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(54) **OPTICAL BYPASS METHOD AND ARCHITECTURE**

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(58) **Field of Search** 385/5, 11, 15, 385/24, 31, 42, 123–124, 141, 142, 144, 147, 14; 359/115, 124–5, 127, 174; 398/79

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(57) **ABSTRACT**

The invention pertains to optical fiber transmission networks, and is particularly relevant to transmission of high volume of data and voice traffic among different locations. In particular, the improvement teaches improvements to an optical transport system to allow for efficient and flexible network evolution.

28 Claims, 8 Drawing Sheets

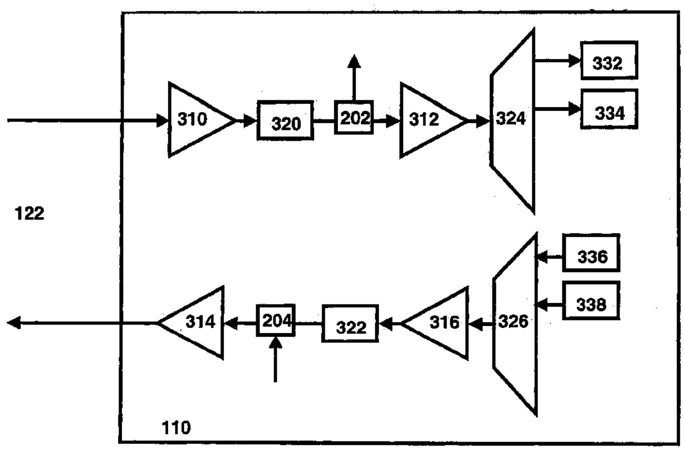

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Figure 1: Prior Art

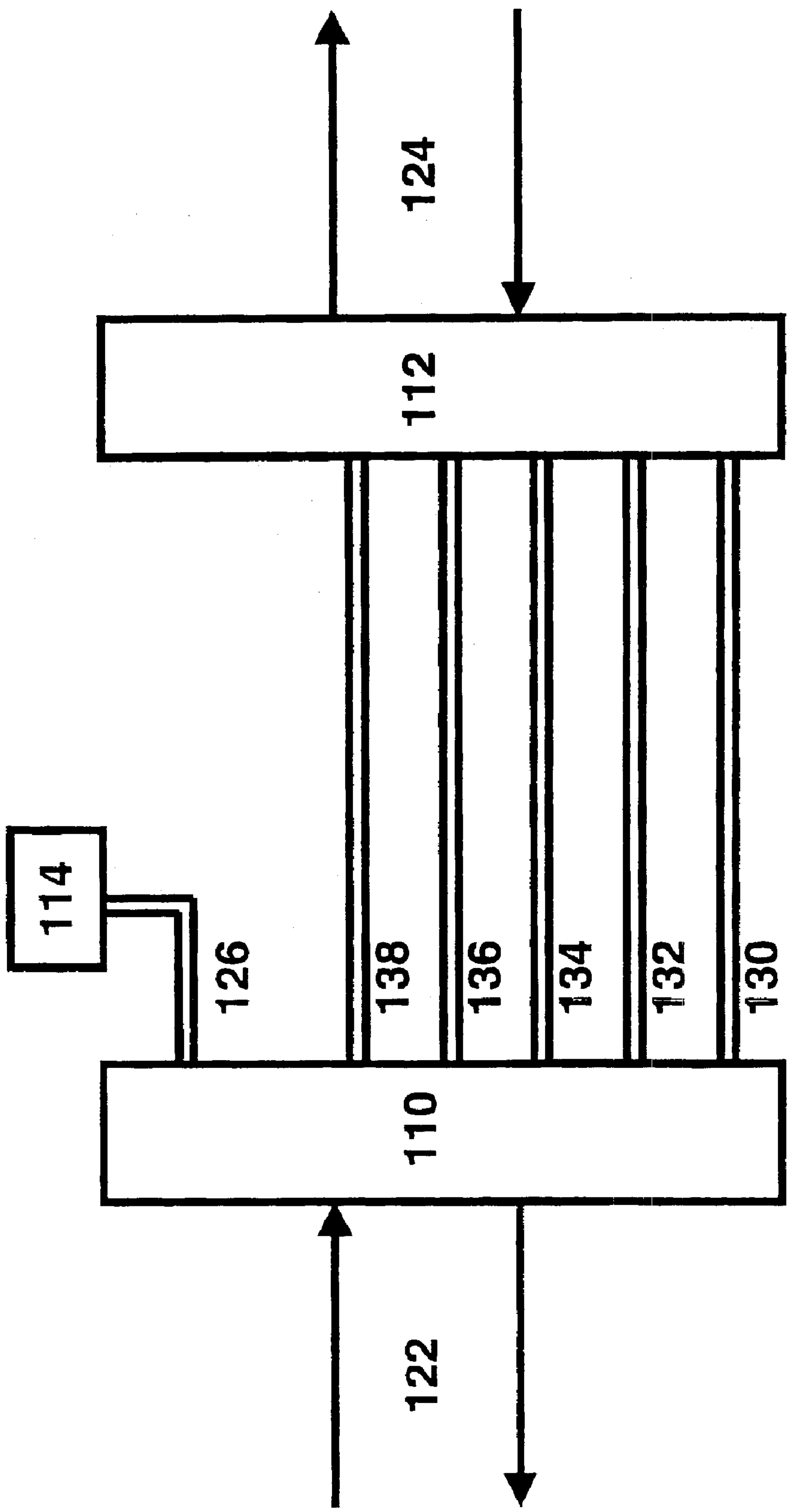


Figure 2:

