en synchronisme avec le contenu de chacune desdites tables (600A, 600B) dans l'autre unité de commande de gestion (400A, 400B).

22. Appareil de commutation de connexion optique selon la revendication 2, **caractérisé en ce qu'**au moins ledit équipement de commutation de connexion optique (101) est placé dans un état redondant, et
ladite unité de commande de gestion (103) inclut :

une unité de stockage d'informations d'équipement (104) adaptée pour stocker une table d'informations d'identification d'équipement principale (600A) dans laquelle des informations d'identification sur un équipement relié à un équipement de commutation de connexion optique actif (101A) sont associées à des informations sur un port d'entrée / sortie dudit équipement de commutation de connexion optique actif (101A) et une table secondaire d'informations d'identification d'équipement (600B) dans laquelle des informations d'identification sur un équipement relié à un équipement de commutation de connexion optique de rechange (101B) sont associées à des informations sur un port d'entrée / sortie dudit équipement de commutation de connexion optique de rechange (101B) ; et
une unité de commande de commutation actif / de rechange, lorsqu'un trouble se produit dans ledit port d'entrée / sortie de travail dudit équipement de commutation de connexion optique actif (101A) ou ledit équipement de commutation de connexion optique de travail (101A) lui-même, adaptée pour commander chacun desdits équipements de commutation de connexion optique (101A, 101B) sur la base de chacune desdites tables (600A, 600B) sur ledit équipement de commutation de connexion optique (101A) pour commuter le port utilisé par ledit équipement vers ledit port d'entrée / sortie dudit équipement de commutation de connexion optique de rechange (101B).

23. Appareil de commutation de connexion optique selon la revendication 22, **caractérisé en ce que** lesdits ports d'entrée / sortie desdits équipements de commutation de connexion optique (101A, 101B) sont pratiquement traités comme un port commun d'un équipement de connexion optique pour gérer le contenu desdites tables (600A, 600B) sous la forme d'une table (600) dans ladite unité de stockage d'informations d'équipement (104).

FIG. 1

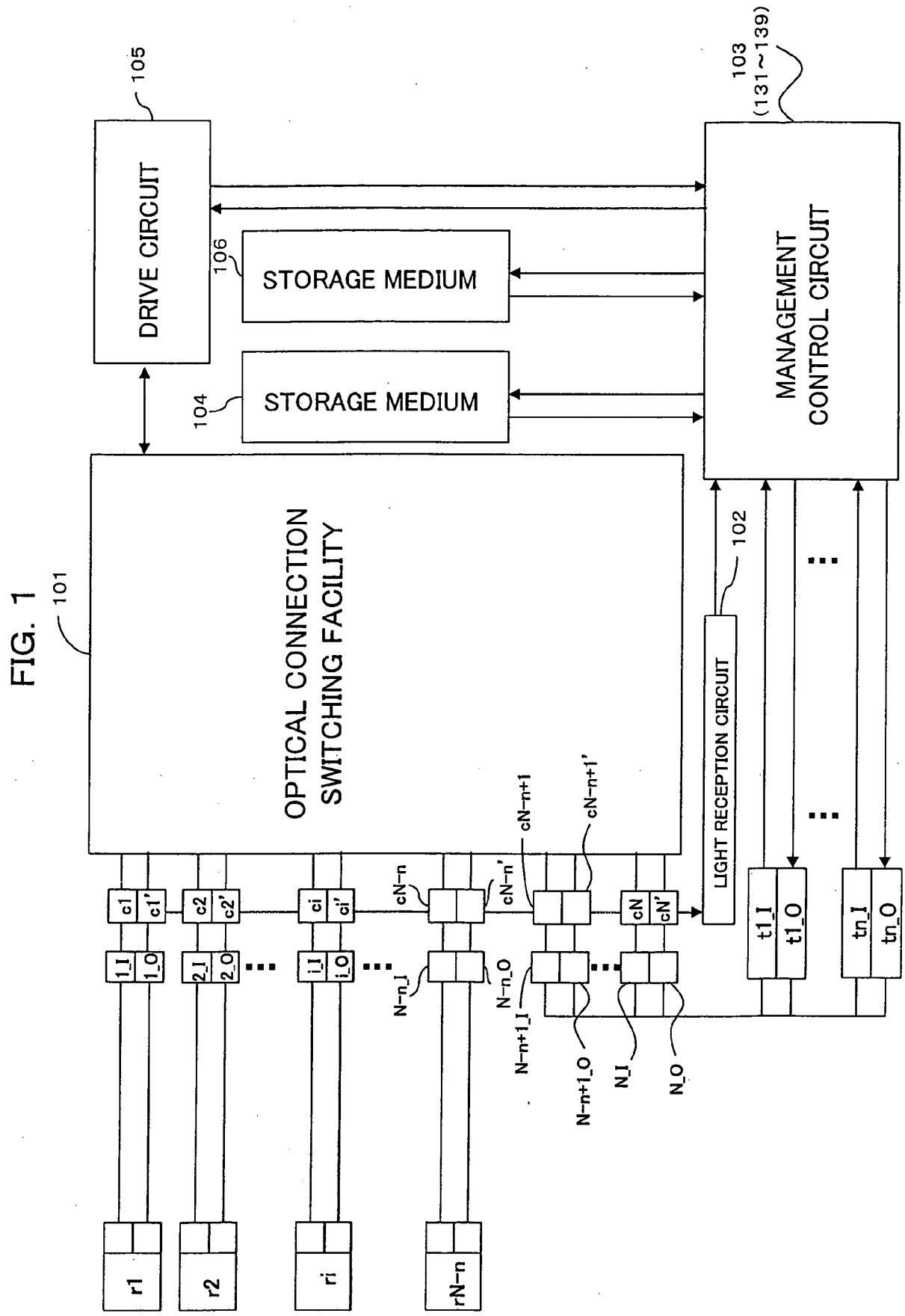

105
DRIVE CIRCUIT
106
STORAGE MEDIUM
104
STORAGE MEDIUM
103
(131~139)
MANAGEMENT CONTROL CIRCUIT
101
OPTICAL CONNECTION SWITCHING FACILITY
102
LIGHT RECEPTION CIRCUIT
c1
c1'
c2
c2'
ci
ci'
cN-n
cN-n'
cN-n+1
cN-n+1'
cN
cN'
1_I
1_O
2_I
2_O
i_I
i_O
N-n_I
N-n_O
N-n+1_I
N-n+1_O
N_I
N_O
t1_I
t1_O
tn_I
tn_O
r1
r2
ri
rN-n

FIG. 2

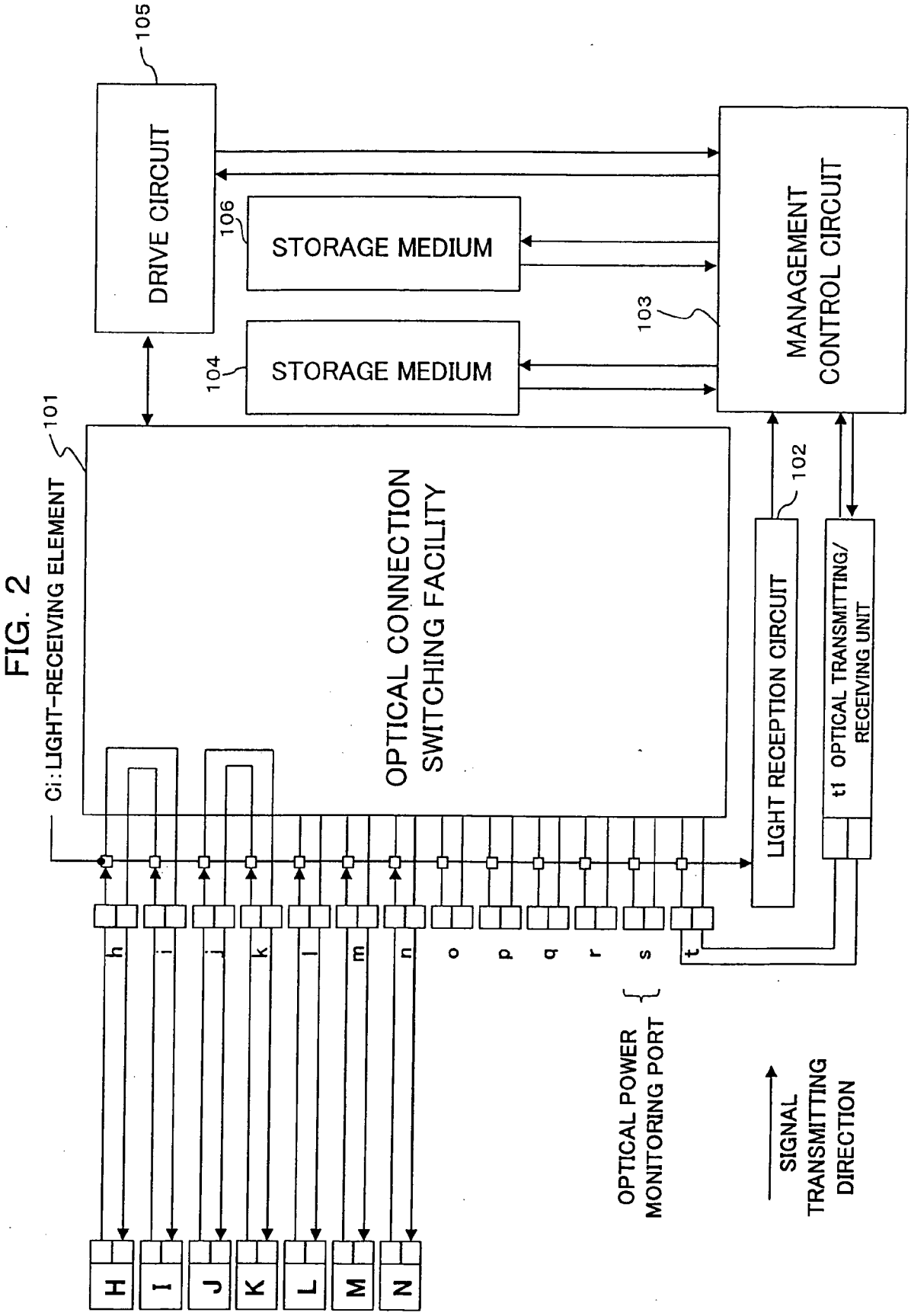

105
DRIVE CIRCUIT
106
STORAGE MEDIUM
104
STORAGE MEDIUM
103
MANAGEMENT CONTROL CIRCUIT
101
Ci: LIGHT-RECEIVING ELEMENT
OPTICAL CONNECTION SWITCHING FACILITY
102
LIGHT RECEPTION CIRCUIT
t1 OPTICAL TRANSMITTING/ RECEIVING UNIT
h
i
j
k
l
m
n
o
p
q
r
s
t
H
I
J
K
L
M
N
OPTICAL POWER MONITORING PORT
SIGNAL TRANSMITTING DIRECTION

FIG. 3

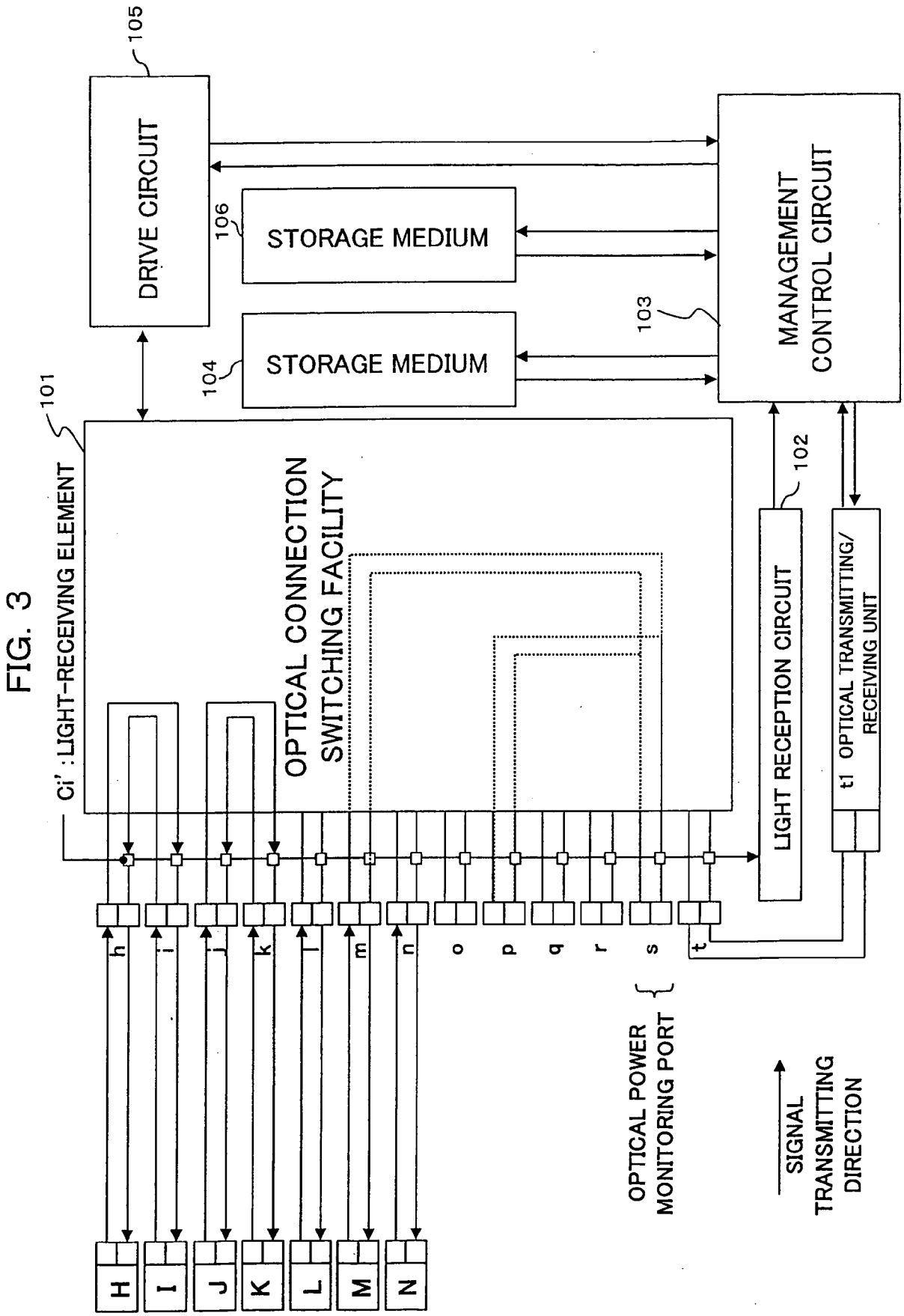

105
DRIVE CIRCUIT
106
STORAGE MEDIUM
104
STORAGE MEDIUM
103
MANAGEMENT CONTROL CIRCUIT
101
Ci' : LIGHT-RECEIVING ELEMENT
OPTICAL CONNECTION SWITCHING FACILITY
102
LIGHT RECEPTION CIRCUIT
t1 OPTICAL TRANSMITTING/ RECEIVING UNIT
h
i
j
k
l
m
n
o
p
q
r
s
t
H
I
J
K
L
M
N
OPTICAL POWER MONITORING PORT
SIGNAL TRANSMITTING DIRECTION

FIG. 4

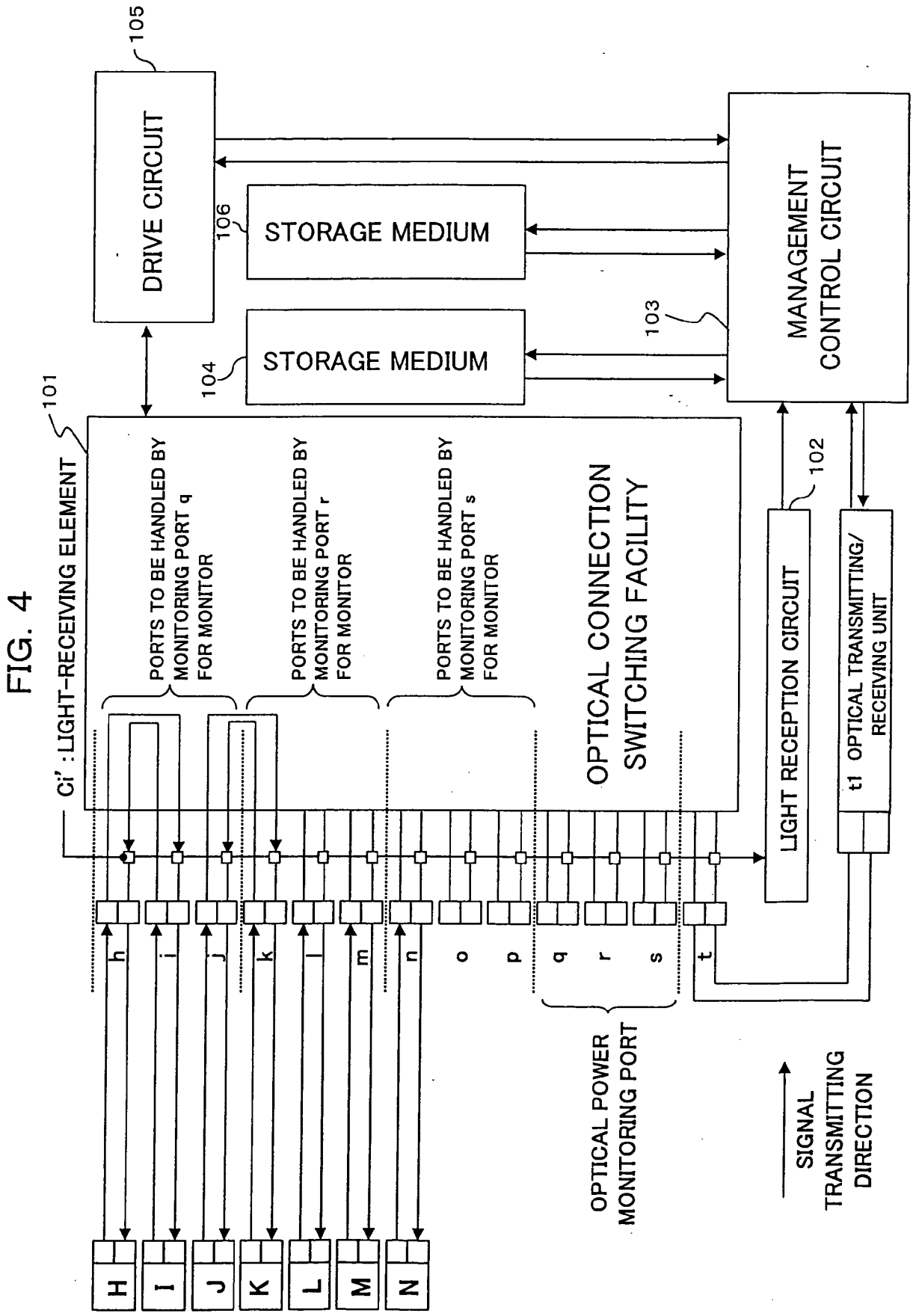

105
DRIVE CIRCUIT
106
STORAGE MEDIUM
104
STORAGE MEDIUM
103
MANAGEMENT CONTROL CIRCUIT
101
Ci' :LIGHT-RECEIVING ELEMENT
PORTS TO BE HANDLED BY MONITORING PORT q FOR MONITOR
PORTS TO BE HANDLED BY MONITORING PORT r FOR MONITOR
PORTS TO BE HANDLED BY MONITORING PORT s FOR MONITOR
OPTICAL CONNECTION SWITCHING FACILITY
102
LIGHT RECEPTION CIRCUIT
t1 OPTICAL TRANSMITTING/ RECEIVING UNIT
h
i
j
k
l
m
n
o
p
q
r
s
t
H
I
J
K
L
M
N
OPTICAL POWER MONITORING PORT
SIGNAL TRANSMITTING DIRECTION

