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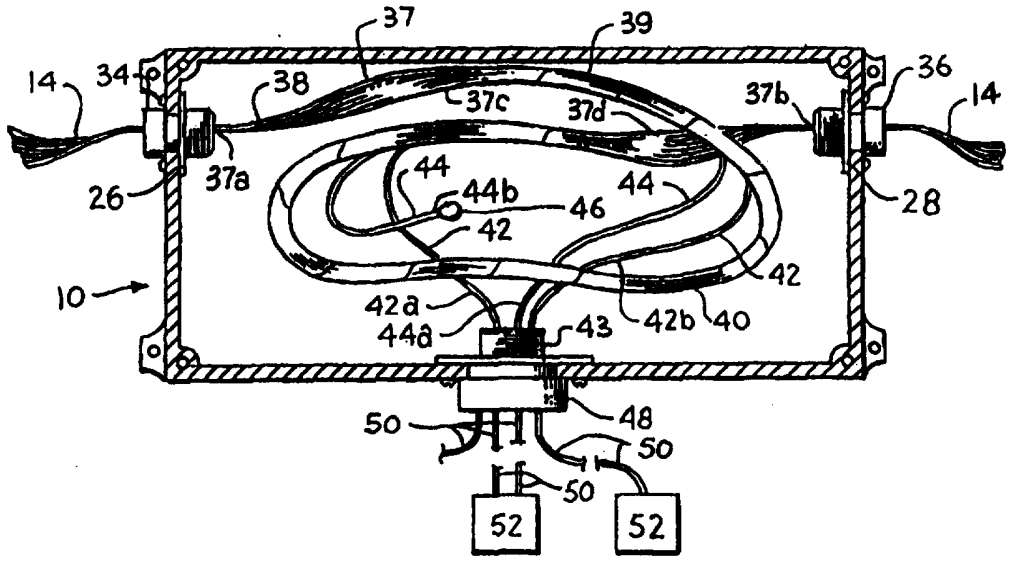
(54) Title: FIBER OPTIC TRUNKLINE FOR AN AIRCRAFT WITH BREAKOUT BOXES THERE ALONG



(57) Abstract

A system and method to breakout and splice into optical circuits in a ribbon cable trunkline extending throughout an aircraft with optical minimal loss. Breakout boxes are positioned at strategic locations along the aircraft's fiber optic trunkline. Within each box, optical fibers in a loose bundle are permanently connected in ribbon cable form to the inner sides of cable connectors physically connected to the box, each extending through a wall of the box. The ribbon cable forms are transitioned into the fibers in the bundle, which are longer than the spacing between the cable connectors. When an optical fiber circuit needs to be broken out at the location of a particular box, the proper fiber in the bundle is cut and one or both ends that result are permanently connected to a breakout connector, also positionned through the box, so that the optical circuit appears on the breakout connector outside the box where a mating connector can be used to further route the optical circuit being broken out.

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FIBER OPTIC TRUNKLINE FOR AN AIRCRAFT WITH BREAKOUT BOXES THERE ALONG

Background of the Invention

During the development, production and modification of aircraft, it is often required that additional connections must be made to the communication busses that extend throughout the aircraft. When an electrical buss is used, techniques to splice into or reroute the wire of a communication channel of the buss are well developed. Aircraft are now being designed using a fiber optic trunkline usually formed using multi-fiber optical ribbon cable. Unfortunately, after the ribbon cable has been constructed, splicing into or breaking out a fiber from the middle thereof is difficult and labor intensive.

Various solutions that allow after manufacture changes to the configuration of fiber optic cables are shown in the prior art. For example, Brown in U.S. Patent 3,902,786 discloses an optical access coupler. Nolf, et al. in U.S. Patent 4,648,068 disclose a technique for protecting an optical fiber breakout one fiber at a time. Hogan, et al. in U.S. Patent 5,109,467 disclose a cabinet in which optical fibers can be interconnected. Balow, et al. in U.S. Patent 5,127,082 disclose a fiber optic patch panel. Bullock, et al. in U.S. Patent 5,267,338 show a low profile cable having component breakouts there along. Karon in U.S. Patent 5,394,502 shows a harness to support breakouts in a fiber optic cable. Dietz, Jr., et al. in U.S. Patent 5,394,503 disclose an optical patch panel wherein the connection between optical fibers can be switched. Korkowski, et al. in U.S. Patent 5,432,875 show a fiber optic connector module, which has beam splitters incorporated therein.