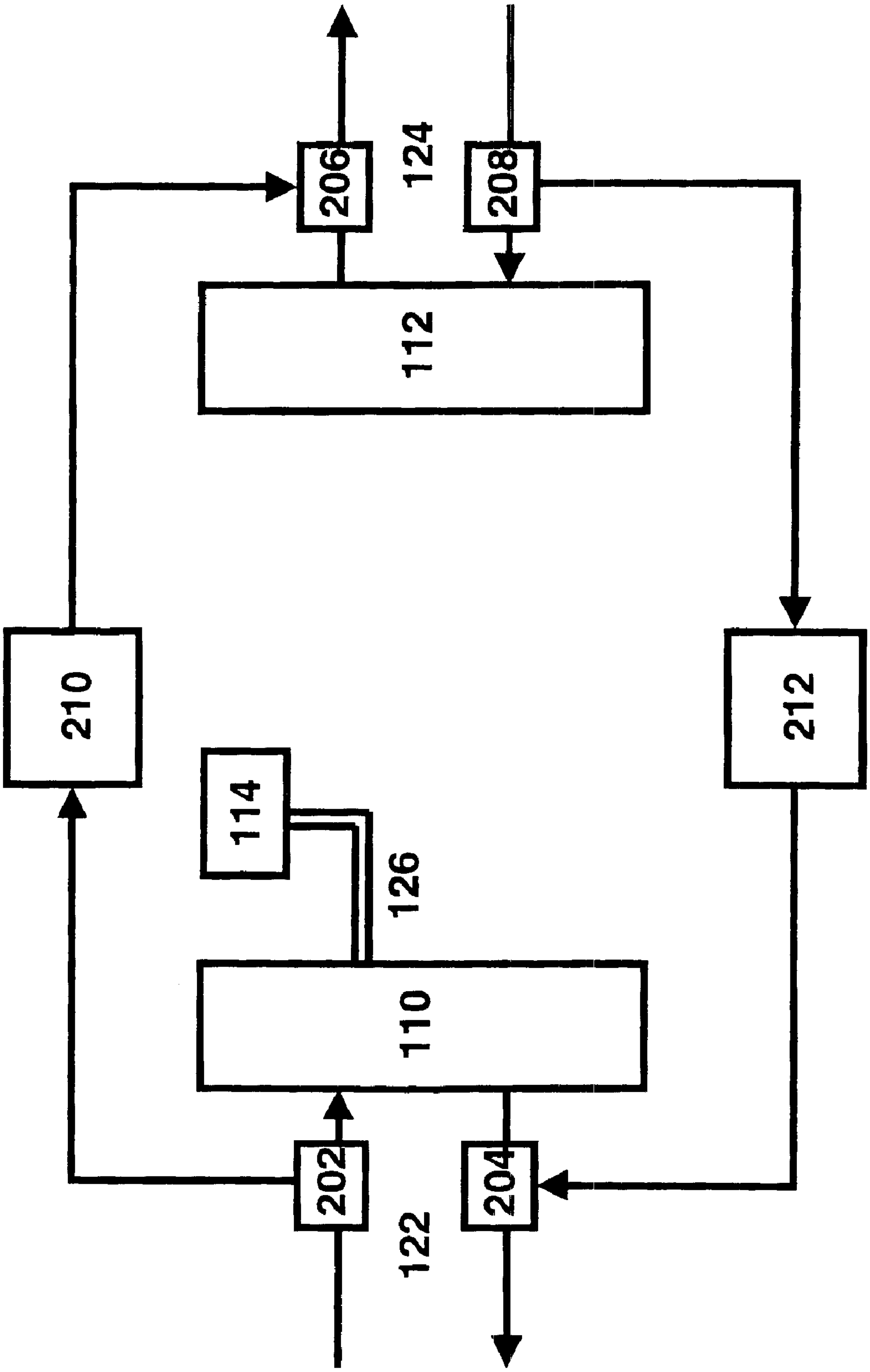
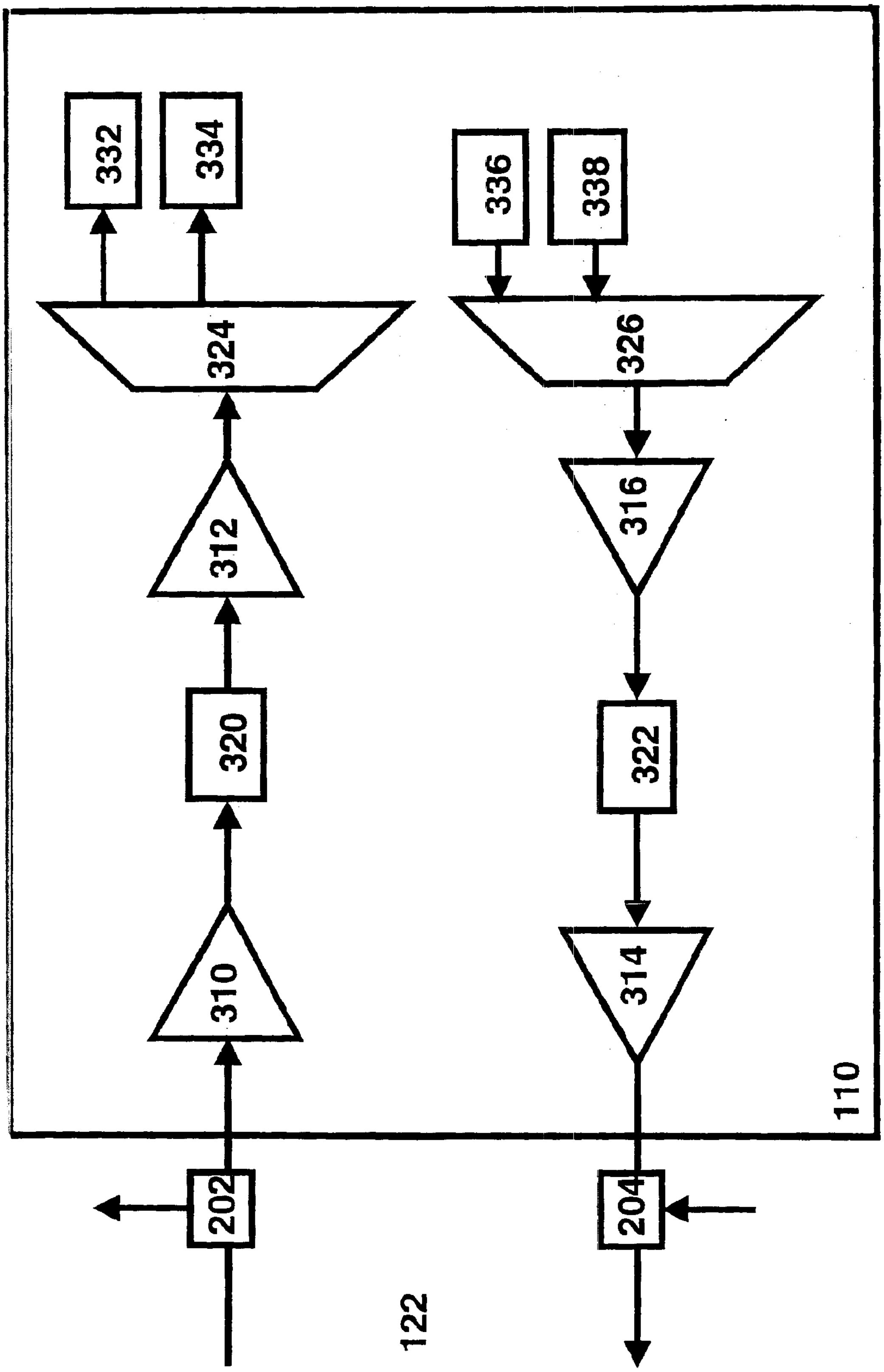