FIG. 5

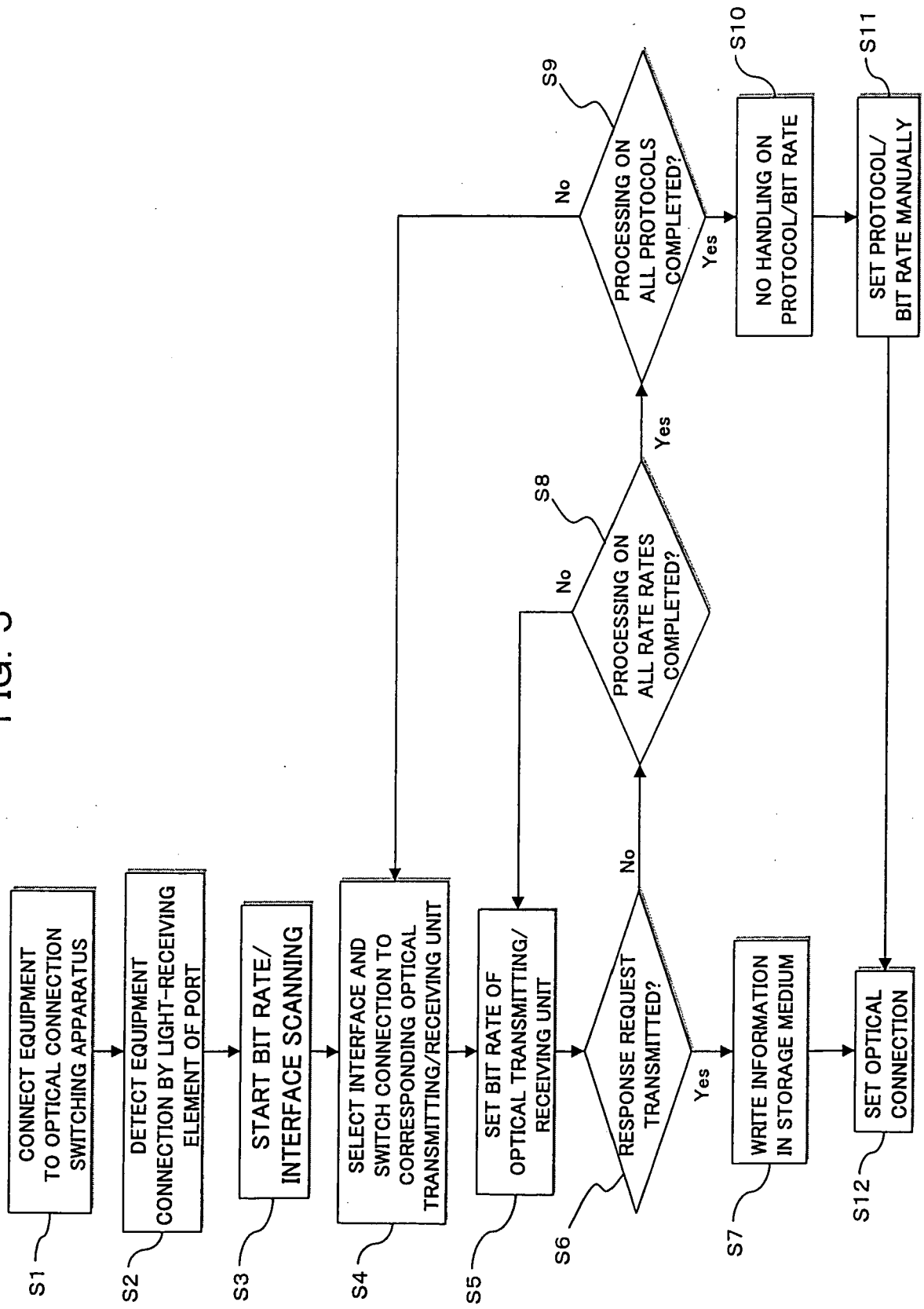

CONNECT EQUIPMENT TO OPTICAL CONNECTION SWITCHING APPARATUS
S1
DETECT EQUIPMENT CONNECTION BY LIGHT-RECEIVING ELEMENT OF PORT
S2
START BIT RATE/ INTERFACE SCANNING
S3
SELECT INTERFACE AND SWITCH CONNECTION TO CORRESPONDING OPTICAL TRANSMITTING/RECEIVING UNIT
S4
SET BIT RATE OF OPTICAL TRANSMITTING/ RECEIVING UNIT
S5
RESPONSE REQUEST TRANSMITTED?
S6
No
Yes
WRITE INFORMATION IN STORAGE MEDIUM
S7
PROCESSING ON ALL RATE RATES COMPLETED?
S8
No
Yes
PROCESSING ON ALL PROTOCOLS COMPLETED?
S9
No
Yes
NO HANDLING ON PROTOCOL/BIT RATE
S10
SET PROTOCOL/ BIT RATE MANUALLY
S11
SET OPTICAL CONNECTION
S12

FIG. 6

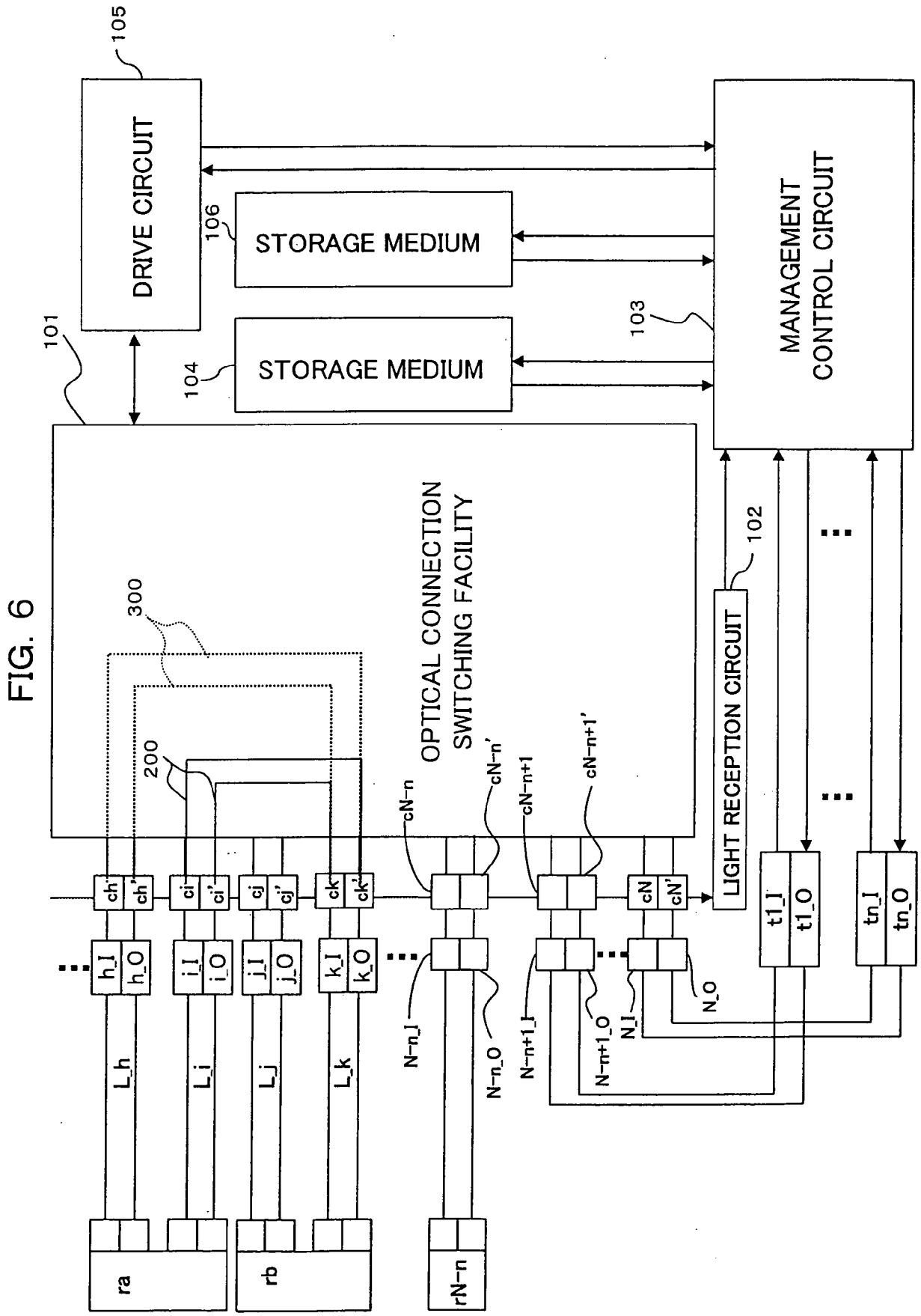

105
DRIVE CIRCUIT
106
STORAGE MEDIUM
104
STORAGE MEDIUM
103
MANAGEMENT CONTROL CIRCUIT
101
OPTICAL CONNECTION SWITCHING FACILITY
300
200
102
LIGHT RECEPTION CIRCUIT
ch
ch'
ci
ci'
cj
cj'
ck
ck'
cN-n
cN-n'
cN-n+1
cN-n+1'
cN
cN'
h_I
h_O
i_I
i_O
j_I
j_O
k_I
k_O
t1_I
t1_O
tn_I
tn_O
N-n_I
N-n_O
N-n+1_I
N-n+1_O
N_I
N_O
L_h
L_i
L_j
L_k
ra
rb
rN-n

FIG. 7

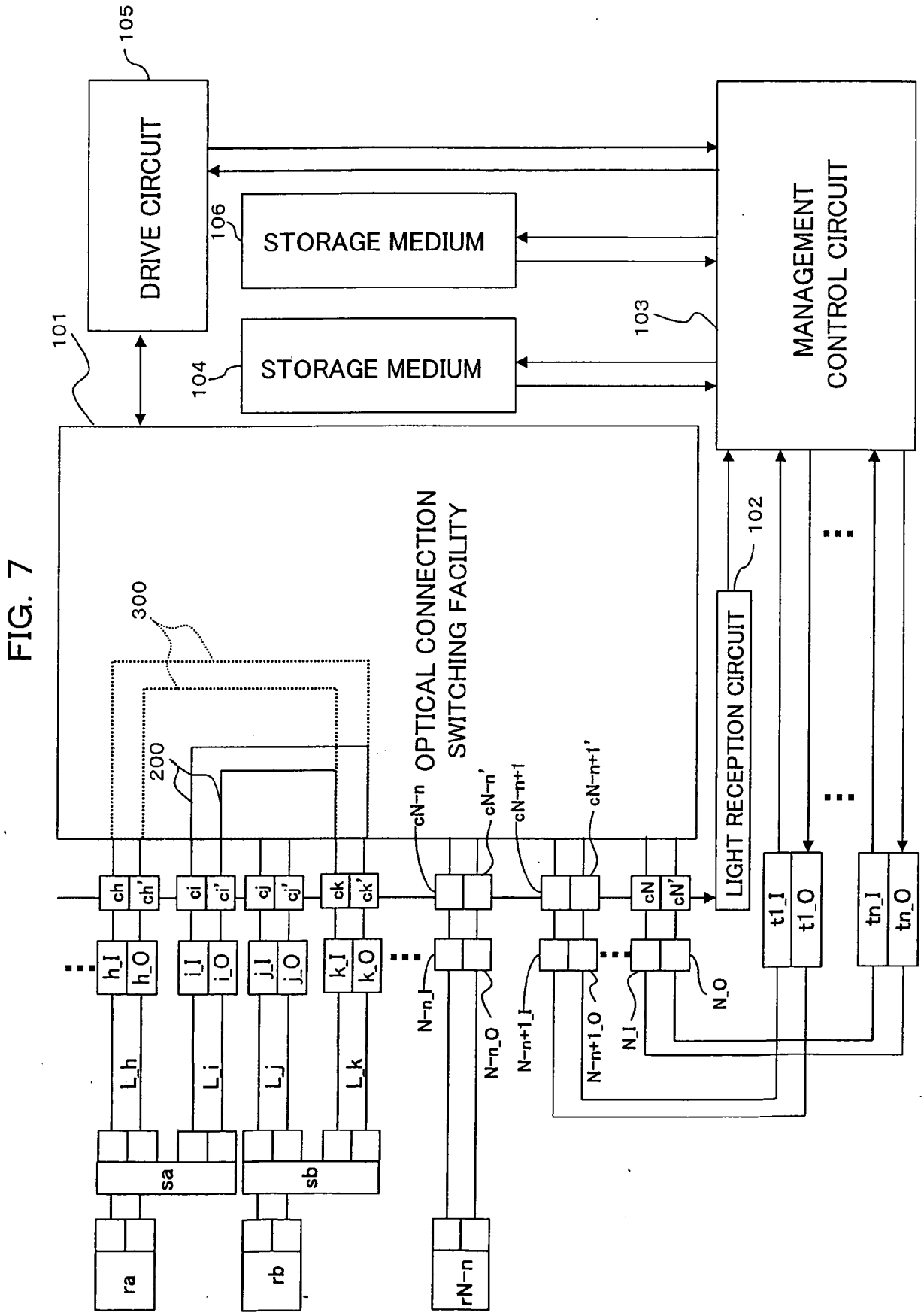

105
DRIVE CIRCUIT
106
STORAGE MEDIUM
104
STORAGE MEDIUM
103
MANAGEMENT CONTROL CIRCUIT
101
OPTICAL CONNECTION SWITCHING FACILITY
300
200
102
LIGHT RECEPTION CIRCUIT
ch
ch'
ci
ci'
cj
cj'
ck
ck'
cN-n
cN-n'
cN-n+1
cN-n+1'
cN
cN'
h_I
h_O
i_I
i_O
j_I
j_O
k_I
k_O
N-n_I
N-n_O
N-n+1_I
N-n+1_O
N_I
N_O
t1_I
t1_O
tn_I
tn_O
L_h
L_i
L_j
L_k
sa
sb
ra
rb
rN-n

FIG. 8

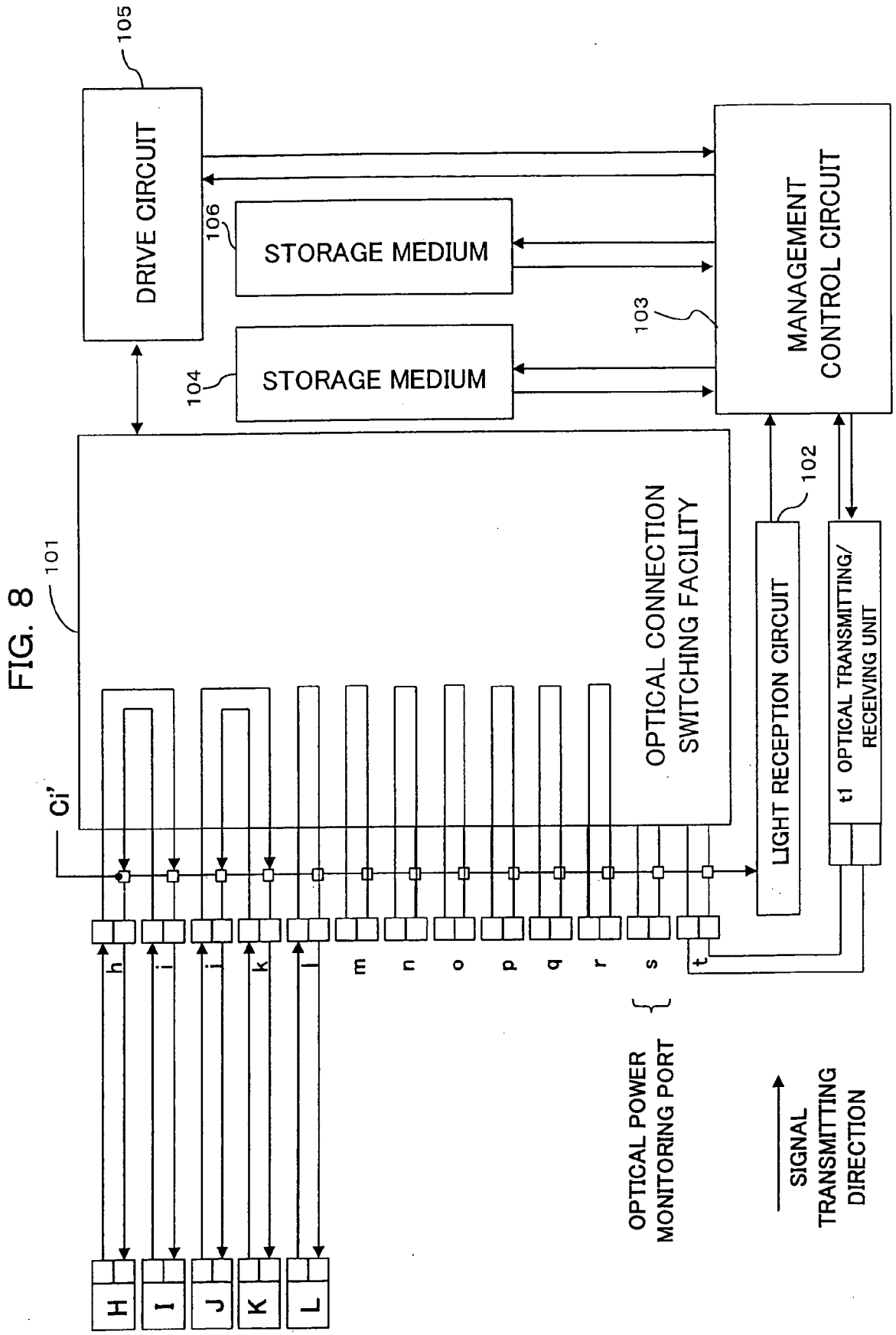

105
DRIVE CIRCUIT
106
STORAGE MEDIUM
104
STORAGE MEDIUM
103
MANAGEMENT CONTROL CIRCUIT
101
OPTICAL CONNECTION SWITCHING FACILITY
102
LIGHT RECEPTION CIRCUIT
t1 OPTICAL TRANSMITTING/ RECEIVING UNIT
Ci'
h
i
j
k
l
m
n
o
p
q
r
s
t
H
I
J
K
L
OPTICAL POWER MONITORING PORT
SIGNAL TRANSMITTING DIRECTION