Renichi Wuguchi, et al. in Japanese application 61-

283669 published October 20, 1988 disclose a fiber optic breakout box with a pair of optical line connectors and a breakout connector mounted thereto for connection to external optical cables. Optical patch cords having connectors on the opposite ends thereof, are used inside the box to make or break connections between the line connectors and the breakout connector to establish the desired optical circuits and to allow the connections to be modified in the field.

Brief Description of the Invention

The present invention provides the ability to breakout and splice into optical circuits in a trunkline extending throughout an aircraft with minimal loss. Breakout boxes are positioned at strategic locations along the aircraft's fiber optic trunkline located along the longitudinal axis of an aircraft. The trunkline is usually constructed using a plurality of multi-fiber ribbon cable segments. Conventional ribbon cable connectors, such as those known as AVMAC to which Berg Electronics owns the rights, are attached to each end of a ribbon cable segment. Mating fixed AVMAC connectors extend through opposite sides of each breakout box. Within the box, fibers in a loose bundle are permanently connected to the inner sides of the fixed ribbon cable connectors. The permanent connection minimizes optical loss and increases the reliability of the trunkline. The bundle preferably is longer than the spacing between the fixed connectors and is formed in a loop. One or more breakout connectors are provided through the box. When an optical fiber circuit needs to be broken out at the location of a particular box, the proper fiber in the bundle is cut and one or both ends that result are permanently connected to a breakout connector so that the optical circuit appears on the connector outside the box where a mating connector can be used to further route the optical circuit. The loop

provides enough slack so that either end of the cut fiber can be terminated and reach any breakout connector. The interior side of the breakout connector may be of any suitable configuration that allows manual permanent fiber connection thereto. The exterior of the breakout connector, however, preferably is of a standard fiber optic cable configuration allowing the circuits that are broken out to be easily connected to various optical components.

Therefore, the present aircraft trunkline with breakout boxes allows optical circuits to be permanently rerouted within the confines of an aircraft with minimal optical power loss. Little optical penalty results because normally the routing of optical cable within an aircraft requires numerous cable segments anyhow that need to be connected together to accommodate installation and repair, and the boxes can be positioned to also fill that purpose.

Therefore, it is an object of the present invention to provide economical means that allow breakouts from optical ribbon cables used as multi-channel optical trunklines in aircraft.

Another object is to provide an aircraft optical cable breakout box in an aircraft optical trunkline which minimizes the optical loss therein, especially for circuits where no breakout is needed.

Another object is to provide an optical cable breakout box having low optical loss so that a multiplicity of the boxes may be positioned along an optical trunkline in an aircraft without requiring excessive power or amplifiers there along.

These and other objects and advantages of the present invention will become apparent to those skilled in the art after considering the following detailed specification, together with accompanying drawing wherein:

Brief Description of the Drawing.

Figure 1 is a diagrammatic side elevational view of an aircraft having an optical trunkline with breakout boxes constructed according to the present invention strategically positioned there along;

Figure 2 is a side view of the breakout box of the present invention with ribbon cable connected at both sides thereof; and

Figure 3 is a cross-sectional view taken at line 3-3 of Figure 2 showing how typical breakouts and splices are accomplished.

Detailed Description of the Shown Embodiment.

Referring to the drawing more particularly by reference numbers, number 10 in Figure 1 refers to breakout boxes positioned along an optical trunk line 12 made up of a plurality of ribbon cables segments 14, which extend longitudinally along the fuselage 16 of an aircraft 18.