Figure 3



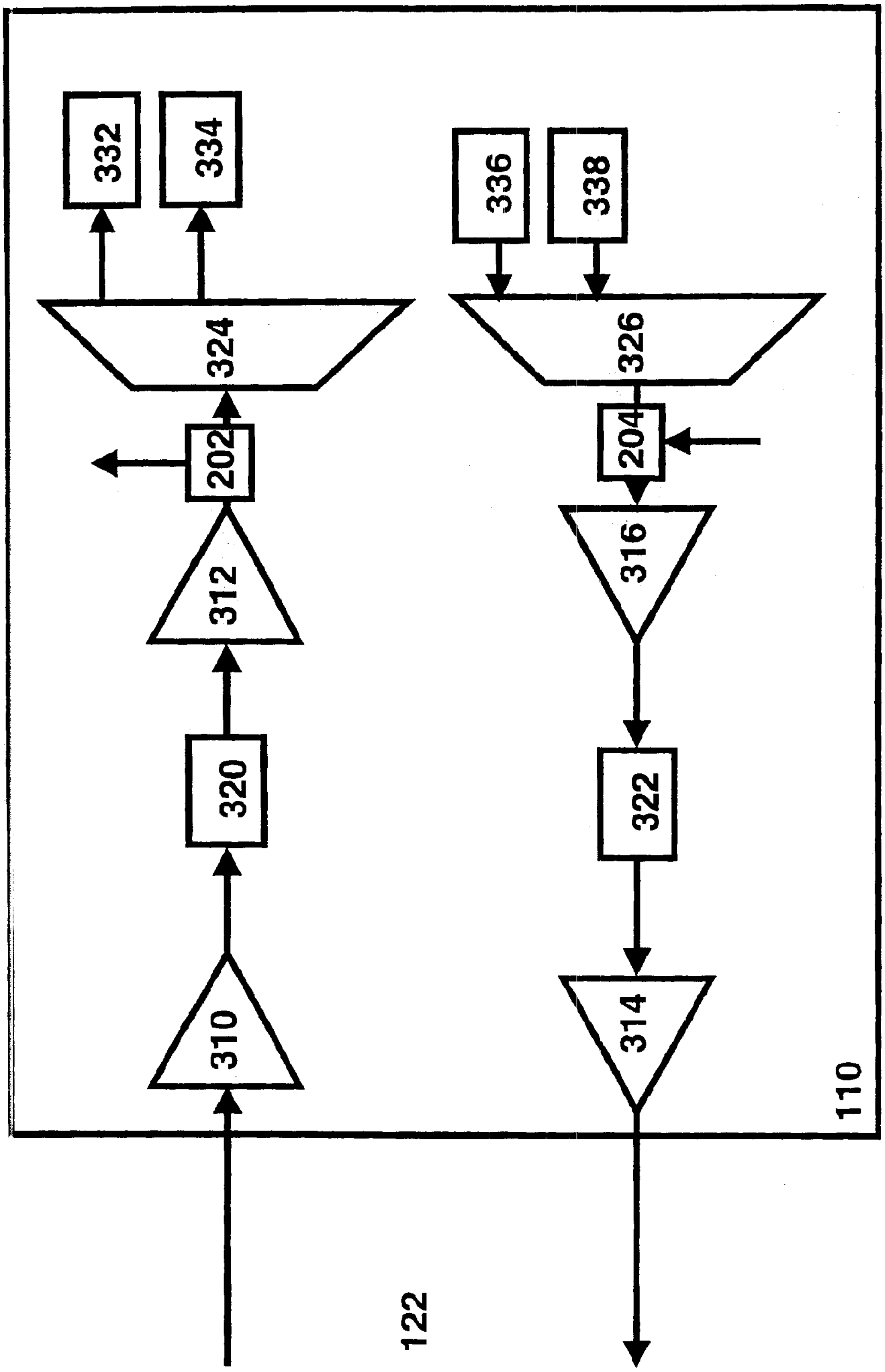


Figure 4

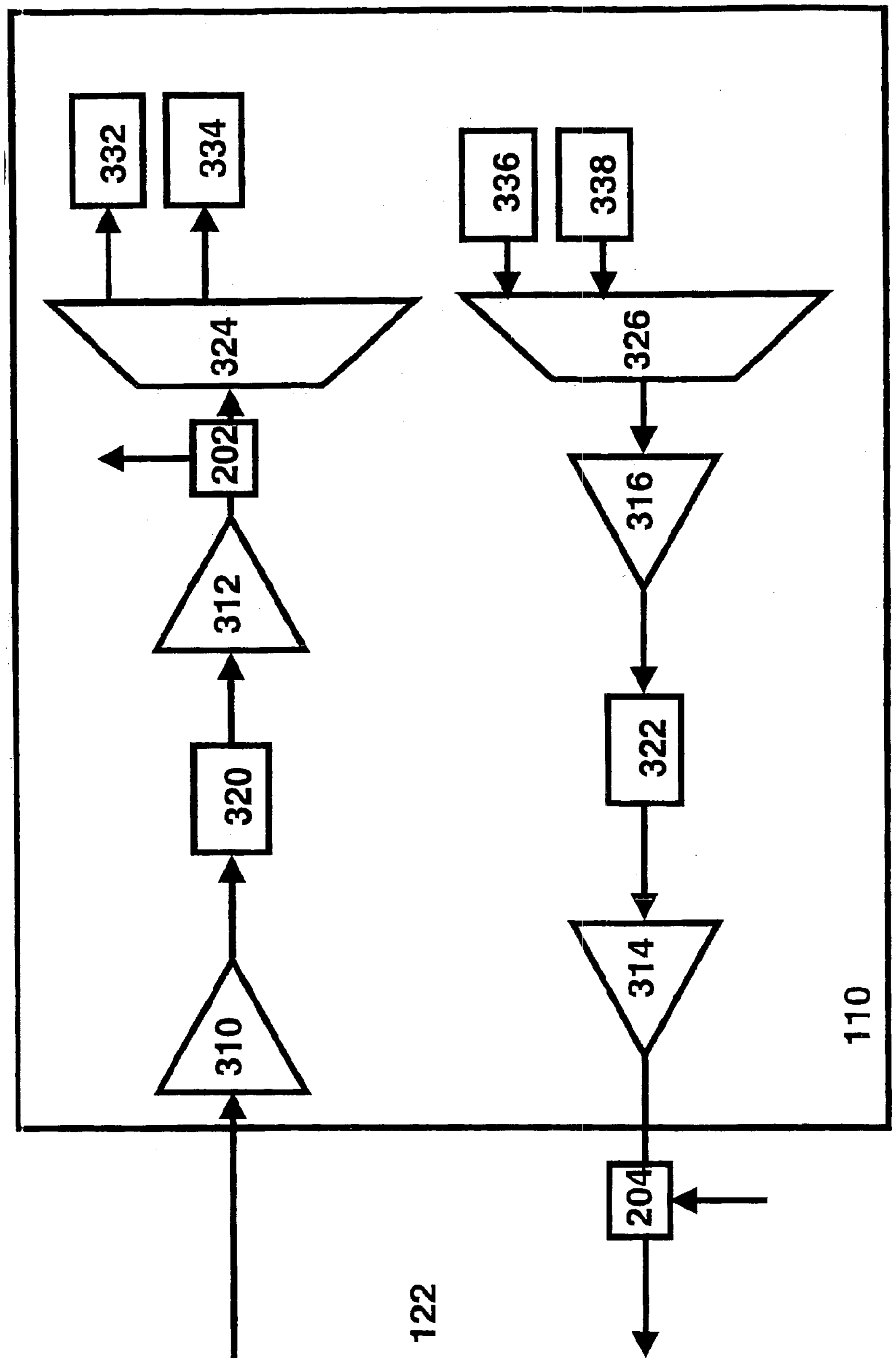


Figure 5

Figure 6

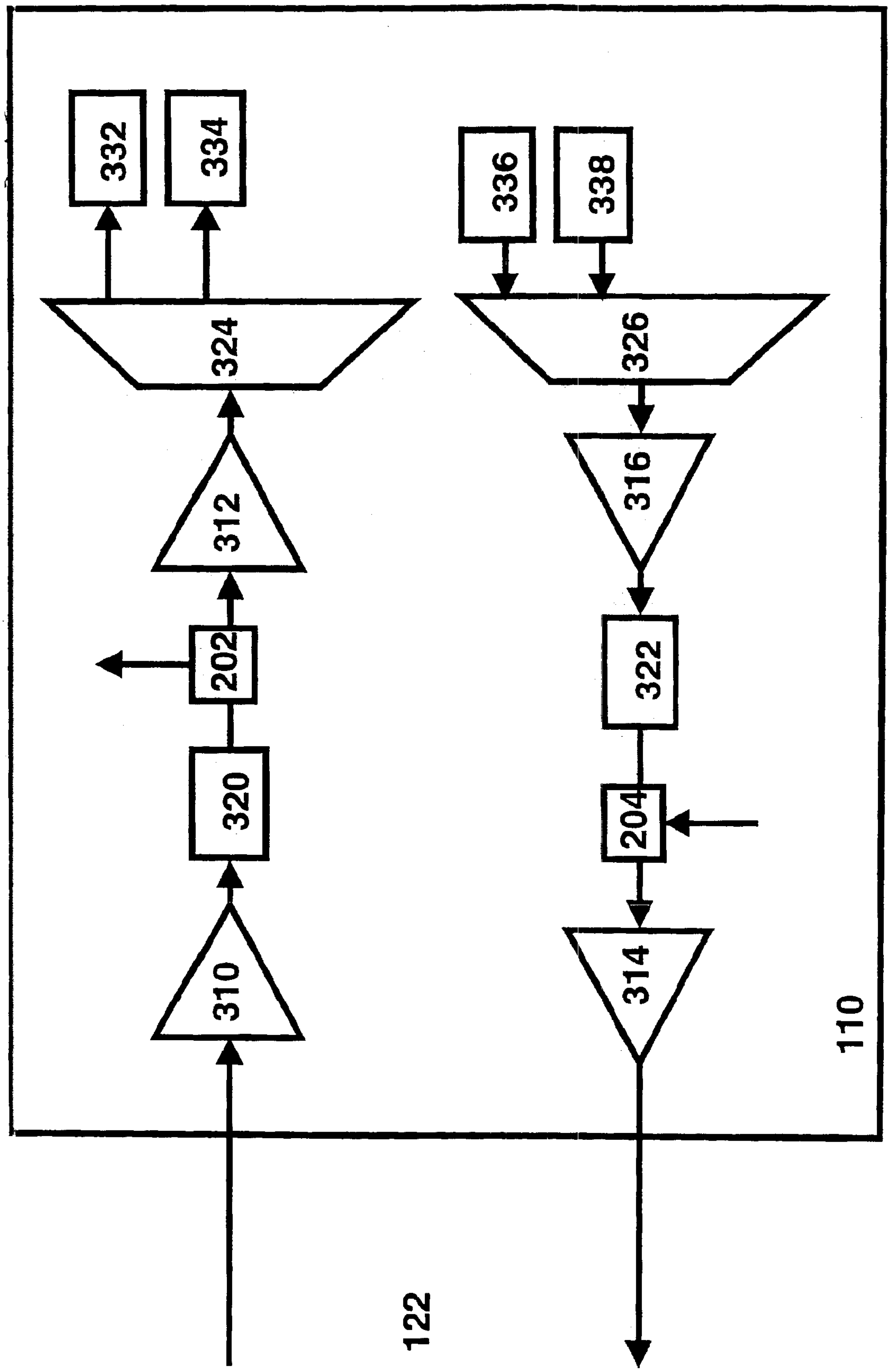
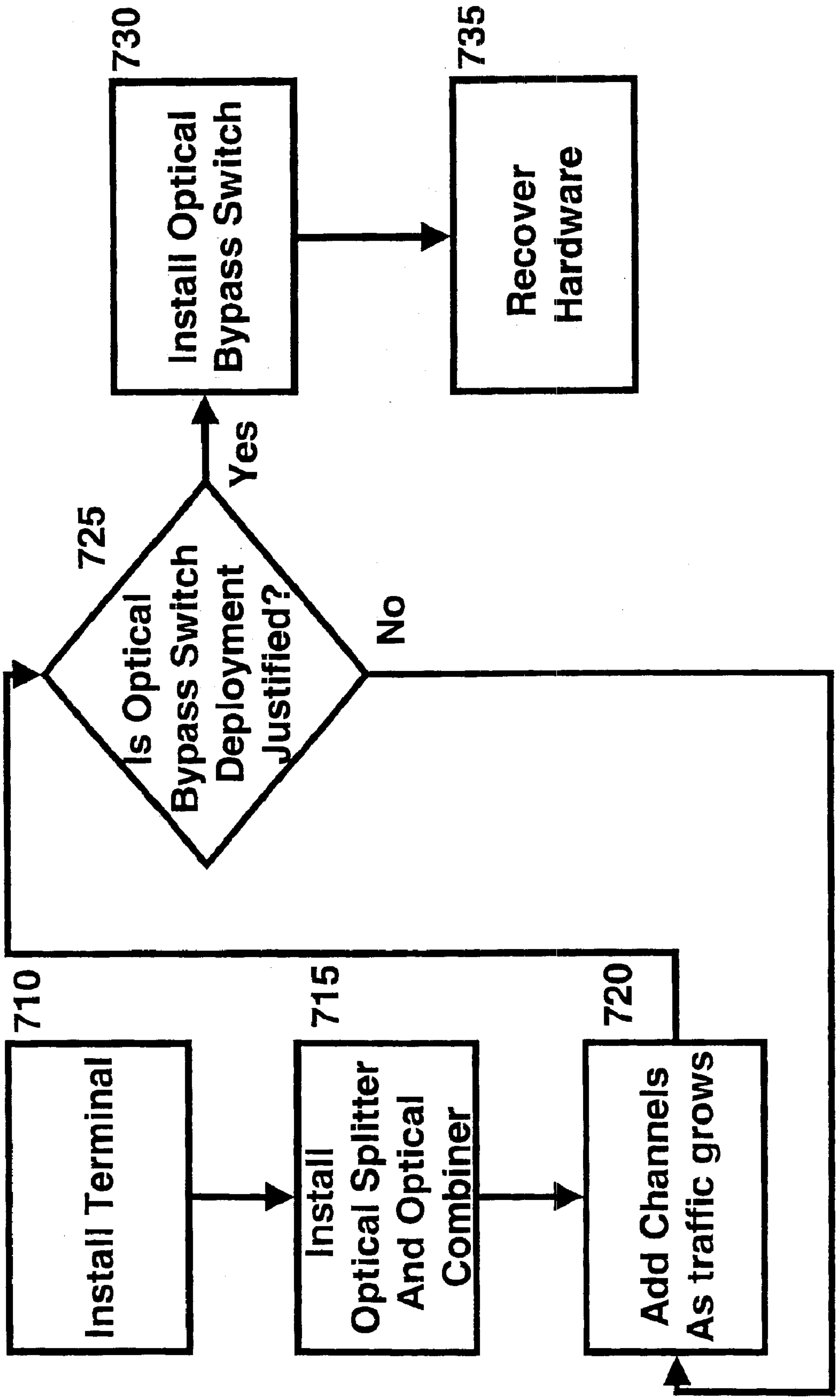


Figure 7


710
Install Terminal
715
Install
Optical Splitter
And Optical
Combiner
720
Add Channels
As traffic grows
725
Is Optical
Bypass Switch
Deployment
Justified?
Yes
No
730
Install Optical
Bypass Switch
735
Recover
Hardware