FIG. 9

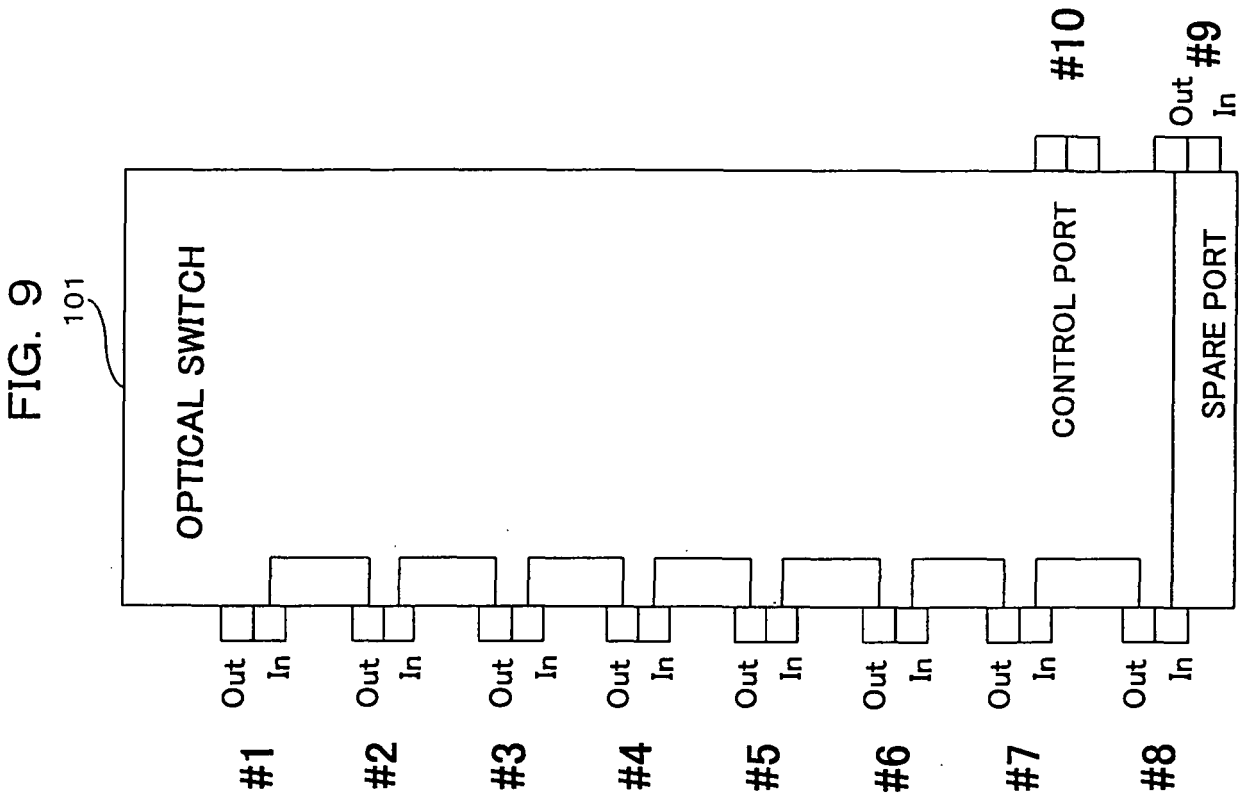

101
OPTICAL SWITCH
CONTROL PORT
SPARE PORT
#10
#9
Out
In
#1
#2
#3
#4
#5
#6
#7
#8
Out
In

FIG. 10(A)

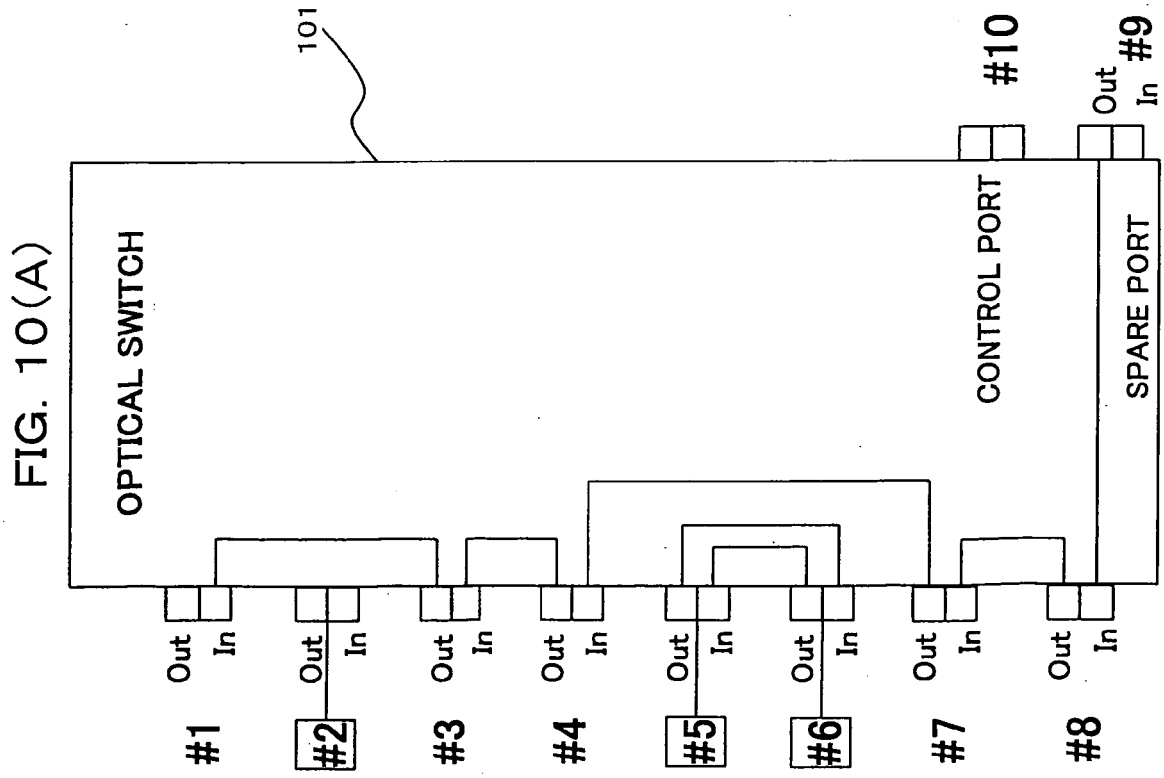


FIG. 10(B)

107

Port	EQUIPMENT CONNECTION	IN-SERVICE	INPUT CONNECTION PARTY (MONITOR POSITION)
1	NO OCCURRENCE	NO	3
2	OCCURRENCE	NO	—
3	NO OCCURRENCE	NO	4
4	NO OCCURRENCE	NO	7
5	OCCURRENCE	YES	6
6	OCCURRENCE	YES	5
7	NO OCCURRENCE	NO	8
8	NO OCCURRENCE	NO	9(SPARE)

FIG. 11(A)

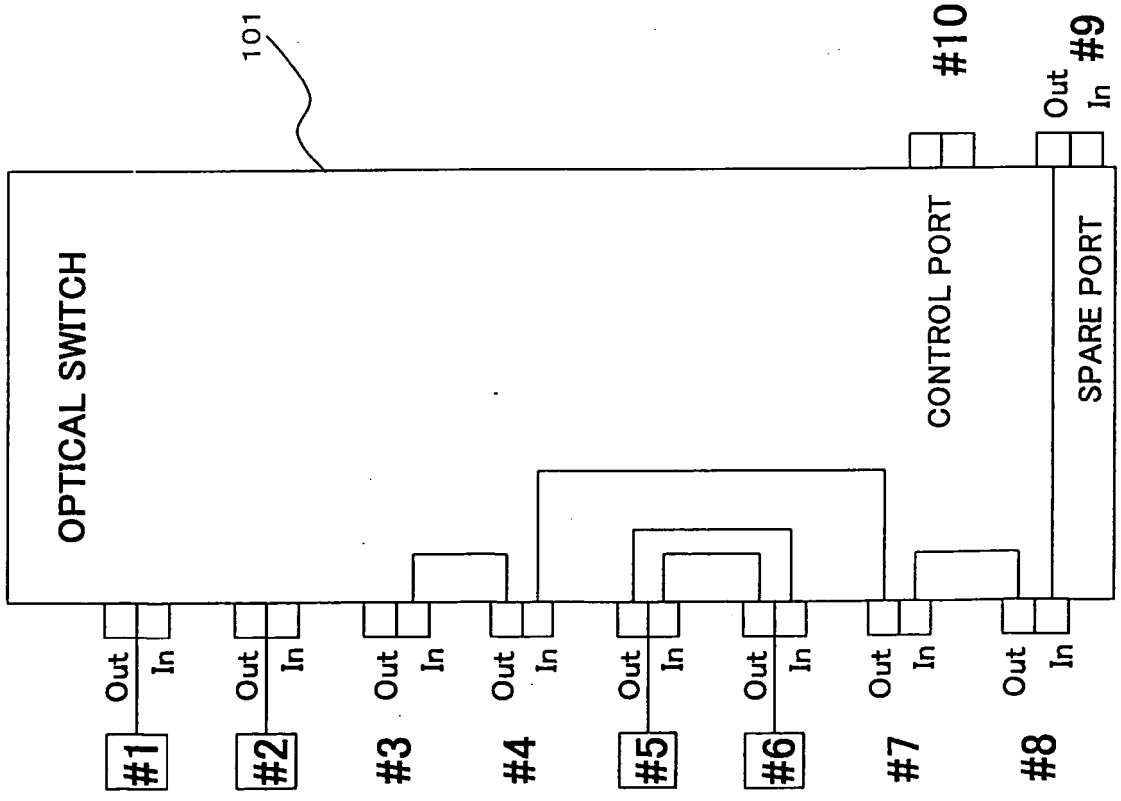


FIG. 11(B)

107

Port	EQUIPMENT CONNECTION	IN-SERVICE	INPUT CONNECTION PARTY (MONITOR POSITION)
1	1	0	—
2	1	0	—
3	0	0	4
4	0	0	7
5	1	6	6
6	1	5	5
7	0	0	8
8	0	0	9(SPARE)

FIG. 12(A)

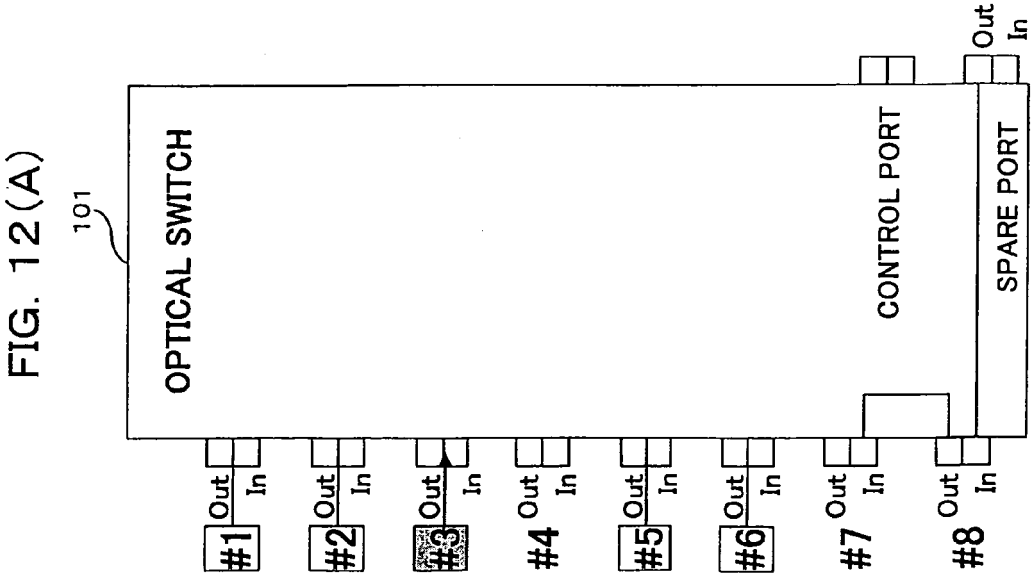


FIG. 12(B)

108

Port	Power [dBm]
1	-6
2	-8
3	-40
4	-40
5	-6
6	-7

108

Port	Power [dBm]
1	-6
2	-8
3	-8
4	-40
5	-6
6	-7

FIG. 12(C)

107

Port	EQUIP-MENT CONN-ECTION	IN-SERVICE	INPUT CONNECTION PARTY (MONITOR POSITION)
1	1	0	--
2	1	0	--
3	0	0	4
4	0	0	7
5	1	6	6
6	1	5	5
7	0	0	8
8	0	0	9(SPARE)

107

Port	EQUIP-MENT CONN-ECTION	IN-SERVICE	INPUT CONNECTION PARTY (MONITOR POSITION)
1	1	0	--
2	1	0	--
3	1	0	4
4	0	0	7
5	1	6	6
6	1	5	5
7	0	0	8
8	0	0	9(SPARE)

FIG. 13

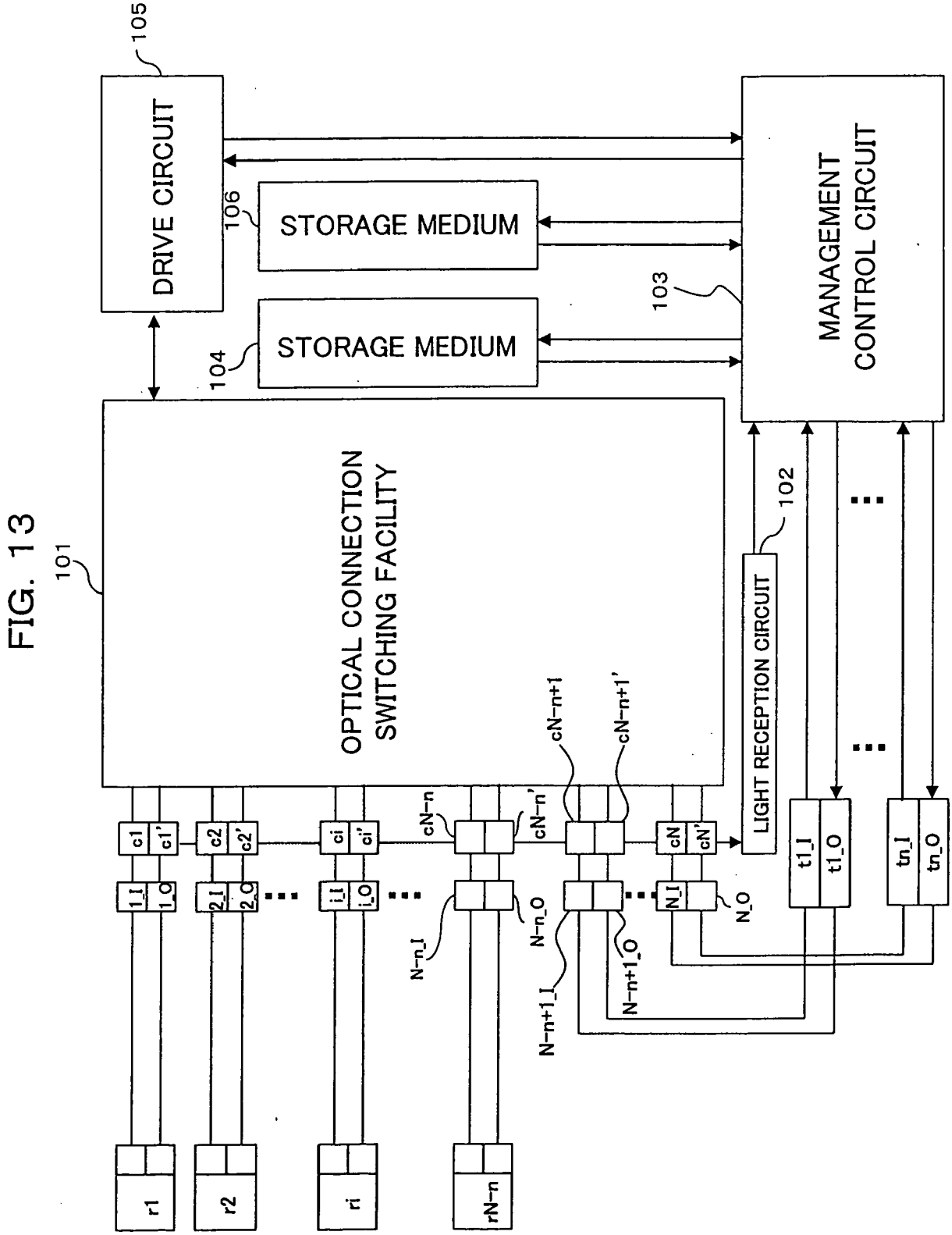

105
DRIVE CIRCUIT
106
STORAGE MEDIUM
104
STORAGE MEDIUM
103
MANAGEMENT CONTROL CIRCUIT
101
OPTICAL CONNECTION SWITCHING FACILITY
102
LIGHT RECEPTION CIRCUIT
c1
c1'
c2
c2'
ci
ci'
cN-n
cN-n'
cN-n+1
cN-n+1'
cN
cN'
1_I
1_O
2_I
2_O
i_I
i_O
N-n_I
N-n_O
N-n+1_I
N-n+1_O
N_I
N_O
t1_I
t1_O
tn_I
tn_O
r1
r2
ri
rN-n

FIG. 14

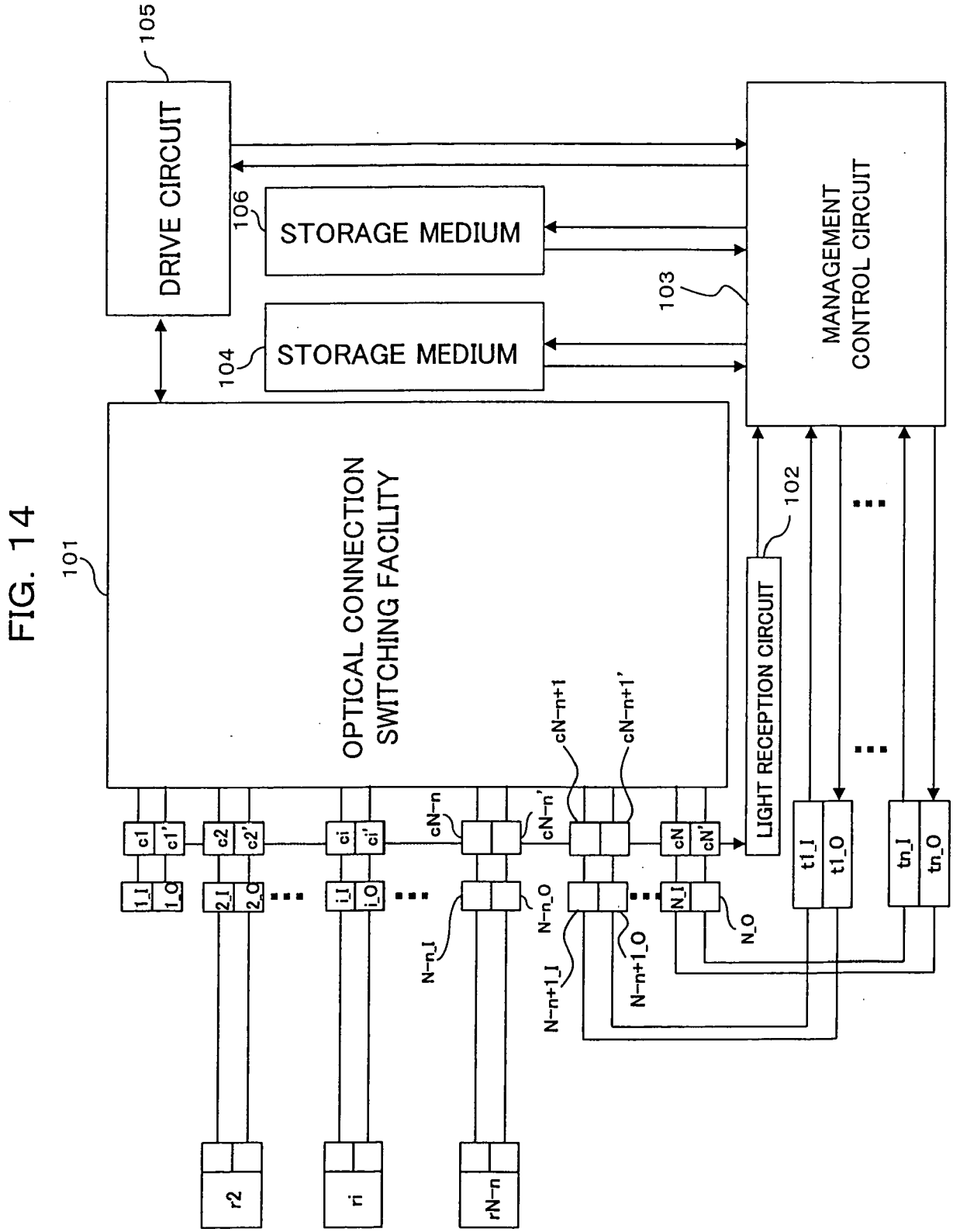

105
DRIVE CIRCUIT
106
STORAGE MEDIUM
104
STORAGE MEDIUM
103
MANAGEMENT CONTROL CIRCUIT
101
OPTICAL CONNECTION SWITCHING FACILITY
102
LIGHT RECEPTION CIRCUIT
c1
c1'
c2
c2'
ci
ci'
cN-n
cN-n'
cN-n+1
cN-n+1'
cN
cN'
1_I
1_O
2_I
2_O
i_I
i_O
N-n_I
N-n_O
N-n+1_I
N-n+1_O
N_I
N_O
t1_I
t1_O
tn_I
tn_O
r2
ri
rN-n