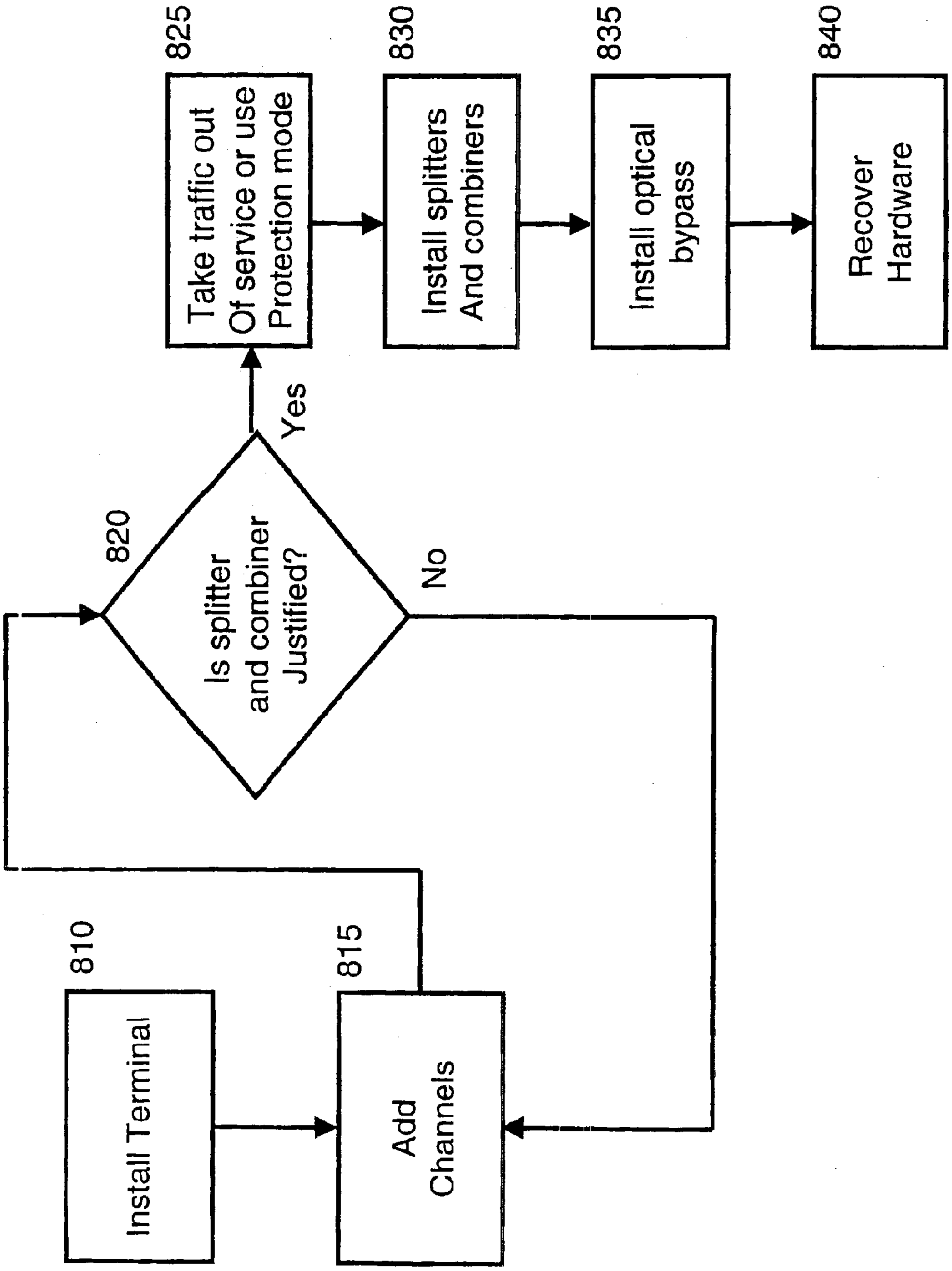

810
Install Terminal
815
Add Channels
820
Is splitter and combiner Justified?
Yes
No
825
Take traffic out Of service or use Protection mode
830
Install splitters And combiners
835
Install optical bypass
840
Recover Hardware

Figure 8

OPTICAL BYPASS METHOD AND ARCHITECTURE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to Provisional Application Ser. No. 60/386,084 entitled "Optical Bypass Method and Architecture", by Young, filed Jun. 4, 2003.

FIELD OF THE INVENTION

The present invention relates, in general, to the field of optical communications, and in particular to optical fiber transmission networks. The invention is particularly relevant to transmission of high volume of data and voice traffic among different locations. In particular, the invention teaches improvements to an optical transport system to allow for efficient and flexible network evolution. The invention teaches a method and architecture for bypassing a terminal site without affecting existing traffic.

BACKGROUND OF THE INVENTION

A goal of many modern long haul optical transport systems is to provide for the efficient transmission of large volumes of voice traffic and data traffic over trans-continental distances at low costs. Various methods of achieving these goals include time division multiplexing (TDM) and wavelength division multiplexing (WDM). In time division multiplexed systems, data streams comprised of short pulses of light are interleaved in the time domain to achieve high spectral efficiency, high data rate transport. In wavelength division multiplexed systems, data streams comprised of short pulses of light of different carrier frequencies, or equivalently wavelength, are co-propagate in the same fiber to achieve high spectral efficiency, high data rate transport.

The transmission medium of these systems is typically optical fiber. In addition there is a transmitter and a receiver. The transmitter typically includes a semiconductor diode laser, and supporting electronics. The laser is often a DFB laser stabilized to a specified frequency on the ITU frequency grid. The laser may be directly modulated with a data train with an advantage of low cost, and a disadvantage of low reach and capacity performance. In many long haul systems, the laser is externally modulated using a modulator. A single stage modulator is sufficient for a non-return-zero (NRZ) modulation format. A two stage modulator is typically used with the higher performance return-to-zero (RZ) modulation format. An example of a modulator technology is the Mach-Zehnder lithium niobate modulator. Alternatively, an electro-absorptive modulator may be used. After binary modulation, a high bit may be transmitted as an optical signal level with more power than the optical signal level in a low bit. Often, the optical signal level in a low bit is engineered to be equal to, or approximately equal to zero. In addition to binary modulation, the data can be transmitted with multiple levels, although in current optical transport systems, a two level binary modulation scheme is predominantly employed. The receiver is located at the opposite end of the optical fiber, from the transmitter. The receiver is typically comprised of a semiconductor photodetector and accompanying electronics.

Typical long haul optical transport dense wavelength division multiplexed (DWDM) systems transmit 40 to 80 10 Gbps (gigabit per second) channels across distances of 1000 to 6000 km in a single 30 nm spectral band. In a duplex

system, traffic is both transmitted and received between parties at opposite end of the link. In a DWDM system, different channels operating at distinct carrier frequencies are multiplexed using a multiplexer. Such multiplexers may be implemented using array waveguide grating (AWG) technology or thin film technology, or a variety of other technologies. After multiplexing, the optical signals are coupled into the transport fiber for transmission to the receiving end of the link. The total link distance may in today's optical transport systems be two different cities separated by continental distances, from 1000 km to 6000 km, for example. To successfully bridge these distances with sufficient optical signal power relative to noise, the signal is periodically amplified using an in line optical amplifier. Typical span distances between optical amplifiers are 50–100 km. Thus, for example, 30 100 km spans would be used to transmit optical signals between points 3000 km apart. Examples of inline optical amplifiers include erbium doped fiber amplifiers (EDFAs) and semiconductor optical amplifiers (SOAs).