FIG. 15

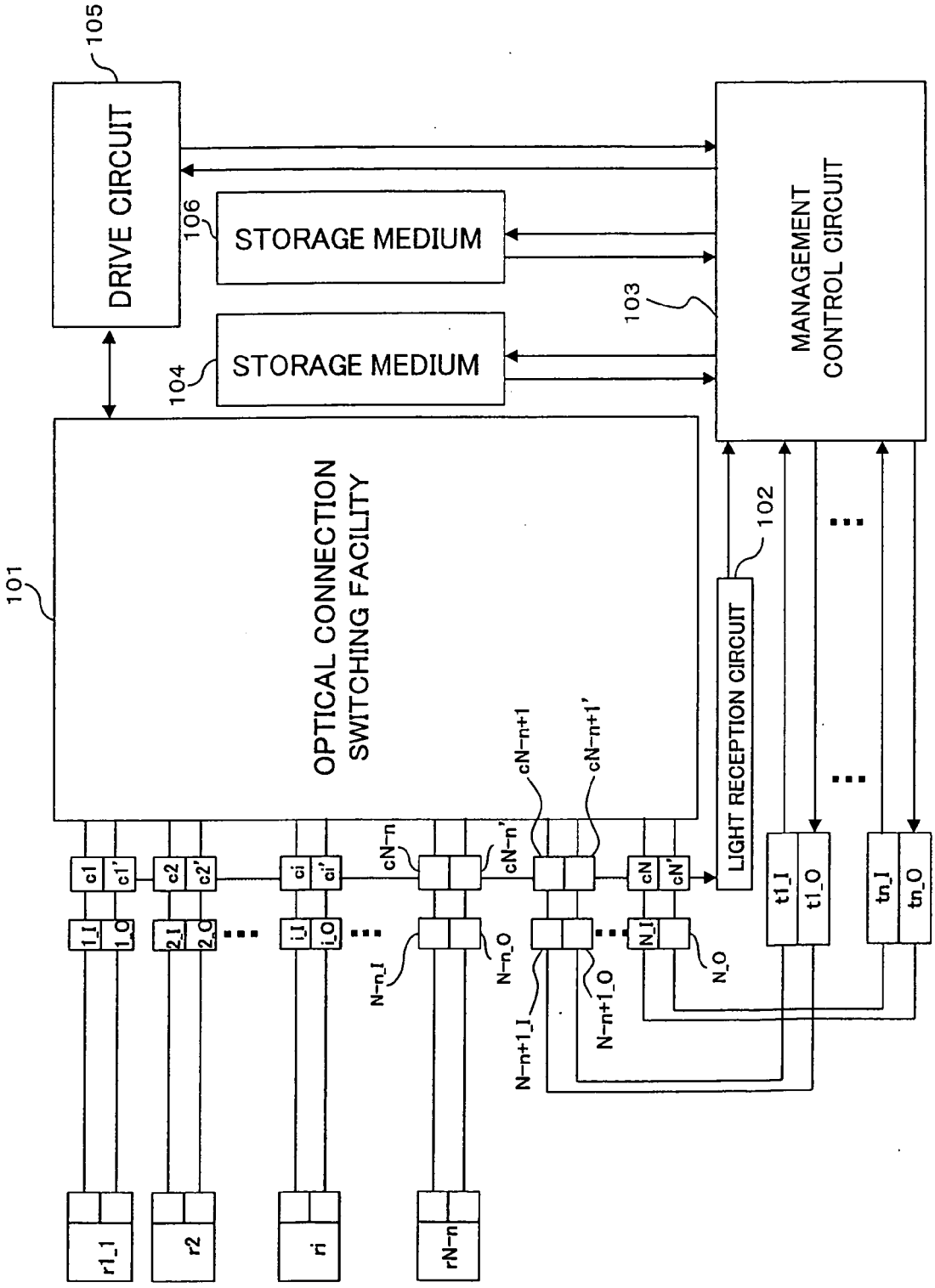

105
DRIVE CIRCUIT
106
STORAGE MEDIUM
104
STORAGE MEDIUM
103
MANAGEMENT CONTROL CIRCUIT
101
OPTICAL CONNECTION SWITCHING FACILITY
102
LIGHT REFLECTION CIRCUIT
c1
c1'
c2
c2'
ci
ci'
cN-n
cN-n'
cN-n+1
cN-n+1'
cN
cN'
t1_I
t1_O
tn_I
tn_O
1_I
1_O
2_I
2_O
i_I
i_O
N-n_I
N-n_O
N-n+1_I
N-n+1_O
N_I
N_O
r1_1
r2
ri
rN-n

FIG. 16

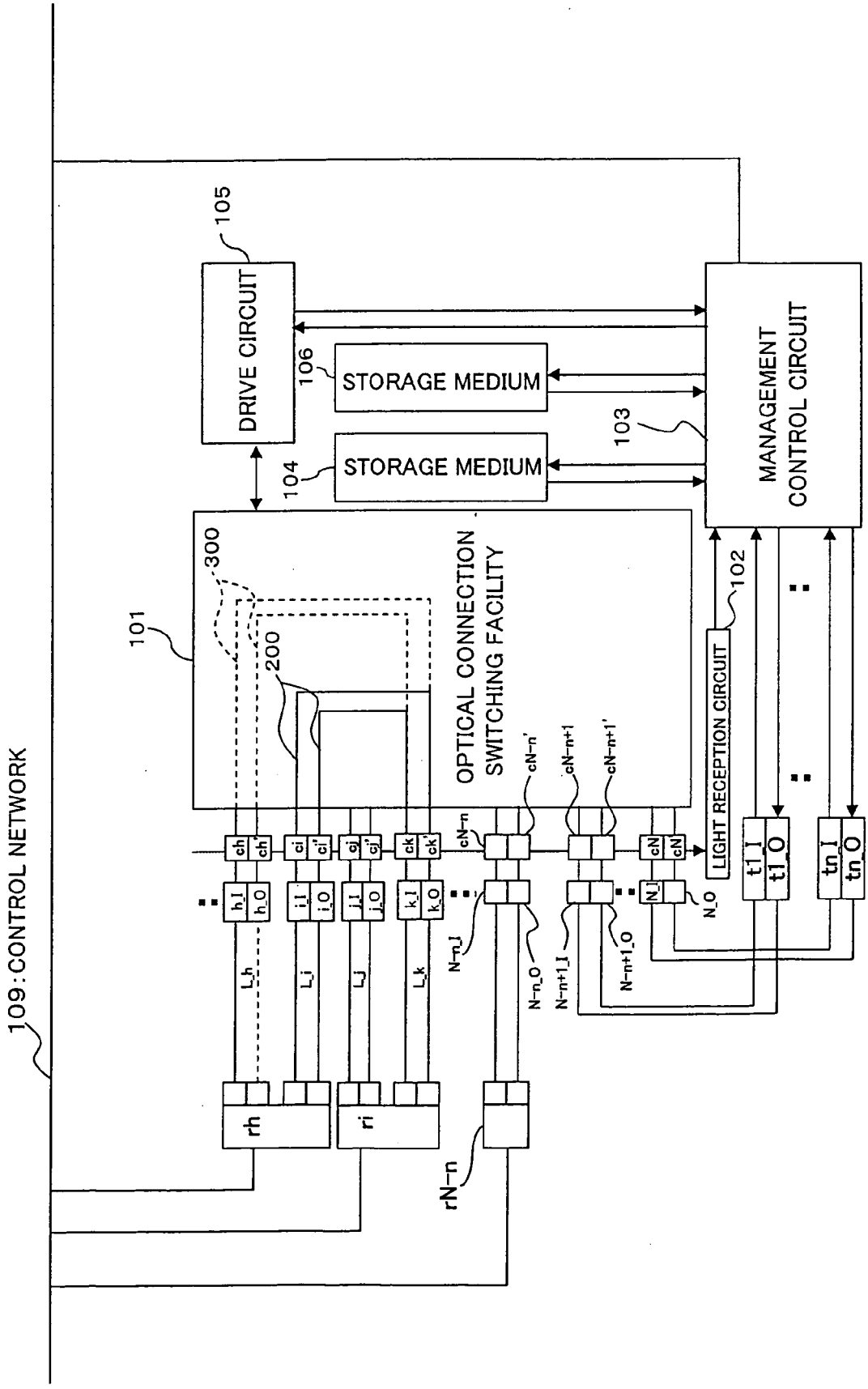

109:CONTROL NETWORK
105
DRIVE CIRCUIT
106
STORAGE MEDIUM
104
STORAGE MEDIUM
103
MANAGEMENT CONTROL CIRCUIT
300
101
200
OPTICAL CONNECTION SWITCHING FACILITY
102
LIGHT RECEPTION CIRCUIT
cN-n'
cN-n+1
cN-n+1'
cN-n
cN
N_I
N_O
t1_I
t1_O
tn_I
tn_O
h_I
h_O
i_I
i_O
j_I
j_O
k_I
k_O
L_h
L_i
L_j
L_k
N-n_I
N-n_O
N-n+1_I
N-n+1_O
rh
ri
rN-n

FIG. 17

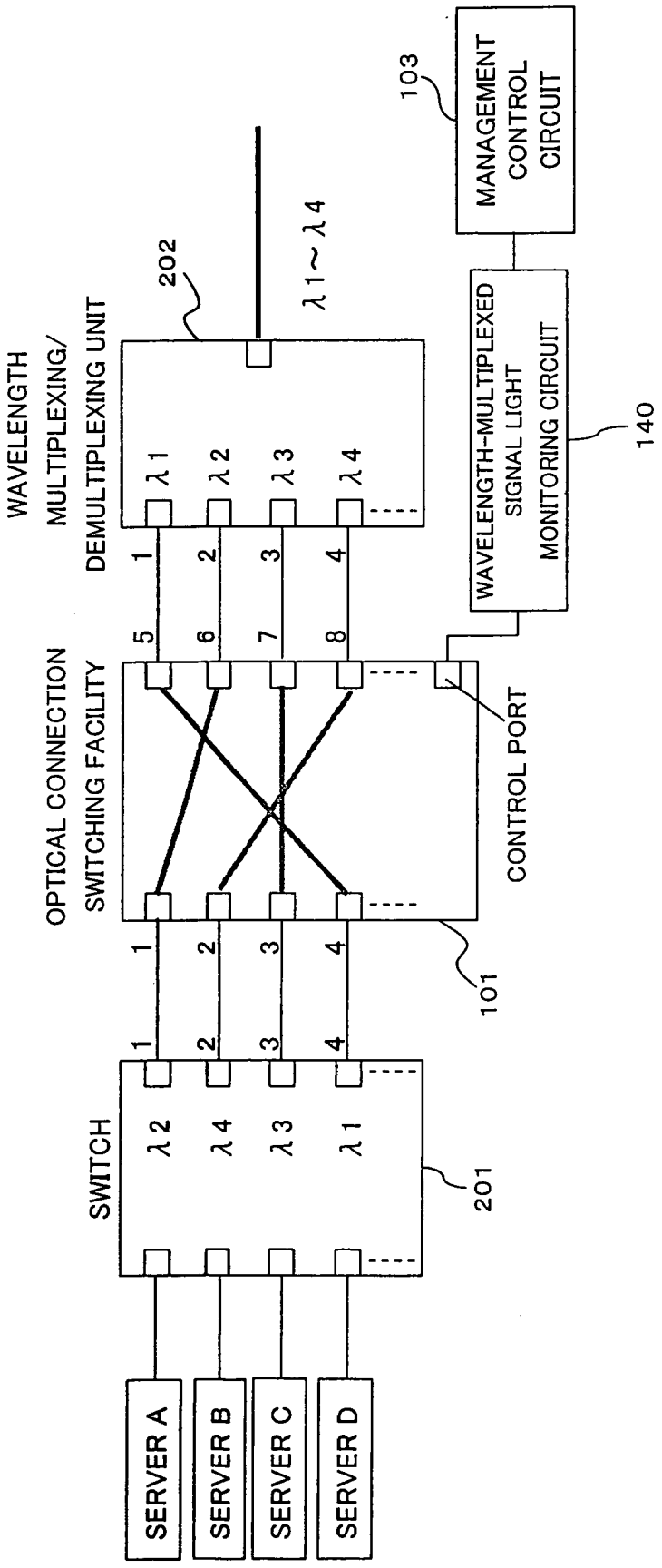

SERVER A
SERVER B
SERVER C
SERVER D
SWITCH
λ2
λ4
λ3
λ1
201
1
2
3
4
OPTICAL CONNECTION SWITCHING FACILITY
101
CONTROL PORT
5
6
7
8
WAVELENGTH MULTIPLEXING/ DEMULTIPLEXING UNIT
202
λ1
λ2
λ3
λ4
λ1～λ4
WAVELENGTH-MULTIPLEXED SIGNAL LIGHT MONITORING CIRCUIT
140
MANAGEMENT CONTROL CIRCUIT
103

FIG. 18

PORT NUMBER OF OPTICAL CONNECTION SWITCHING APPARATUS	PORT NUMBER OF CONNECTION DESTINATION AFTER PASSING THROUGH OPTICAL CONNECTION SWITCHING APPARATUS	CONNECTION EQUIPMENT	PORT NUMBER IN CONNECTION EQUIPMENT	TRANSMITTABLE WAVELENGTH OF EACH PORT
1	6	SWITCH A	1	λ2
2	8	SWITCH A	2	λ4
3	7	SWITCH A	3	λ3
4	5	SWITCH A	4	λ1
5	4	WAVELENGTH MULTIPLEXING/ DEMULTIPLEXING UNIT	1	λ1
6	1	WAVELENGTH MULTIPLEXING/ DEMULTIPLEXING UNIT	2	λ2
7	3	WAVELENGTH MULTIPLEXING/ DEMULTIPLEXING UNIT	3	λ3
8	2	WAVELENGTH MULTIPLEXING/ DEMULTIPLEXING UNIT	4	λ4

FIG. 19

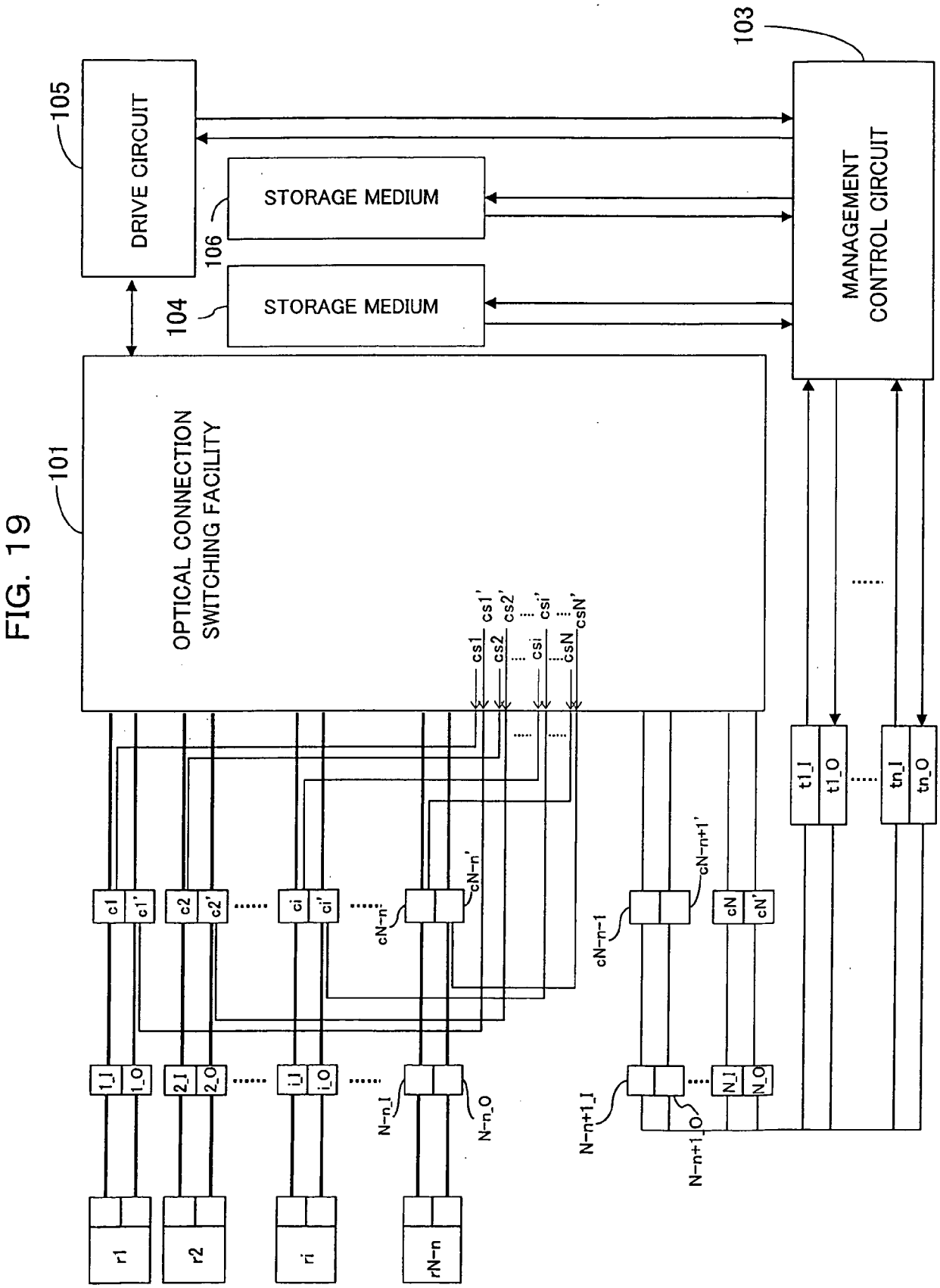

103
105
DRIVE CIRCUIT
STORAGE MEDIUM
106
STORAGE MEDIUM
104
MANAGEMENT CONTROL CIRCUIT
101
OPTICAL CONNECTION SWITCHING FACILITY
cs1
cs1'
cs2
cs2'
csi
csi'
csN
csN'
t1_I
t1_O
tn_I
tn_O
c1
c1'
c2
c2'
ci
ci'
cN-n
cN-n'
cN-n-1
cN-n+1'
cN
cN'
1_I
1_O
2_I
2_O
i_I
i_O
N-n_I
N-n_O
N-n+1_I
N-n+1_O
N_I
N_O
r1
r2
ri
rN-n