At the receiving end of the link, the optical channels are demultiplexed using a demultiplexer. Such demultiplexers may be implemented using array waveguide (AWG) technology or thin film technology, or a variety of other technologies. Each channel is then optically coupled to separate optical receivers.

Other common variations include the presence of post-amplifiers and pre-amplifiers just before and after the multiplexer and de-multiplexer. Often, there is also included dispersion compensation with the in line amplifiers. These dispersion compensators adjust the phase information of the optical pulses in order to compensate for the chromatic dispersion in the optical fiber while appreciating the role of optical nonlinearities in the optical fiber. Another variation that may be employed is the optical dropping and adding of channels at cities located in between the two end cities. The invention disclosed herein, would find application in any of these variations, as well as others.

Traditionally, optical transport systems are deployed in networks in order to provide connectivity among many cities on a continental or global basis. The selection of type and quantity of equipment is done according to a traffic demand schedule, and differences in demand, or changing demand will consequently change the optimum network design. Modern networks are characterized by large capital and operational costs and must be managed efficiently to be profitable in a competitive market. From a technological standpoint the efficient buildout of a network in a changing traffic demand environment is hampered by the flexibility of current optical transport equipment. There is a need for flexible optical transport systems that support optimal network designs under different traffic loads.

SUMMARY OF THE INVENTION

In the present invention, improvements to an optical transport system to allow for efficient and flexible network evolution are disclosed. More specifically, the invention teaches a method and architecture for bypassing a terminal site without affecting existing traffic.

In one embodiment of the invention, an architecture for optically bypassing a terminal site is taught.

In another embodiment of the invention, a method for optically bypassing a terminal site is taught.

In another embodiment of the invention, a means of upgrading a terminal site to behave effectively like an optical add-drop (OADM) site is taught.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the features and advantages of the present invention, reference is now made to the detailed description of the invention along with the accompanying figures in which corresponding numerals in the different figures refer to corresponding parts and in which:

FIG. **1** is a schematic illustration of a prior art terminal site with an inefficient implementation of pass through traffic.

FIG. **2** is a schematic illustration of a terminal site with pass through traffic managed by an optical bypass switch in accordance with the invention.

FIG. **3** is a schematic illustration of a terminal showing the connection location to the optical bypass switch in accordance with a preferred embodiment.

FIG. **4** is a schematic illustration of a terminal showing the connection location to the optical bypass switch in accordance with an alternate preferred embodiment.

FIG. **5** is a schematic illustration of a terminal showing the connection location to the optical bypass switch in accordance with an alternate preferred embodiment.

FIG. **6** is a schematic illustration of a terminal showing the connection location to the optical bypass switch in accordance with an alternate preferred embodiment.

FIG. **7** is flowchart of a method of optically bypassing a terminal site in accordance with a preferred embodiment.

FIG. **8** is a flowchart of a method of evaluating the need for and installing optical splitters.

DETAILED DESCRIPTION OF THE INVENTION

While the making and using of various embodiments of the present invention are discussed in detail below, it should be appreciated that the present invention provides many applicable inventive concepts that can be embodied in a wide variety of specific contexts. The specific embodiments described herein are merely illustrative of specific ways to make and use the invention and do not delimit the scope of the invention.

In FIG. **1** is shown a prior art block diagram of a terminal site of an optical communications network. In FIG. **1** is shown long haul fiber pair **122**, terminal **110**, terminal **112** and long haul fiber pair **124**. Long haul fiber pair **122** and long haul fiber pair **124** are realized by cabled optical fiber such as SMF-28 or LEAF and provide media for transmitting long haul optical signals to adjacent network elements such as terminal sites, OADM sites, or amplifier sites. Terminal **110** and terminal **112** comprise a set of line cards including transceiver cards, amplifier cards, dispersion compensation cards multiplexer-demultiplexer cards, and other functional line cards. Terminal **110** provides optical to electrical termination of optical signals from long haul fiber pair **122**. Terminal **110** also provides electrical to optical generation for electrical signals sent on long haul fiber pair **122**. Terminal **112** provides optical to electrical termination from long haul fiber pair **124**. Terminal **112** also provides electrical to optical generation for electrical signals sent on long haul fiber pair **124**.

Also shown in FIG. **1** is local fiber patch cord pair **126** and local node element **114**. Local node element **114** may comprise a local terminal that is part of a short haul, or metro system, or it may be a switch or router. Local fiber patch cord pair **126** is realized by a pair of connectorized jacketed optical fibers. A non-limiting representative length range of local fiber patch cord pair **126** is 10 m–10 km. Local fiber patch cord pair **126** provides the transmission media for optical signals between terminal **110** and local node element **114**.

Also shown in FIG. **1** are pass through fiber patch cord pair **130**, pass through fiber patch cord pair **132**, pass through fiber patch cord pair **134**, pass through fiber patch cord pair **136**, and pass through fiber patch cord pair **138**. Pass through fiber patch cord pair **130** is realized by a pair of connectorized jacketed optical fibers. A non-limiting representative length range of pass through fiber patch cord pair **130** is 10–100 m. Pass through fiber patch cord pair **132** is realized by a pair of connectorized jacketed optical fibers. A non-limiting representative length range of pass through fiber patch cord pair **132** is 10–100 m. Pass through fiber patch cord pair **134** is realized by a pair of connectorized jacketed optical fibers. A non-limiting representative length range of pass through fiber patch cord pair **134** is 10–100 m. Pass through fiber patch cord pair **136** is realized by a pair of connectorized jacketed optical fibers. A non-limiting representative length range of pass through fiber patch cord pair **136** is 10–100 m. Pass through fiber patch cord pair **138** is realized by a pair of connectorized jacketed optical fibers. A non-limiting representative length range of pass through fiber patch cord pair **138** is 10–100 m. The exact number of local fiber patch cord pairs and pass through fiber patch cord pairs is merely representative and non-limiting. The relative number of local fiber patch cord pairs to pass through fiber patch cord pairs is merely representative and non-limiting. Further, the number of local fiber patch cord pairs and pass through fiber patch cord pairs will change as the traffic in the network changes, over the lifetime of the system. Initially, terminal **110** will drop and add more traffic to local node element **114**, than will be patched through to terminal **112**. As the network grows, however, much of the traffic will end up patched through from terminal **110** to terminal **112**. Modem transport equipment can support as many as 200 channels so the cost, management and routing of patch cords becomes problematic.

The invention seeks to eliminate pass through fiber patch cords in a network traffic flexible manner with no impact on the initial cost of the system. Further, since each fiber patch cord pair is connected to a transceiver card, the cost of said card will also be reduced or eliminated due to the benefits of the invention.

In FIG. **2** is shown a schematic illustration of a terminal site with pass through traffic managed by an optical bypass switch in accordance with one aspect of the invention. Shown in FIG. **2** are optical splitter **202**, optical combiner **204**, optical combiner **206** and optical splitter **208**. In a preferred embodiment, optical splitter **202** is realized by a thin film optical decoupler. In an alternate embodiment, optical splitter **202** is realized by a fused optical fiber decoupler. In a preferred embodiment, optical combiner **204** is realized by a thin film optical coupler. In an alternate embodiment, optical combiner **204** is realized by a fused optical fiber coupler. In a preferred embodiment, optical combiner **206** is realized by a thin film optical coupler. In an alternate embodiment, optical combiner **206** is realized by a fused optical fiber coupler. In a preferred embodiment, optical splitter **208** is realized by a thin film optical decoupler. In an alternate embodiment, optical splitter **208** is realized by a fused optical fiber decoupler.