FIG. 20

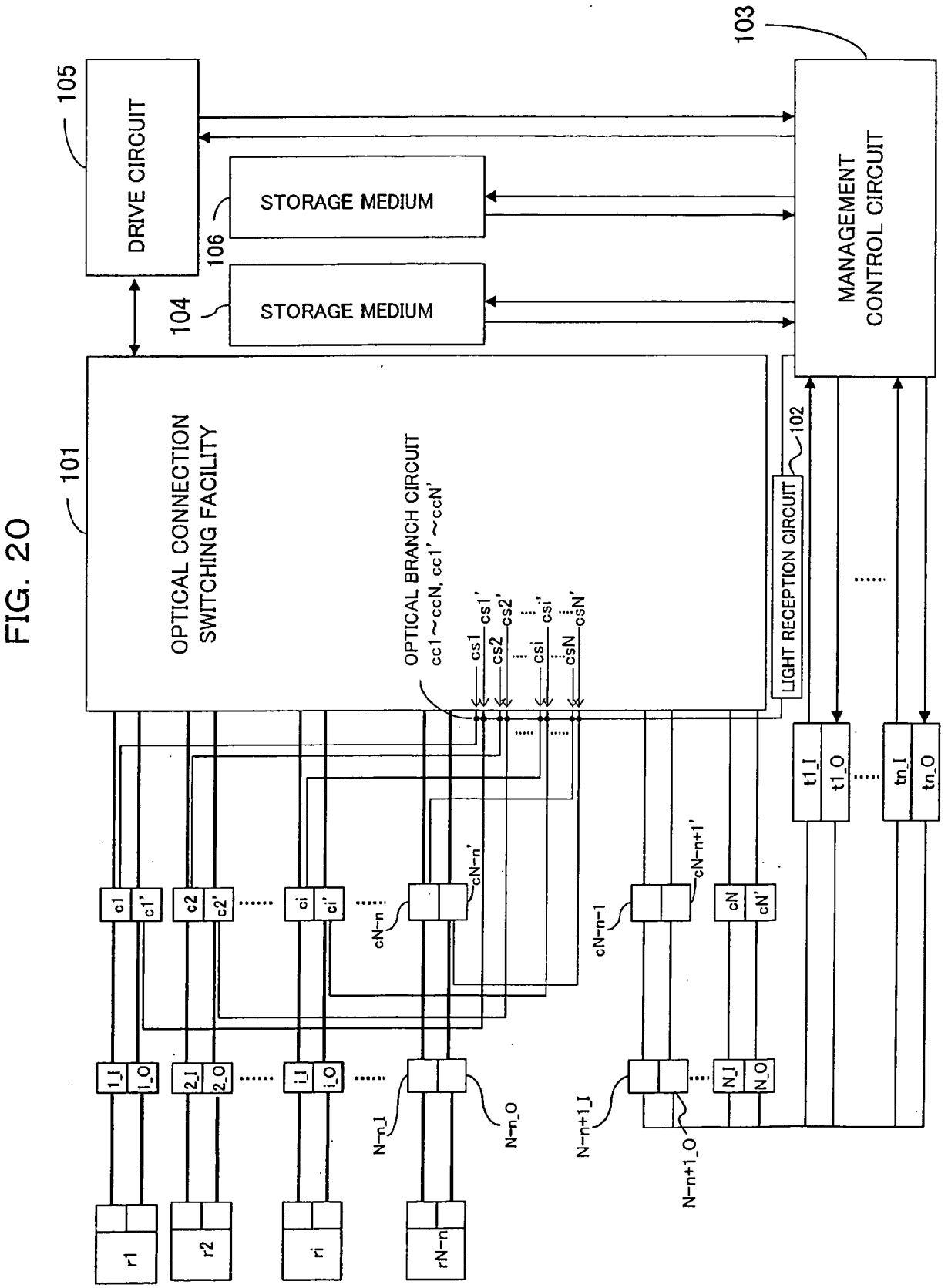

103
105
DRIVE CIRCUIT
STORAGE MEDIUM
106
STORAGE MEDIUM
104
MANAGEMENT CONTROL CIRCUIT
101
OPTICAL CONNECTION SWITCHING FACILITY
OPTICAL BRANCH CIRCUIT
cc1~ccN, cc1'~ccN'
LIGHT RECEPTION CIRCUIT
102
cs1
cs1'
cs2
cs2'
csi
csi'
csN
csN'
t1_I
t1_O
tn_I
tn_O
c1
c1'
c2
c2'
ci
ci'
cN-n
cN-n'
cN-n+1
cN-n+1'
cN
cN'
1_I
1_O
2_I
2_O
i_I
i_O
N_I
N_O
N-n_I
N-n_O
N-n+1_I
N-n+1_O
r1
r2
ri
rN-n

FIG. 21

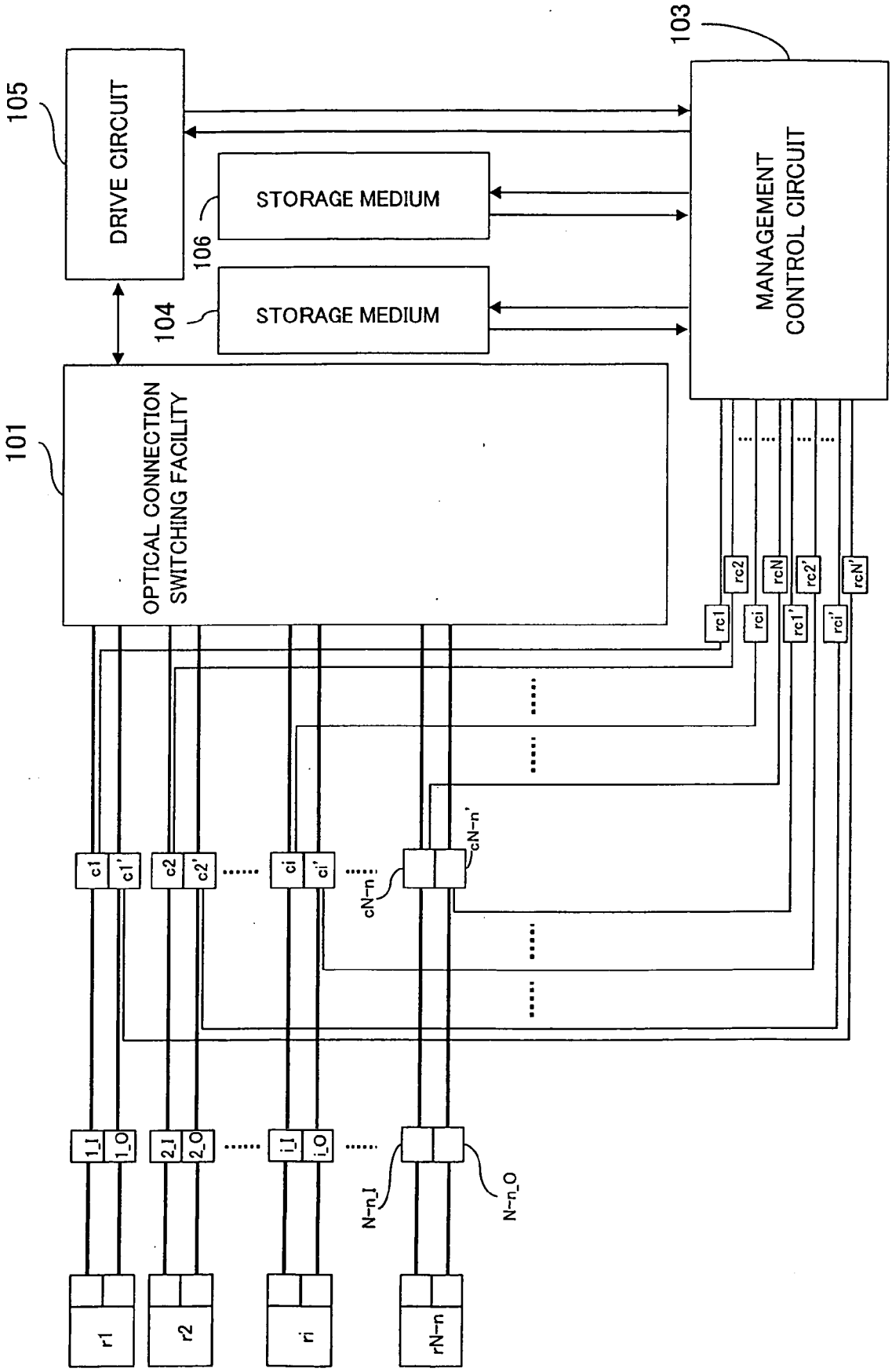

103
105
DRIVE CIRCUIT
STORAGE MEDIUM
106
STORAGE MEDIUM
104
MANAGEMENT CONTROL CIRCUIT
101
OPTICAL CONNECTION SWITCHING FACILITY
rc2
rcN
rc2'
rcN'
rc1
rci
rc1'
rci'
c1
c1'
c2
c2'
ci
ci'
cN-n
cN-n'
1_I
1_O
2_I
2_O
i_I
i_O
N-n_I
N-n_O
r1
r2
ri
rN-n

FIG. 22

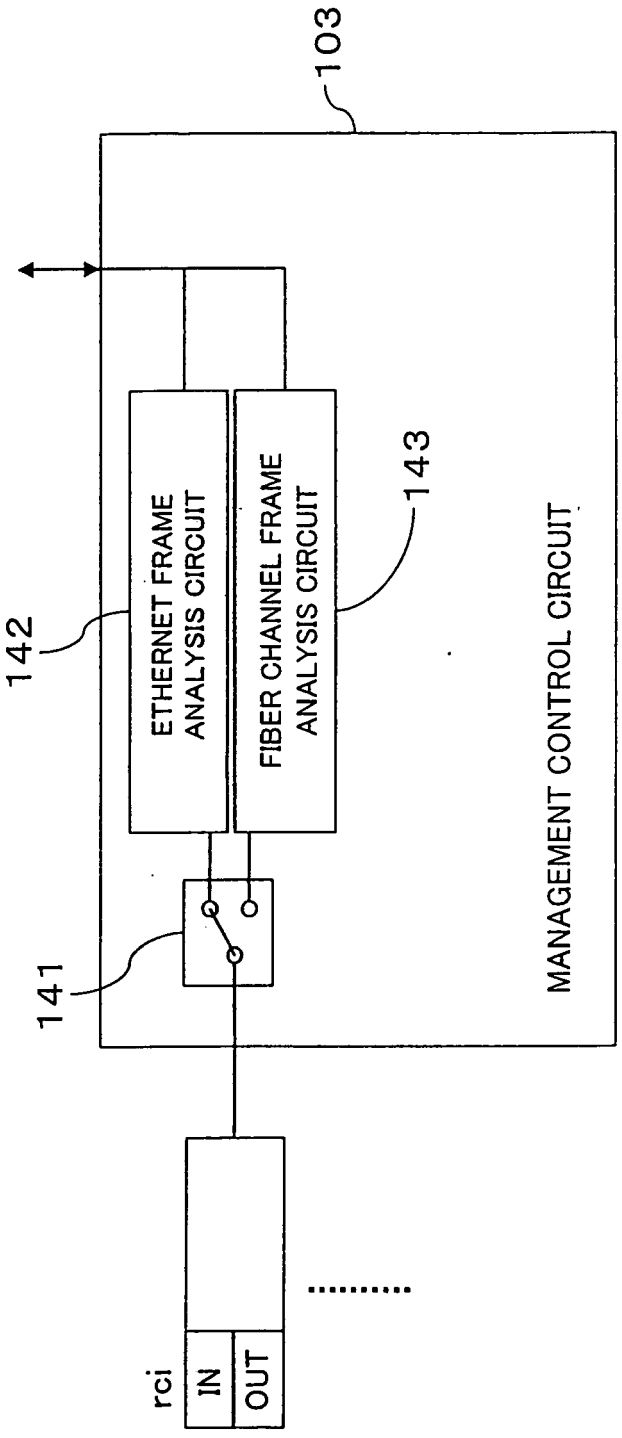

103
142
ETHERNET FRAME ANALYSIS CIRCUIT
143
FIBER CHANNEL FRAME ANALYSIS CIRCUIT
MANAGEMENT CONTROL CIRCUIT
141
rci
IN
OUT

FIG. 23

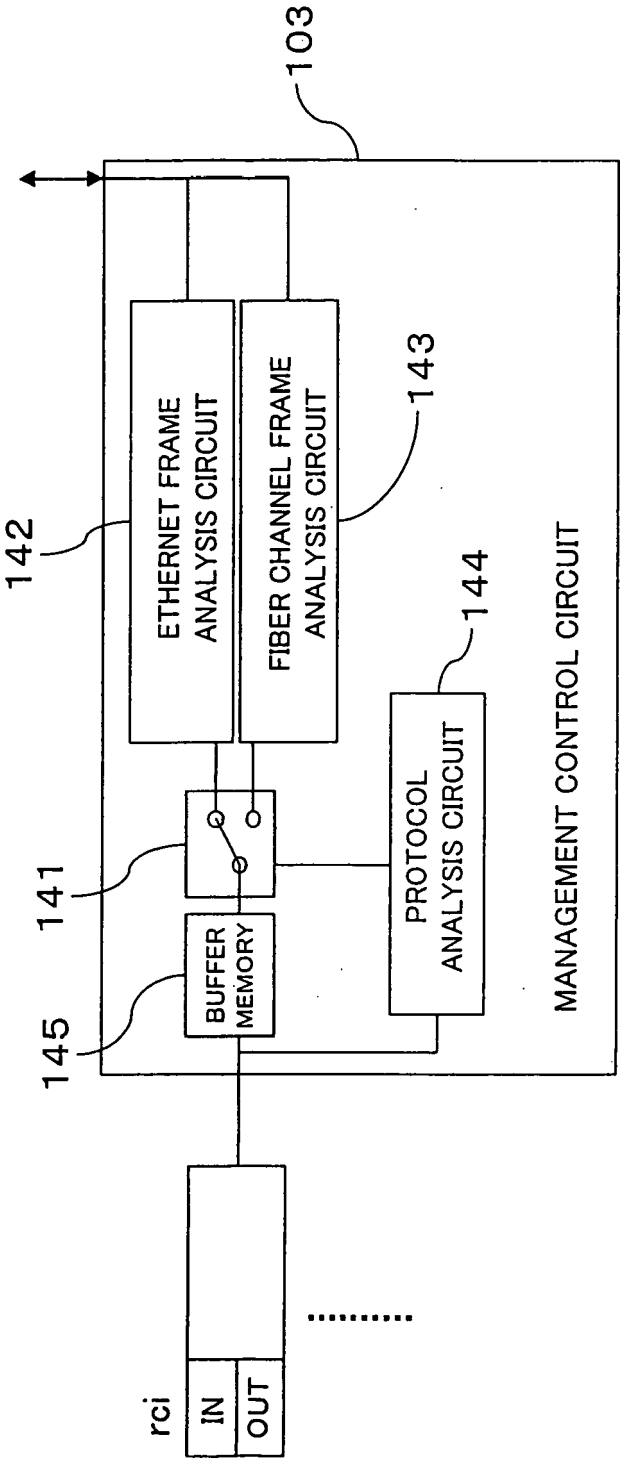

103
142
ETHERNET FRAME ANALYSIS CIRCUIT
FIBER CHANNEL FRAME ANALYSIS CIRCUIT
143
144
PROTOCOL ANALYSIS CIRCUIT
MANAGEMENT CONTROL CIRCUIT
141
145
BUFFER MEMORY
rci
IN
OUT

FIG. 24

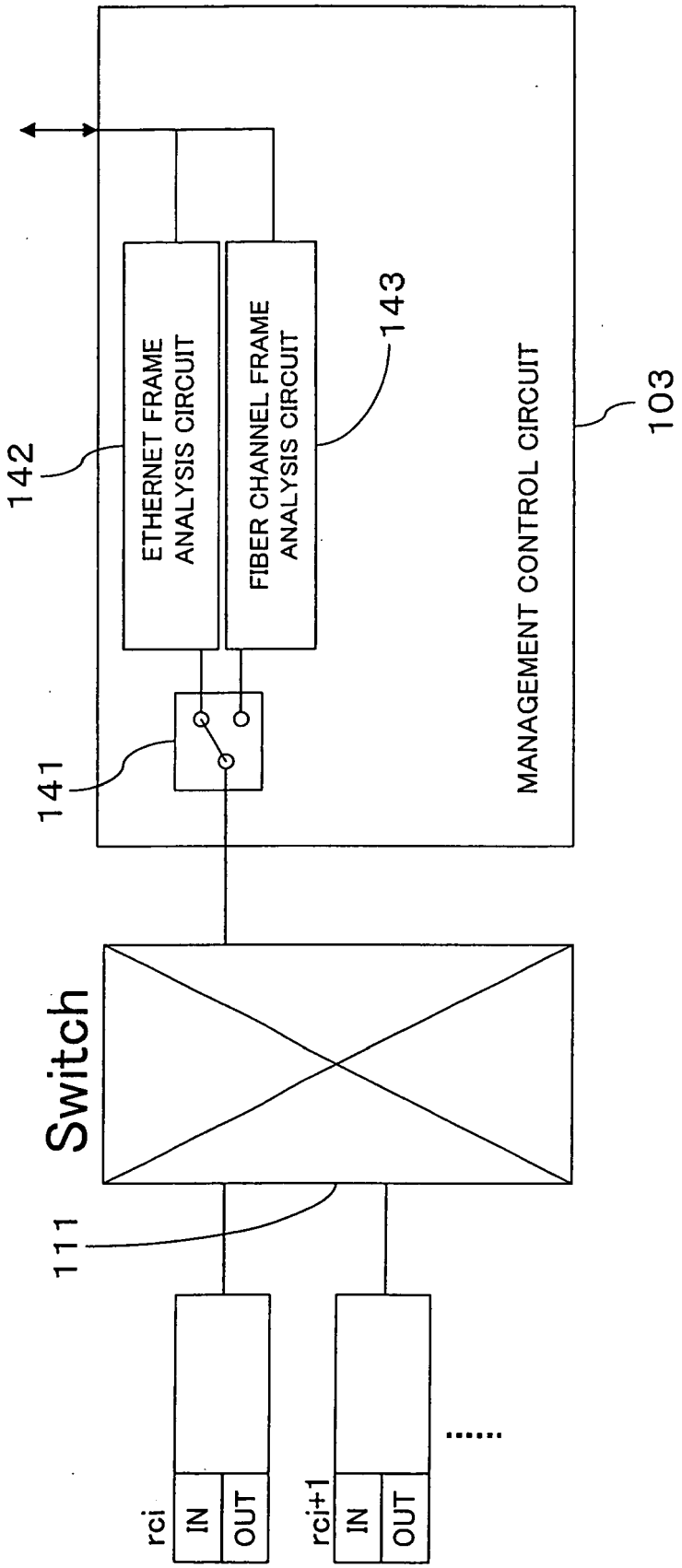

ETHERNET FRAME ANALYSIS CIRCUIT
FIBER CHANNEL FRAME ANALYSIS CIRCUIT
MANAGEMENT CONTROL CIRCUIT
142
143
103
141
Switch
111
rci
IN
OUT
rci+1
IN
OUT
.....