Also shown in FIG. **2** is optical bypass switch **210** and optical bypass switch **212**. In a preferred embodiment, optical bypass switch **210** is realized by a dynamic spectral equalizer. In a preferred embodiment, optical bypass switch

212 is realized by a dynamic spectral equalizer. Dynamic spectral equalizers are commercially available and perform three basic functions. Firstly, dynamic spectral equalizers spectrally decompose the DWDM wavelengths (channels) on the input fiber into physically separate paths. Secondly, dynamic spectral equalizers provide channel by channel attenuation or extinguishing on a programmable and changeable basis. Thirdly, dynamic spectral equalizers spectrally recombine the non-extinguished channels onto a single output fiber.

The signal flow path of the invention may now be understood in reference to FIG. 2. An input DWDM signal propagating in long haul fiber pair **122** towards terminal **110** is split by optical splitter **202** so that a portion of the signal continues to propagate towards terminal **110** and the remaining portion propagates into optical bypass switch **210**. Within optical bypass switch **210**, the DWDM signal is decomposed by a diffraction grating or other spectral decomposition device. The separated channels are subsequently attenuated. The attenuation is set so that channel powers will be compatible with those channels that will be combined from the terminal in optical combiner **206**. If a particular channel is to be transmitted from terminal **112**, optical bypass switch **210** extinguishes that channel's wavelength. In normal mode of operation, if a particular channel is to be received in terminal **110** optical bypass switch **210** extinguishes that channel's wavelength. In broadcast mode of operation, if a particular channel is to be received in terminal **110** optical bypass switch **210** does not extinguish that channel's wavelength, however in this mode, terminal **112** may not transmit at this wavelength. The remaining channels are then recombined in optical bypass switch **210** and output optical bypass switch **210**. The output signal is combined with the transmitted signals from terminal **112** in optical combiner **206**.

The reverse signal flow is similar, and will now be disclosed explicitly. An input DWDM signal propagating in long haul fiber pair **124** towards terminal **112** is split by optical splitter **208** so that a portion of the signal continues to propagate towards terminal **112** and the remaining portion propagates into optical bypass switch **212**. Within optical bypass switch **212**, the DWDM signal is decomposed by a diffraction grating or other spectral decomposition device. The separated channels are subsequently attenuated. The attenuation is set so that channel powers will be compatible with those channels that will be combined from the terminal in optical combiner **204**. If a particular channel is to be transmitted from terminal **110**, optical bypass switch **212** extinguishes that channel's wavelength. In normal mode of operation, if a particular channel is to be received in terminal **112** optical bypass switch **212** extinguishes that channel's wavelength. In broadcast mode of operation, if a particular channel is to be received in terminal **112** optical bypass switch **212** does not extinguish that channel's wavelength, however in this mode, terminal **110** may not transmit at this wavelength. The remaining channels are then recombined in optical bypass switch **212** and output optical bypass switch **212**. The output signal is combined with the transmitted signals from terminal **110** in optical combiner **204**.

In a preferred embodiment optical bypass switch **210** and optical bypass switch **212** are combined in a single bidirectional optical bypass switch commercially sold as a bidirectional dynamic spectral equalizer.

This architecture and method of creating optical bypass of a terminal node allows for the recovery of expensive transceivers at a terminal site, regardless of when the terminal was deployed. The optical bypass architecture may be designed and deployed for a wide variety of existing equipment in current networks. The programmability of optical bypass switch **210** and optical bypass switch **212** eliminates detailed pre-planning of a network which leads to inefficiency.

An important aspect of this invention is that only optical splitter **202**, optical combiner **204**, optical combiner **206** and optical splitter **208** need be installed with the system at initial deployment. In this manner, optical bypass switch **210** and optical bypass switch **212** can be deployed in a non-traffic effecting manner at the point in time when a sufficient amount of bypass traffic exists.

In FIG. **3** is shown a block diagram of certain components of terminal **110** and their arrangement relative to long haul optical fiber pair **122**, optical splitter **202** and optical combiner **204**. Shown in FIG. **3** are input first stage optical amplifier **310**, input dispersion compensator **320**, input second stage optical amplifier **312**, demultiplexer **324**, optical receiver **332** and optical receiver **334**. Together, input first stage optical amplifier **310**, input dispersion compensator **320**, input second stage optical amplifier **312**, demultiplexer **324**, optical receiver **332** and optical receiver **334** comprise the receiving portion of terminal **110**. Also shown in FIG. **3** are output first stage optical amplifier **316**, output dispersion compensator **322**, output second stage optical amplifier **314**, multiplexer **326**, optical transmitter **336** and optical transmitter **338**. Together, output first stage optical amplifier **316**, output dispersion compensator **322**, output second stage optical amplifier **314**, multiplexer **326**, optical transmitter **336** and optical transmitter **338** comprise the transmitting portion of terminal **110**. In a preferred embodiment input first stage optical amplifier **310**, input second stage optical amplifier **312**, output first stage optical amplifier **316** and output second stage optical amplifier **314** are realized by erbium doped fiber amplifiers (EDFAs). Input first stage optical amplifier **310**, input second stage optical amplifier **312**, output first stage optical amplifier **316** and output second stage optical amplifier **314** function to combat the impairment of attenuation that the optical signals encounter in long haul fiber pair **122**. In a preferred embodiment, input dispersion compensator **320** and output dispersion compensator **322** are realized by specialty dispersion compensating fiber. Input dispersion compensator **320** and output dispersion compensator **322** function to combat the impairment of dispersion that the optical signals encounter in fiber pair **122**. In a preferred embodiment optical receiver **332** and optical receiver **334** are realized with semiconductor photodetectors and high speed amplifying, filtering and decision electronics, as is well known in the art. In a preferred embodiment optical transmitter **336** and optical transmitter **338** are realized with semiconductor lasers modulators, biasing and drive electronics, as is well known in the art. The number of optical receivers and optical transmitters in FIG. **1** is not meant to be restrictive. Modern optical transport systems may comprise 200 optical receivers and the same number of optical transmitters. Further, as channel counts become high, additional optical amplifiers may also be deployed. It should also be noted that if optical splitter **202** and optical combiner **204** are applied to an existing terminal **110**, then the internal arrangement of terminal **110** and even the presence of the components within terminal **110** may vary.

In FIG. **3**, optical splitter **202** and optical combiner **204** are located outside and in close proximity to terminal **110**. This location offers logistical advantages including ease of operation and installation. In alternate embodiments of this invention, alternate locations provide alternate advantages.

Referring now to FIG. **4** for an alternate preferred embodiment of the invention, optical splitter **202** and optical combiner **204** are located in alternate locations internal to terminal **110**. In this embodiment of the invention, input first stage optical amplifier **310**, input second stage optical amplifier **312**, output first stage optical amplifier **316** and output second stage optical amplifier **314** function to combat the approximate 3dB loss associated with optical splitter **202** and optical combiner **204**.

Referring now to FIG. **5** for an alternate preferred embodiment of the invention, optical splitter **202** is located internal to terminal **110** after input first stage optical amplifier **310**, input second stage optical amplifier **312** to allow input first stage optical amplifier **310**, input second stage optical amplifier **312** to amplify the weak input optical signal arriving at terminal **110**. Optical combiner **204** is located after output second stage optical amplifier **314**. This embodiment allows for the correct dispersion compensation amount to be applied to the optical signals.

Referring now to FIG. **6** for an alternate preferred embodiment of the invention, optical splitter **202** is located internal to terminal **110** after input dispersion compensator **320** and before input second stage optical amplifier **312**. In this embodiment optical combiner **204** is located internal to terminal **110** after output dispersion compensator **320** and before output second stage optical amplifier **312**. This embodiment allows for the correct dispersion compensation amount to be applied to the optical signals, with the smallest impact to system performance and no impact to terminal optical loss budget.

In FIG. **7** is shown a flow chart of a method for optically bypassing a terminal site is taught in accordance with the invention. In step **710**, terminal **110** is installed at a terminal site in an optical network. In step **715**, Optical splitter **202** and optical combiner **204** are installed in or in close proximity to terminal **110**. In step **720**, add channels to the network as traffic demand grows. In step **725**, the decision is made whether optical bypass switch **210** and optical bypass switch **212** are justified economically. This decision is based on capital costs and discounted operational costs at the time of the decision. If the decision is negative, then no bypass switch is installed, until additional channels are added. If the decision is positive, then optical bypass switch **210** and optical bypass switch **212** are installed in step **730**. In step **735**, transceiver and other hardware may be recovered and redeployed elsewhere in the network.

FIG. **8** shows a flow chart of a method for evaluating the need for installing optical splitters at a terminal site in accordance with the invention for which optical bypass was not originally envisioned. In step **810**, terminal **110** is installed at a terminal site on an optical network. In step **815**, channels are added in the normal course to the optical network as traffic grows. At step **820** an evaluation is made of the necessity for a splitter and optical bypass system. The decision is based on capital costs and discounted operational costs at the time of the decision. If the decision is negative, then no splitter is installed, until additional channels are added. If the decision is positive, then the splitter and optical combiner are installed in step **830**. In step **835**, the optical bypass switch is installed. In step **840** transceiver and other hardware may be recovered and redeployed elsewhere in the network.

While this invention has been described in reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications and combinations of the illustrative embodiments, as well as other embodiments of the invention, will be apparent to persons skilled in the art upon reference to the description. It is therefore intended that the appended claims encompass any such modifications or embodiments.

What is claimed is:

1. A terminal for use in an optical bypass system comprising:

an optical splitter connected to an incoming optical fiber;

a first amplifier connected to the optical splitter;

at least one optical receiver connected to the optical amplifier;

an optical combiner connected to an outgoing optical fiber;

a second amplifier connected to the optical combiner;

at least one optical transmitter connected to the second amplifier.

2. The terminal of claim **1** wherein the first amplifier is a multi stage amplifier.

3. The terminal of claim **2** wherein a dispersion compensation module is interposed between the stages of the multi stage amplifier.

4. The terminal of claim **1** wherein the second amplifier is a multi stage amplifier.

5. The terminal of claim **4** wherein a dispersion compensation module is interposed between the stages of the multi stage amplifier.

6. The terminal of claim **1** wherein the optical splitter is connected to a first bypass switch.

7. The terminal of claim **6** wherein the first bypass switch is a dynamic spectral equalizer.

8. The terminal of claim **6** wherein the optical combiner is connected to a second bypass switch.

9. The terminal of claim **8** wherein the second bypass switch is a dynamic spectral equalizer.

10. A terminal for use in an optical bypass system comprising:

a first amplifier connected an incoming optical fiber;

an optical splitter connected to the first amplifier;

at least one optical receiver connected to the optical splitter;

a second amplifier connected to an outgoing optical fiber;

an optical combiner connected to the second amplifier;

at least one optical transmitter connected to the optical combiner.

11. The terminal of claim **10** wherein the first amplifier is a multi stage amplifier.

12. The terminal of claim **11** wherein a dispersion compensation module is interposed between the stages of the multi stage amplifier.

13. The terminal of claim **10** wherein the second amplifier is a multi stage amplifier.

14. The terminal of claim **13** wherein a dispersion compensation module is interposed between the stages of the multi stage amplifier.

15. The terminal of claim **10** wherein the optical splitter is connected to a first bypass switch.

16. The terminal of claim **15** wherein the first bypass switch is a dynamic spectral equalizer.

17. The terminal of claim **15** wherein the optical combiner is connected to a second bypass switch.

18. The terminal of claim **17** wherein the second bypass switch is a dynamic spectral equalizer.

19. A terminal for use in an optical bypass system comprising:

a first amplifier connected to an incoming optical fiber;

an optical splitter connected to the first amplifier;

at least one optical receiver connected to the optical splitter;

an optical combiner connected to an outgoing optical fiber;

a second amplifier connected to the optical combiner;

at least one optical transmitter connected to the second amplifier.

20. The terminal of claim **19** wherein the first amplifier is a multi stage amplifier.

21. The terminal of claim **20** wherein a dispersion compensation module is interposed between the stages of the multi stage amplifier.

22. The terminal of claim **19** wherein the second amplifier is a multi stage amplifier.

23. The terminal of claim **22** wherein a dispersion compensation module is interposed between the stages of the multi stage amplifier.

24. The terminal of claim **19** wherein the optical splitter is connected to a first bypass switch.

25. The terminal of claim **24** wherein the first bypass switch is a dynamic spectral equalizer.

26. A terminal for use in an optical bypass system comprising:

an incoming multi stage amplifier having at least an incoming first stage and an incoming second stage connected to an incoming optical fiber;

a first dispersion compensation module connected to the incoming first stage;

an optical splitter connected to the first dispersion compensation module and to the incoming second stage;

at least one optical receiver connected to the incoming second stage;

an outgoing multi stage amplifier having at least an outgoing first stage and an outgoing second stage connected to an outgoing optical fiber;

an optical combiner connected to the outgoing second stage;

a second dispersion compensation module connected to the optical combiner;

the outgoing first stage connected to the dispersion combiner;

at least one optical transmitter connected to the outgoing first stage.

27. A terminal for use in an optical bypass system comprising:

an incoming multi stage amplifier having at least an incoming first stage and an incoming second stage connected to an incoming optical fiber;

a first dispersion compensation module connected to the incoming first stage;

an optical splitter connected to the first dispersion compensation module and to the incoming second stage;

at least one optical receiver connected to the incoming second stage;

an outgoing multi stage amplifier having at least an outgoing first stage and an outgoing second stage connected to an outgoing optical fiber;

an optical combiner connected to the outgoing second stage;

a second dispersion compensation module connected to the optical combiner;

the outgoing first stage connected to the dispersion combiner;

at least one optical transmitter connected to the outgoing first stage wherein the optical splitter is connected to a first bypass switch.

28. A terminal for use in an optical bypass system comprising:

an incoming multi stage amplifier having at least an incoming first stage and an incoming second stage connected to an incoming optical fiber;

a first dispersion compensation module connected to the incoming first stage;

an optical splitter connected to the first dispersion compensation module and to the incoming second stage;

at least one optical receiver connected to the incoming second stage;

an outgoing multi stage amplifier having at least an outgoing first stage and an outgoing second stage connected to an outgoing optical fiber;

an optical combiner connected to the outgoing second stage;

a second dispersion compensation module connected to the optical combiner;

the outgoing first stage connected to the dispersion combiner;

at least one optical transmitter connected to the outgoing first stage wherein the first bypass switch is a dynamic spectral equalizer.

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