FIG. 25

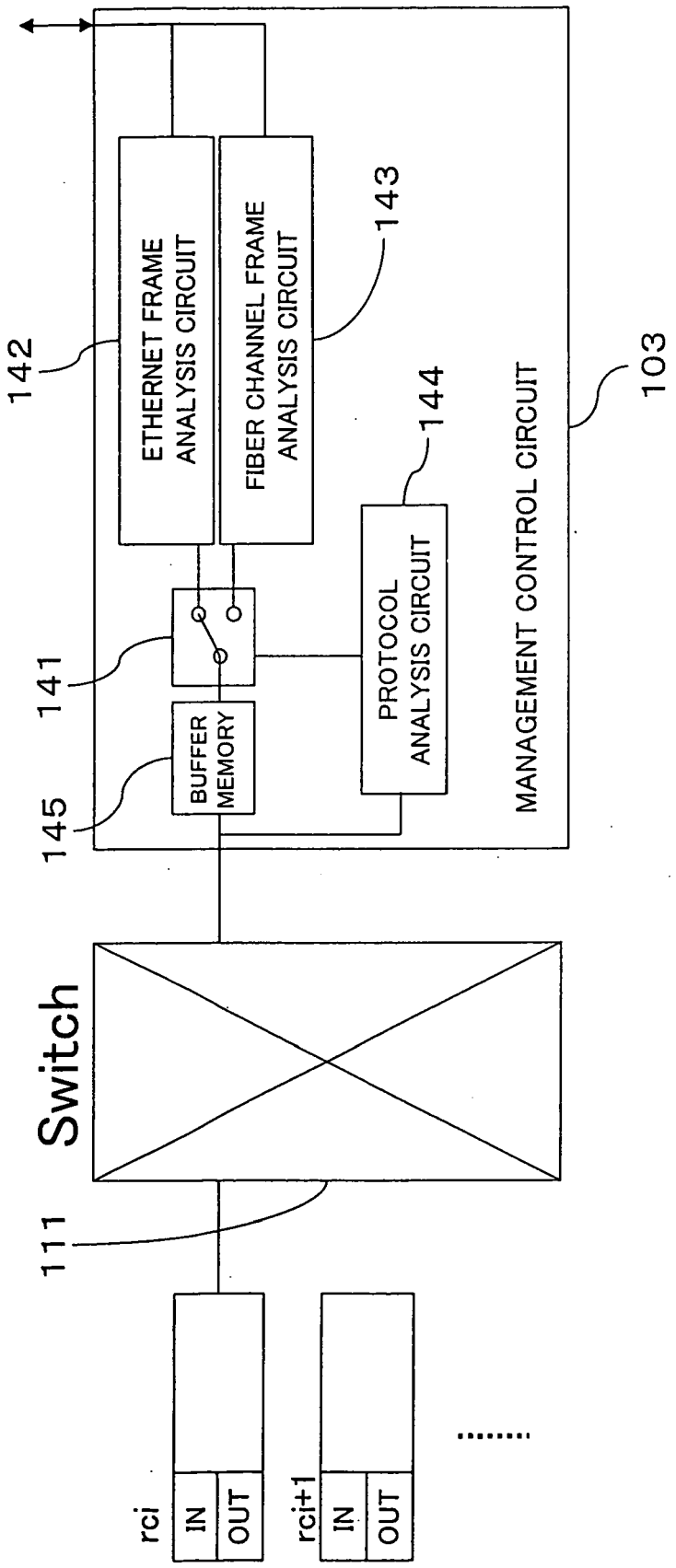

142
ETHERNET FRAME ANALYSIS CIRCUIT
143
FIBER CHANNEL FRAME ANALYSIS CIRCUIT
144
PROTOCOL ANALYSIS CIRCUIT
103
MANAGEMENT CONTROL CIRCUIT
141
145
BUFFER MEMORY
Switch
111
rci
IN
OUT
rci+1
IN
OUT

FIG. 26(A)

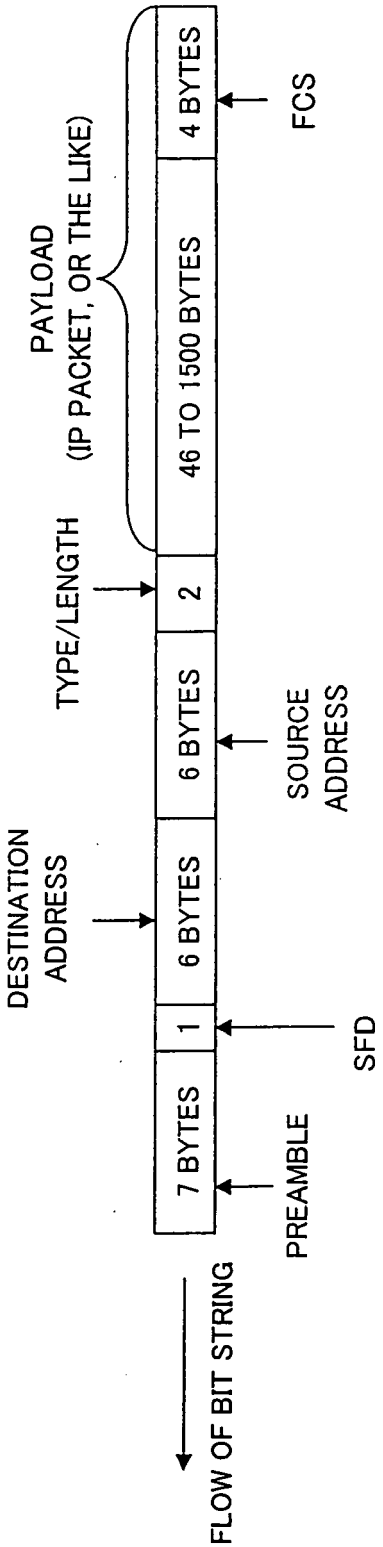


FIG. 26(B)

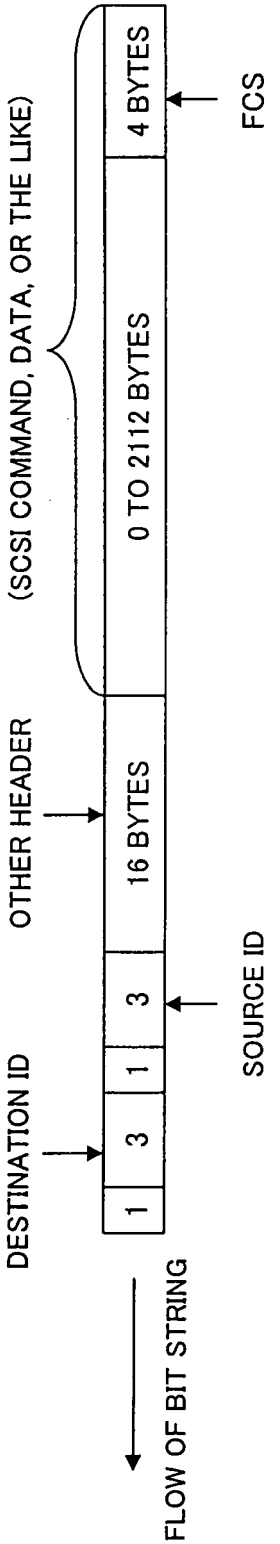


FIG. 27

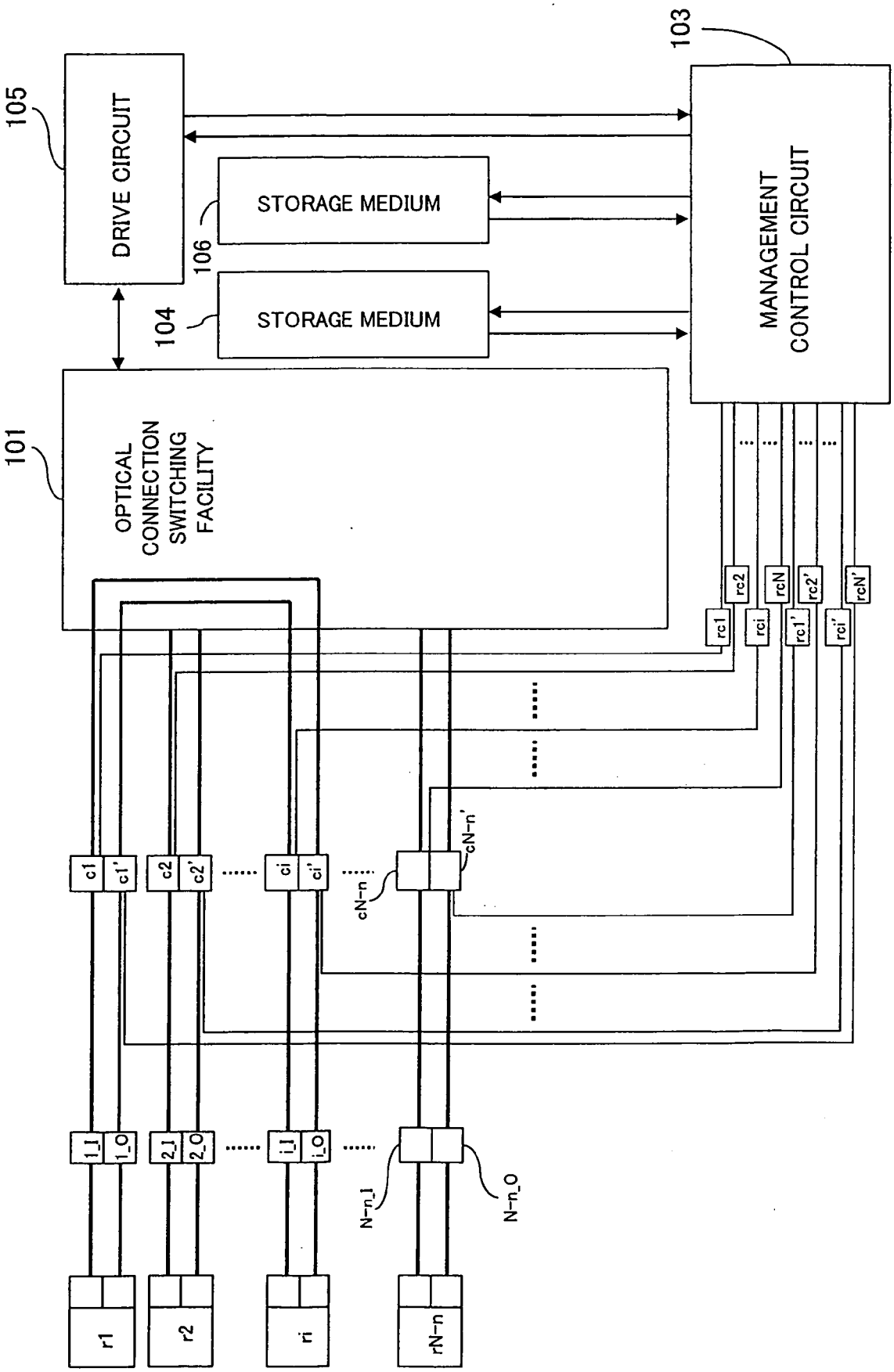

103
105
DRIVE CIRCUIT
STORAGE MEDIUM
106
STORAGE MEDIUM
104
MANAGEMENT CONTROL CIRCUIT
101
OPTICAL CONNECTION SWITCHING FACILITY
rc2
rcN
rcN'
rc2'
rc1
rci
rc1'
rci'
c1
c1'
c2
c2'
ci
ci'
cN-n
cN-n'
1_I
1_O
2_I
2_O
i_I
i_O
N-n_I
N-n_O
r1
r2
ri
rN-n

FIG. 28

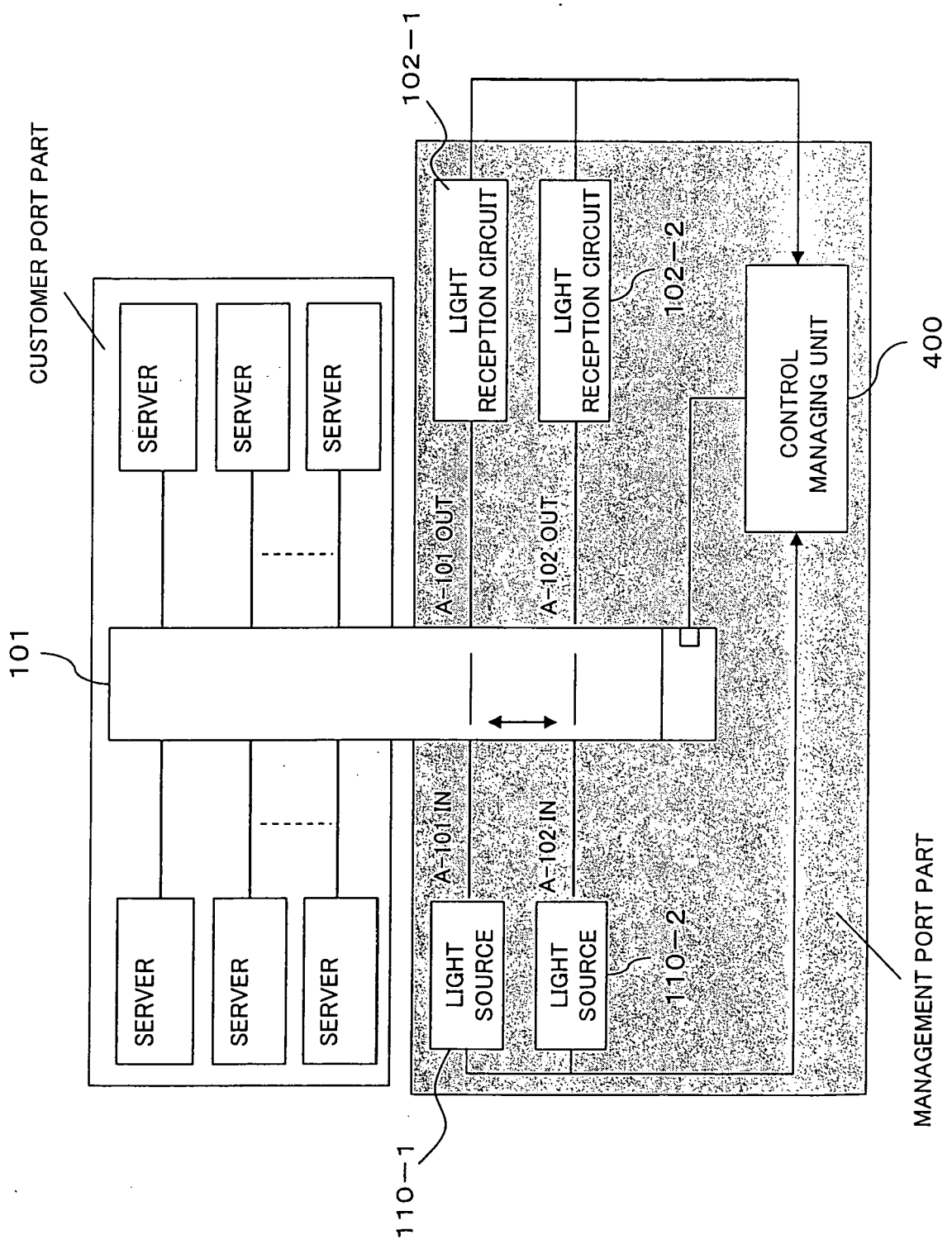

CUSTOMER PORT PART
SERVER
SERVER
SERVER
SERVER
SERVER
SERVER
101
102-1
LIGHT RECEPTION CIRCUIT
LIGHT RECEPTION CIRCUIT
102-2
A-101 OUT
A-102 OUT
A-101 IN
A-102 IN
LIGHT SOURCE
LIGHT SOURCE
110-2
110-1
CONTROL MANAGING UNIT
400
MANAGEMENT PORT PART

FIG. 29

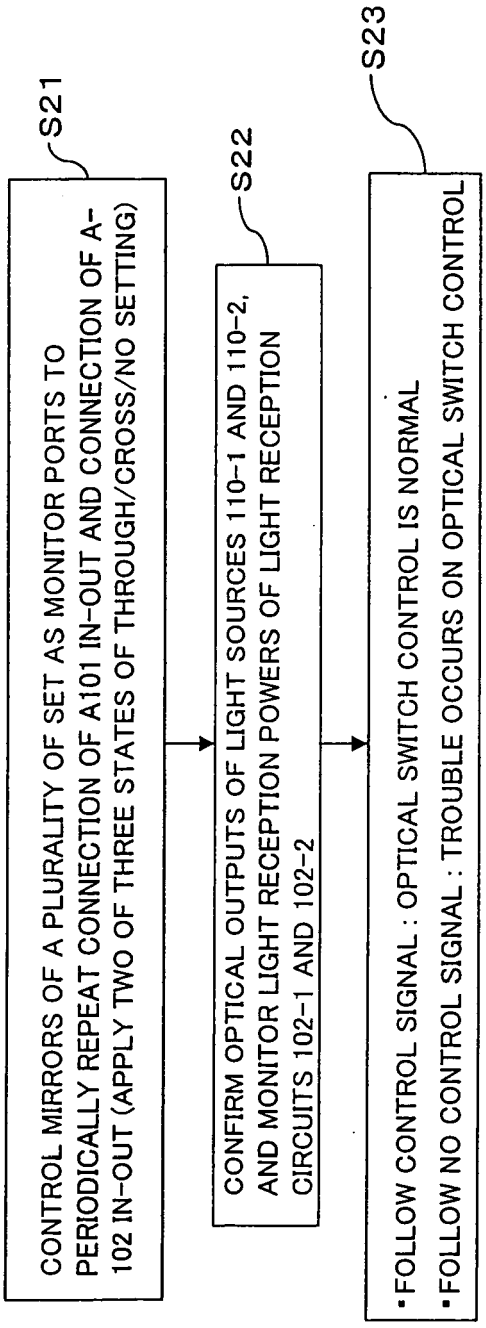

S21
CONTROL MIRRORS OF A PLURALITY OF SET AS MONITOR PORTS TO PERIODICALLY REPEAT CONNECTION OF A101 IN-OUT AND CONNECTION OF A-102 IN-OUT (APPLY TWO OF THREE STATES OF THROUGH/CROSS/NO SETTING)
S22
CONFIRM OPTICAL OUTPUTS OF LIGHT SOURCES 110-1 AND 110-2, AND MONITOR LIGHT RECEPTION POWERS OF LIGHT RECEPTION CIRCUITS 102-1 AND 102-2
S23
• FOLLOW CONTROL SIGNAL : OPTICAL SWITCH CONTROL IS NORMAL
• FOLLOW NO CONTROL SIGNAL : TROUBLE OCCURS ON OPTICAL SWITCH CONTROL

FIG. 30

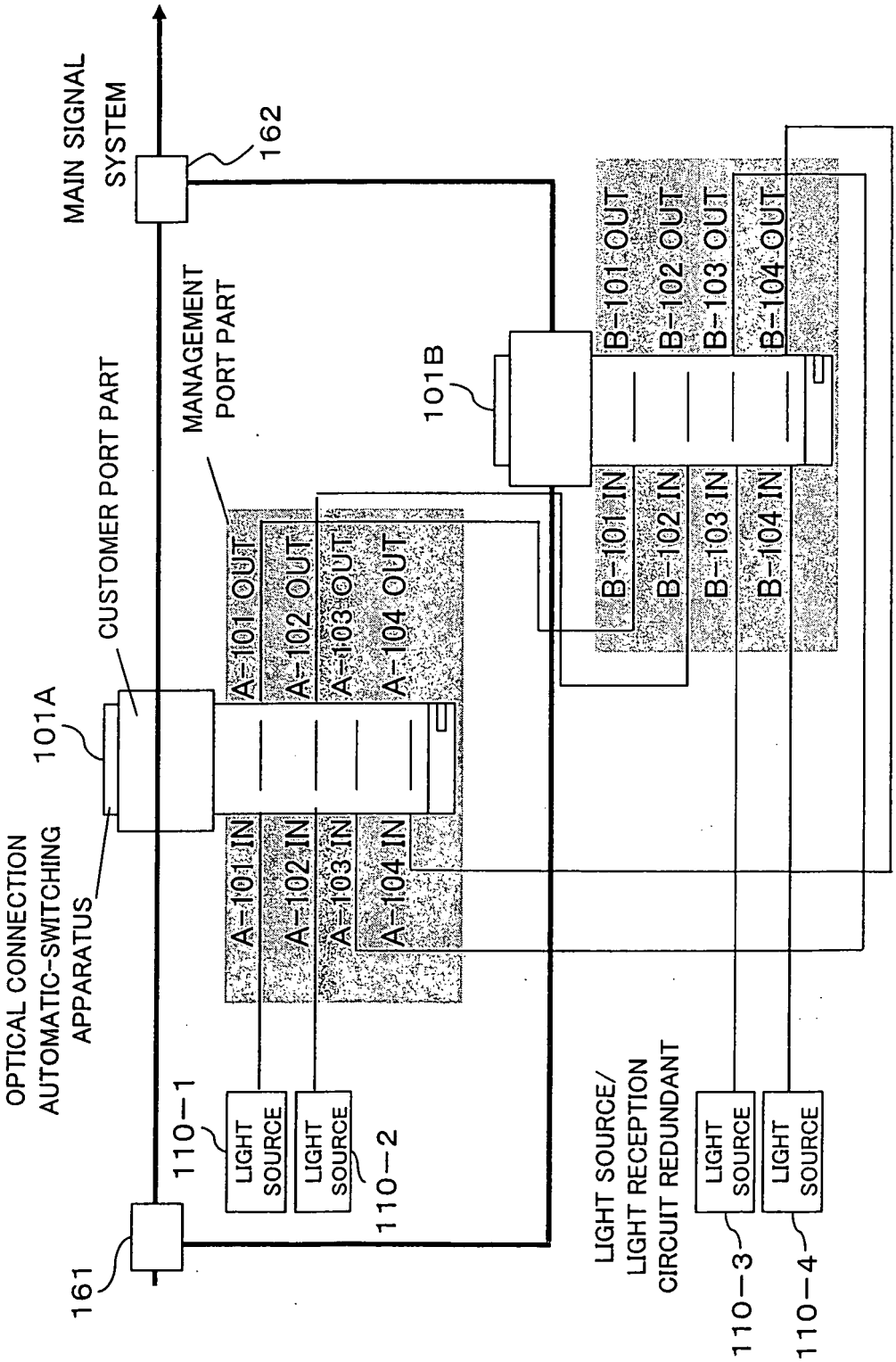

MAIN SIGNAL SYSTEM
162
MANAGEMENT PORT PART
CUSTOMER PORT PART
101A
101B
OPTICAL CONNECTION AUTOMATIC-SWITCHING APPARATUS
A-101 OUT
A-102 OUT
A-103 OUT
A-104 OUT
A-101 IN
A-102 IN
A-103 IN
A-104 IN
B-101 OUT
B-102 OUT
B-103 OUT
B-104 OUT
B-101 IN
B-102 IN
B-103 IN
B-104 IN
LIGHT SOURCE
LIGHT SOURCE
LIGHT SOURCE
LIGHT SOURCE
110-1
110-2
110-3
110-4
161
LIGHT SOURCE/ LIGHT RECEPTION CIRCUIT REDUNDANT

FIG. 31

500 DETECTION TABLE

Case	1	2	3	4
A101	-	-	O	O
A102	-	-	O	O
A103	-	-	O	×
A104	-	-	O	×
B101	O	×	-	-
B102	O	×	-	-
B103	O	O	-	-
B104	O	O	-	-
ABNORMAL EQUIPMENT	NO	A	NO	B

FIG. 32(A)

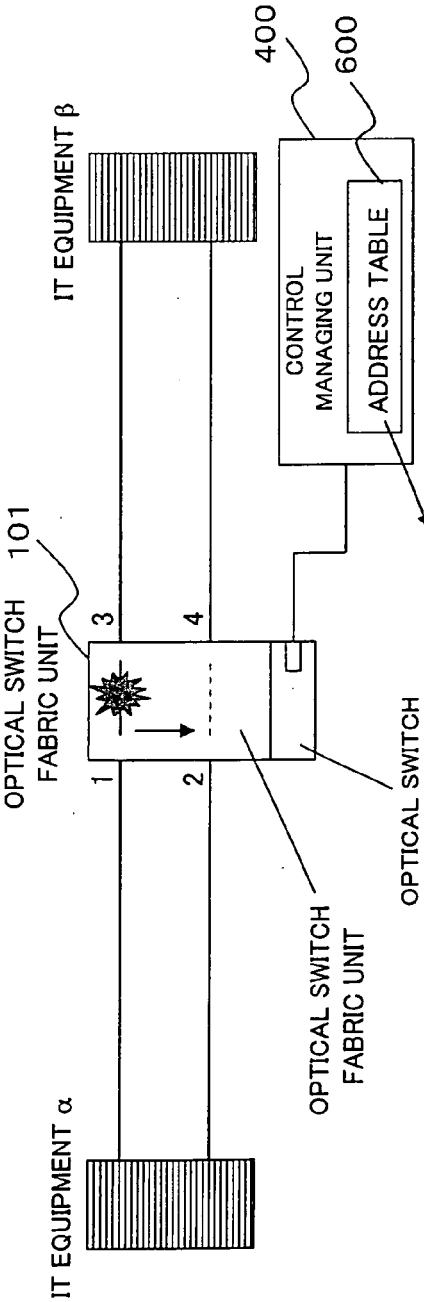


FIG. 32(B)

600

PORT No.	IT EQUIPMENT ADDRESS	CONNECTION DESTINATION PORT No./ADDRESS	STATE OF PATH
1	α	3, β	WORK 1
2	α	– (4, β)	SPARE 1
3	β	1, α	WORK 2
4	β	– (2, α)	SPARE 2

700

600

PORT No.	IT EQUIPMENT ADDRESS	CONNECTION DESTINATION PORT No./ADDRESS	STATE OF PATH
1	α	–	–
2	α	4, β	WORK
3	β	–	–
4	β	2, α	WORK

FIG. 32(C)

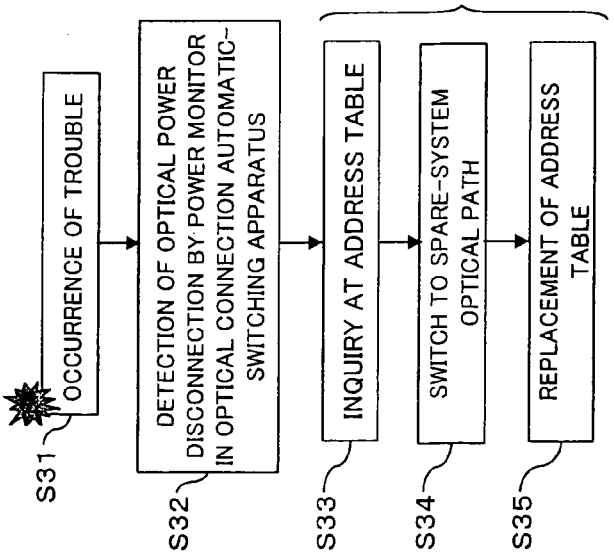


FIG. 33

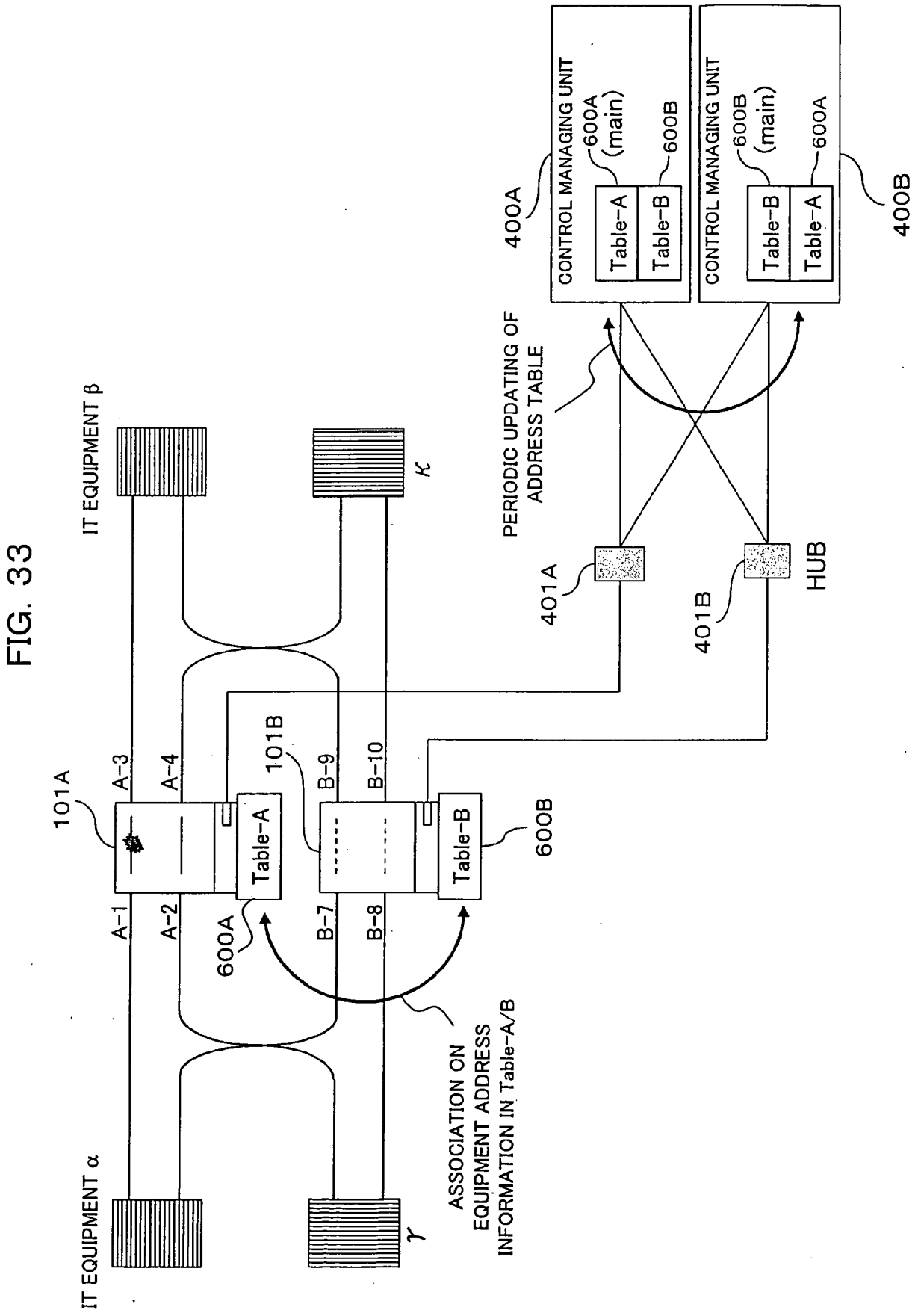
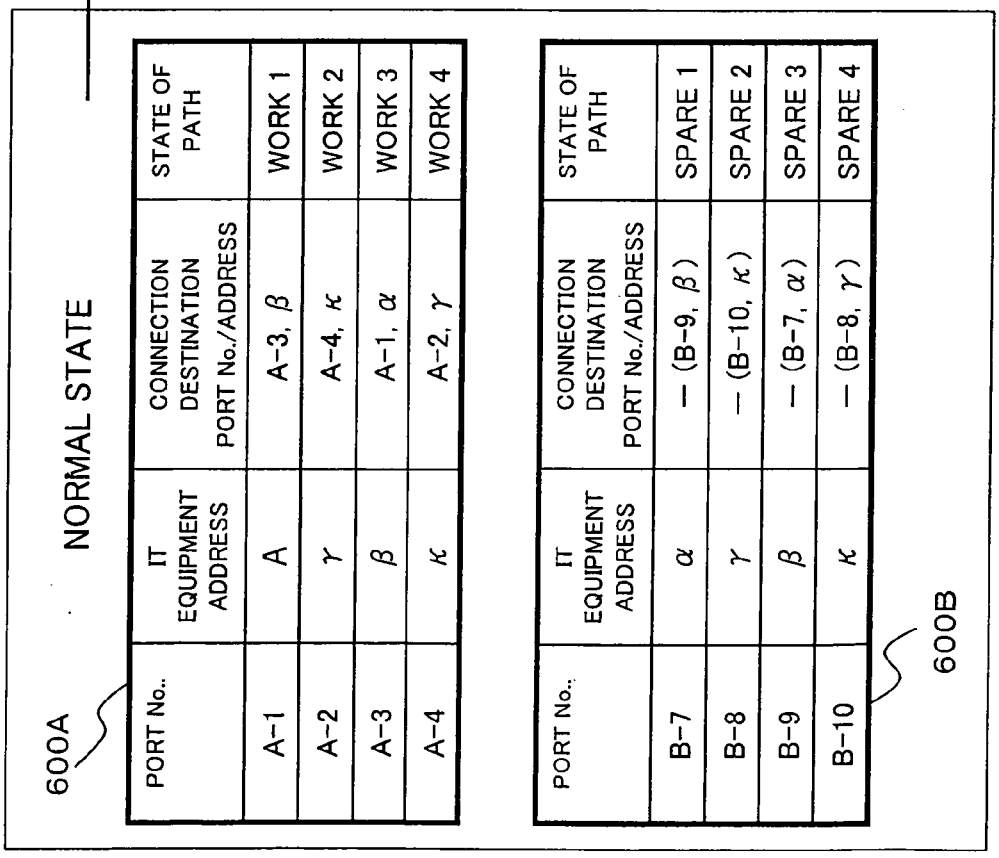

IT EQUIPMENT α
IT EQUIPMENT β
γ
κ
101A
101B
A-1
A-2
A-3
A-4
B-7
B-8
B-9
B-10
Table-A
Table-B
600A
600B
ASSOCIATION ON EQUIPMENT ADDRESS INFORMATION IN Table-A/B
PERIODIC UPDATING OF ADDRESS TABLE
401A
401B
HUB
400A
400B
CONTROL MANAGING UNIT
600A (main)
600B
600B (main)
600A

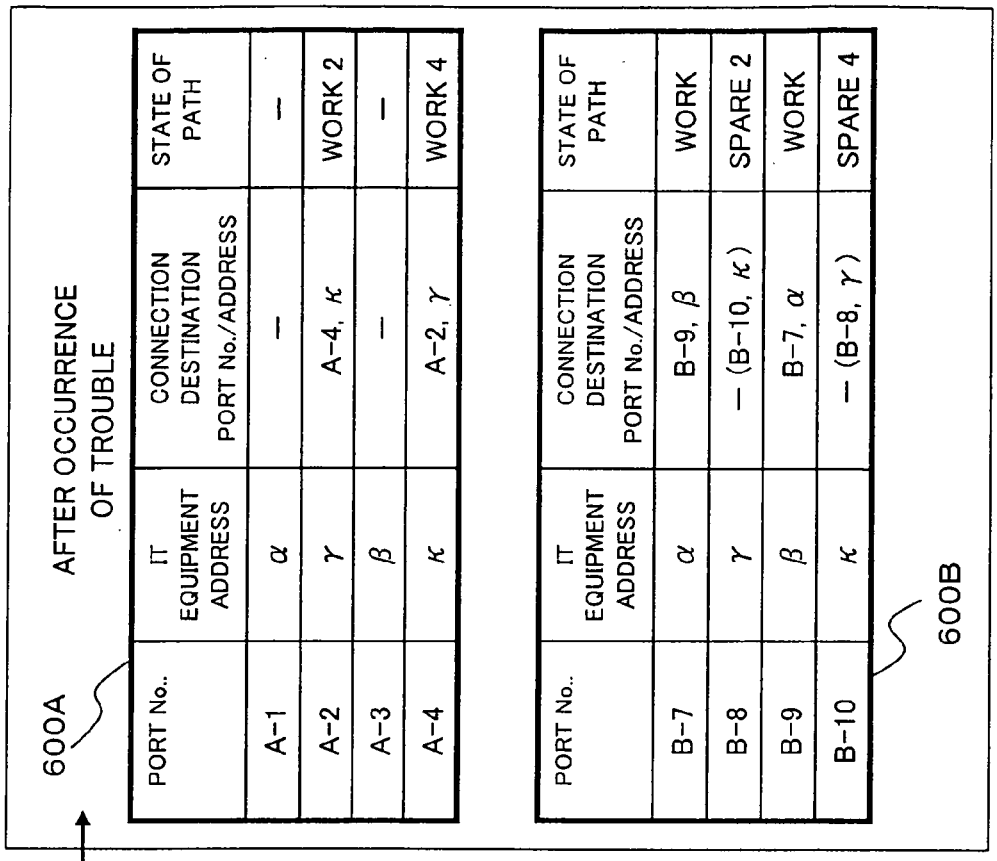
FIG. 34(A)



PORT No..	IT EQUIPMENT ADDRESS	CONNECTION DESTINATION PORT No./ADDRESS	STATE OF PATH
A-1	A	A-3, β	WORK 1
A-2	γ	A-4, κ	WORK 2
A-3	β	A-1, α	WORK 3
A-4	κ	A-2, γ	WORK 4

PORT No..	IT EQUIPMENT ADDRESS	CONNECTION DESTINATION PORT No./ADDRESS	STATE OF PATH
B-7	α	— (B-9, β)	SPARE 1
B-8	γ	— (B-10, κ)	SPARE 2
B-9	β	— (B-7, α)	SPARE 3
B-10	κ	— (B-8, γ)	SPARE 4

FIG. 34(B)



PORT No..	IT EQUIPMENT ADDRESS	CONNECTION DESTINATION PORT No./ADDRESS	STATE OF PATH
A-1	α	—	—
A-2	γ	A-4, κ	WORK 2
A-3	β	—	—
A-4	κ	A-2, γ	WORK 4

PORT No..	IT EQUIPMENT ADDRESS	CONNECTION DESTINATION PORT No./ADDRESS	STATE OF PATH
B-7	α	B-9, β	WORK
B-8	γ	— (B-10, κ)	SPARE 2
B-9	β	B-7, α	WORK
B-10	κ	— (B-8, γ)	SPARE 4

FIG. 35

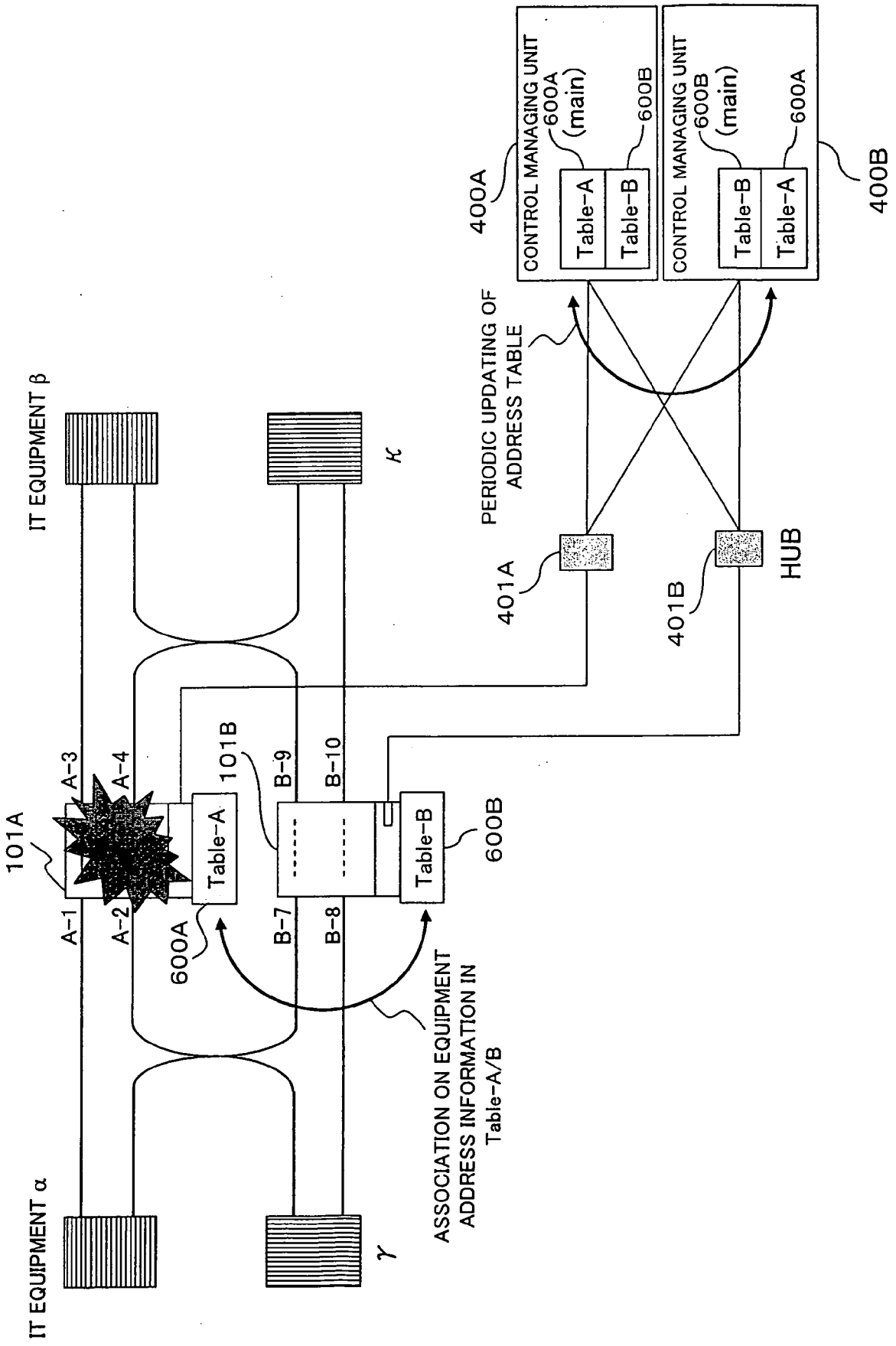

IT EQUIPMENT α
IT EQUIPMENT β
γ
κ
101A
A-1
A-2
A-3
A-4
101B
Table-A
Table-B
600A
600B
B-7
B-8
B-9
B-10
ASSOCIATION ON EQUIPMENT ADDRESS INFORMATION IN Table-A/B
PERIODIC UPDATING OF ADDRESS TABLE
400A
400B
CONTROL MANAGING UNIT
(main)
401A
401B
HUB

FIG. 36(A)

600A NORMAL STATE

PORT No..	IT EQUIPMENT ADDRESS	CONNECTION DESTINATION PORT No./ADDRESS	STATE OF PATH
A-1	α	A-3, β	WORK 1
A-2	γ	A-4, κ	WORK 2
A-3	β	A-1, α	WORK 3
A-4	κ	A-2, γ	WORK 4

PORT No..	IT EQUIPMENT ADDRESS	CONNECTION DESTINATION PORT No./ADDRESS	STATE OF PATH
B-7	α	— (B-9, β)	SPARE 1
B-8	γ	— (B-10, κ)	SPARE 2
B-9	β	— (B-7, α)	SPARE 3
B-10	κ	— (B-8, γ)	SPARE 4

600B

FIG. 36(B)

600A AFTER OCCURRENCE OF TROUBLE

PORT No..	IT EQUIPMENT ADDRESS	CONNECTION DESTINATION PORT No./ADDRESS	STATE OF PATH
A-1	α	—	—
A-2	γ	—	—
A-3	β	—	—
A-4	κ	—	—

PORT No..	IT EQUIPMENT ADDRESS	CONNECTION DESTINATION PORT No./ADDRESS	STATE OF PATH
B-7	α	B-9, β	WORK
B-8	γ	B-10, κ	WORK
B-9	β	B-7, α	WORK
B-10	κ	B-8, γ	WORK

600B

FIG. 37

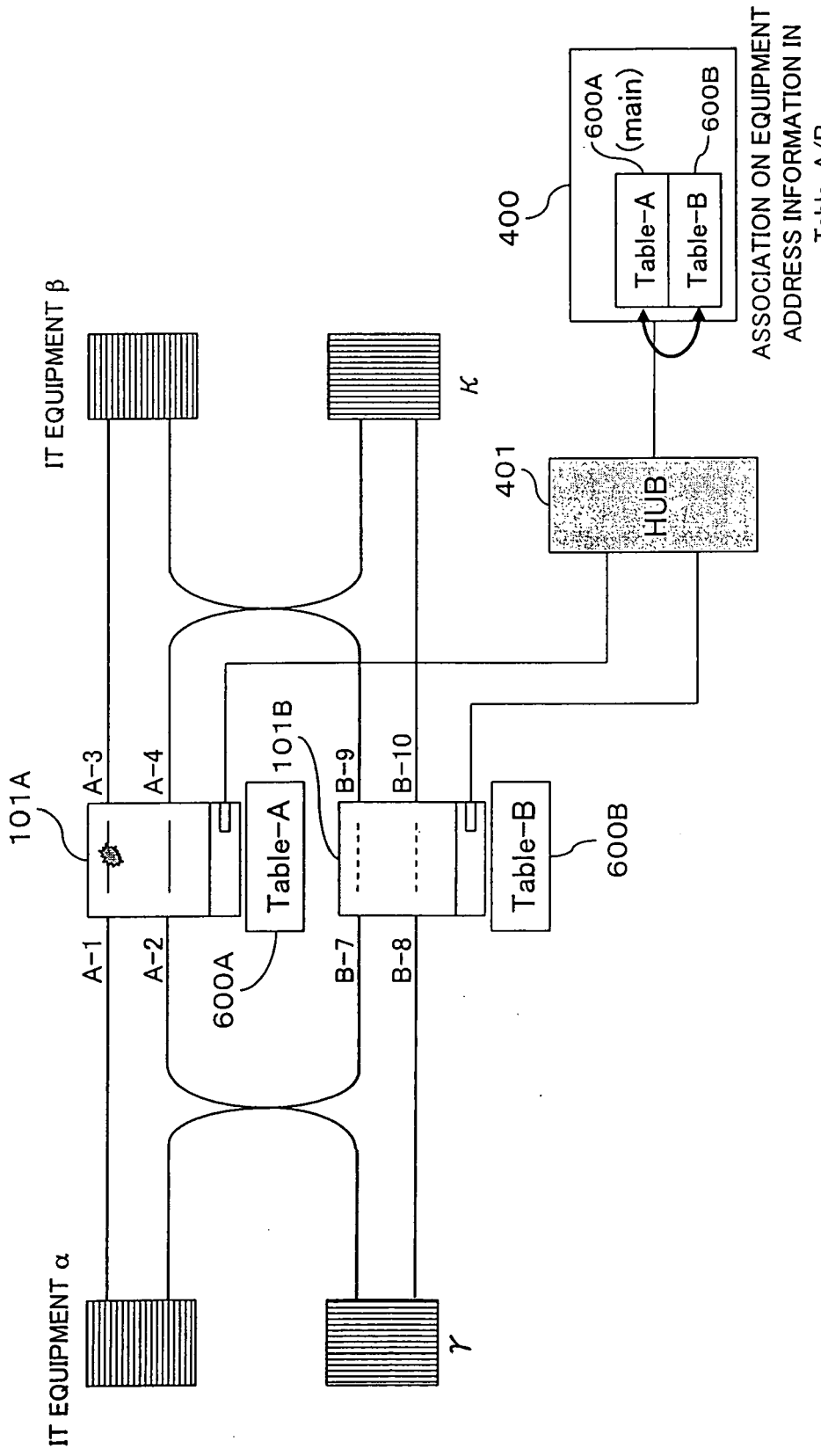

IT EQUIPMENT α
IT EQUIPMENT β
101A
A-1
A-2
A-3
A-4
600A
Table-A
101B
B-7
B-8
B-9
B-10
Table-B
600B
γ
κ
400
600A
(main)
600B
Table-A
Table-B
ASSOCIATION ON EQUIPMENT
ADDRESS INFORMATION IN
Table-A/B
401
HUB

FIG. 38

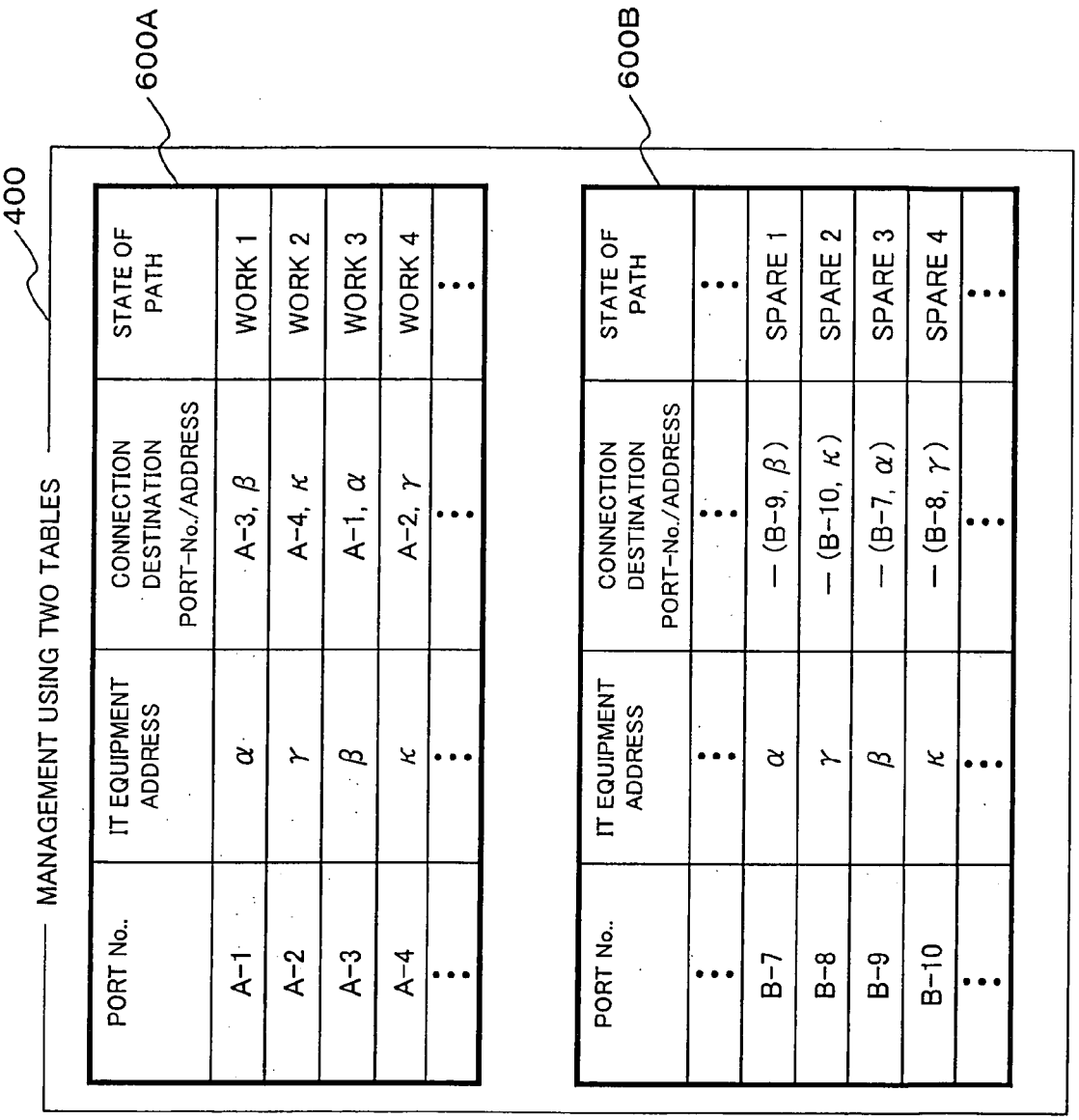
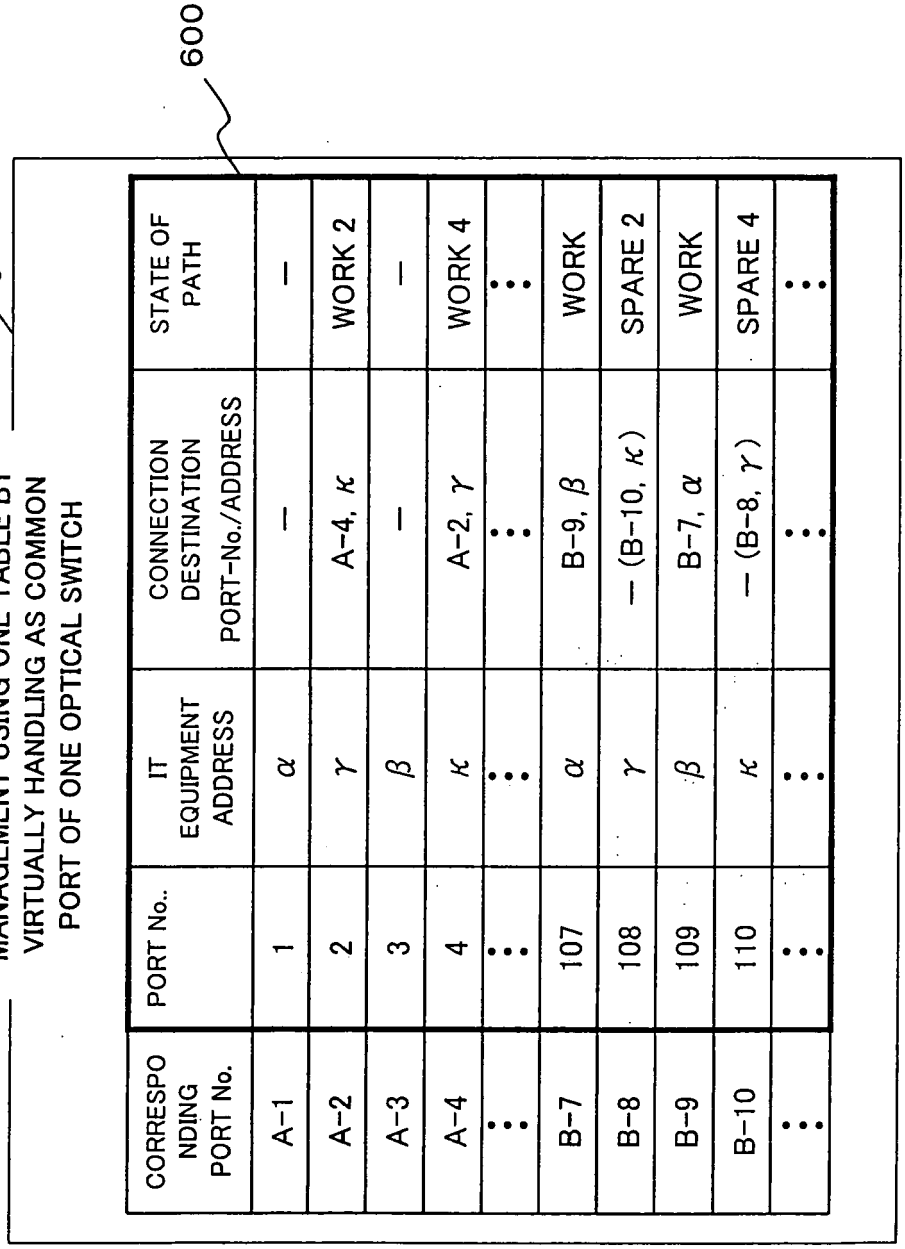

400
MANAGEMENT USING TWO TABLES
600A
PORT No.
IT EQUIPMENT ADDRESS
CONNECTION DESTINATION PORT-No./ADDRESS
STATE OF PATH
A-1
α
A-3, β
WORK 1
A-2
γ
A-4, κ
WORK 2
A-3
β
A-1, α
WORK 3
A-4
κ
A-2, γ
WORK 4
600B
PORT No.
IT EQUIPMENT ADDRESS
CONNECTION DESTINATION PORT-No./ADDRESS
STATE OF PATH
B-7
α
— (B-9, β)
SPARE 1
B-8
γ
— (B-10, κ)
SPARE 2
B-9
β
— (B-7, α)
SPARE 3
B-10
κ
— (B-8, γ)
SPARE 4

FIG. 39


400
600
MANAGEMENT USING ONE TABLE BY VIRTUALLY HANDLING AS COMMON PORT OF ONE OPTICAL SWITCH
CORRESPONDING PORT No.
PORT No..
IT EQUIPMENT ADDRESS
CONNECTION DESTINATION PORT-No./ADDRESS
STATE OF PATH
A-1 | 1 | α | — | —
A-2 | 2 | γ | A-4, κ | WORK 2
A-3 | 3 | β | — | —
A-4 | 4 | κ | A-2, γ | WORK 4
B-7 | 107 | α | B-9, β | WORK
B-8 | 108 | γ | — (B-10, κ) | SPARE 2
B-9 | 109 | β | B-7, α | WORK
B-10 | 110 | κ | — (B-8, γ) | SPARE 4

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2004100796 A **[0001]**
- JP 4427463 B **[0001]**
- JP HEI10135952 B **[0011] [0019]**
- JP HEI1165980 A **[0011]**
- JP HEI1165980 B **[0011] [0019]**
- JP 2000341359 A **[0012] [0019]**
- JP 2000209622 A **[0012] [0019]**
- JP 2002232409 A **[0013] [0019]**
- JP 2002095023 A **[0018]**
- JP 2003289557 A **[0018]**
- JP 2004040726 A **[0018]**
- WO 0133896 A1 **[0022]**
- WO 9724822 A1 **[0023]**