As shown in Figures 2 and 3, the box 10 includes a container 20 closed by a cover 22 held in place by suitable fasteners 24. An input/output port connector 26 and an output/input port connector 28 are provided at the opposite ends 30 and 32 of the container 20. The optical connectors 26 and 28 are designed to mate with optical plugs 34 and 36 attached to the ends of the ribbon cable segments 14. The optical loss between the connectors 26 and 28, and the plugs 34 and 36 can be very low. The optical connectors 26 and 28 are connected by a pre-made breakout cable 37 that includes a plurality of individual optical fibers 38. The ends 37a and 37b of the breakout cable are in the form of ribbon cable for connection to the fibers in the optical plugs 34 and 36, whereas breakout portions 37c and 37d where the plurality of fibers 38 are broken out, sheathed, and formed into a central loose bundle 39. The loose bundle 39 has enough extra length so that a loop 40 can be formed within the box 10 between the connectors 26 and 28. The loop 40

provides enough slack in each of the fibers of the central bundle 39 so that as shown in Figure 3, a fiber 42 can be cut at its middle, terminated, and both ends 42a and 42b be permanently connected to a suitable branch port connector 43 by manual means when the cover 22 of the container 20 has been removed. Normally, this would be accomplished by disconnecting the connectors 26 and 28 from the optical plugs 34 and 36, removing the box 10 from the aircraft 18 for the modification work, and reinstalling the box 10 in the aircraft 18. A fiber 44 also can be cut and only one end 44a of two ends 44a and 44b that result, be terminated and attached to the connector 43. If the unconnected end 44b is an extension of an active optical circuit, a light absorbing termination 46 is applied thereto. In this way, any circuit present on the trunkline 12 can be broken out at any breakout box 10 either by splicing to a loop circuit, or by cutting into the fiber circuit and leaving the remaining portion thereof dead or unconnected across the box 10.

Connections are made to the branch port connector 43 by a suitable male or female plug 48, which can be made up having the suitable number of fibers 50 extending therefrom to optical units 52.

The breakout boxes 10 can be configured as shown in Figure 3 during their manufacture and yet provide the versatility to allow changes to accommodate changes in the configuration of the aircraft 18. Some changes might be cutting shaped passages 54 and/or 56 (Figure 2) through the box 10 so that optical connectors with different configurations can be used in the future without requiring disturbance of the connector 43.

Thus, there has been shown a novel optical trunkline with breakout boxes there along specifically for use on aircraft where minimal optical loss is required and, in most cases, few changes are needed during the lifetime of the aircraft so that permanent connections are desired, which

fulfills all of the objects and advantages sought therefor. Many changes, alterations, modifications and other uses and applications of the subject breakout box will become apparent to those skilled in the art after considering the specification together with the accompanying drawing. All such changes, alterations and modifications which do not depart from the spirit and scope of the invention are deemed to be covered by the invention which is limited only by the claims that follow.

Claims

1. An optical trunkline for an aircraft having:

at least two trunkline multi-fiber optical cable segments, each having:

first and second ends; and

an optical plug on at least one of said first and second ends; and

a circuit breakout box including:

an inside;

an outside; and

an access extending from said inside to said outside;

a cover for closing said access;

a first optical connector attached to said box extending from said inside to said outside of said box, said first optical connector having:

a first outside portion adapted to removably connect to said optical plug of one of said optical cable segments; and

a first inside portion adapted for permanent optical connection to a plurality of optical fibers;

a second optical connector attached to said box extending from said inside to said outside of said box, said second optical connector having:

a second outside portion adapted to removably connect to said optical plug of one of said optical cable segments; and

a second inside portion adapted for permanent optical connection to a plurality of optical fibers;

a bundle of optical fibers positioned within said box, at least one optical fiber of said bundle of optical fibers being permanently connected between said first and second inside portions of said first and second connectors; and

at least one breakout connector having:

a third outside portion adapted to removably connect to at least one optical fiber; and

a third inside portion adapted for permanent optical connection to at least one optical fiber from said bundle of optical fibers.

2. The optical trunkline as defined in claim 1 wherein said first and second connectors are a fixed distance apart and said at least one breakout connector is positioned closer to said first and second connectors than said fixed distance, said bundle of optical fibers being substantially longer than said fixed distance so that if said at least one optical fiber is severed in the middle thereof, both resulting ends thereof are of sufficient length to be permanently connected to said at least one breakout connector.

3. The optical trunkline as defined in claim 2 wherein said at least two optical cable segments are optical ribbon cables, and said bundle of optical fibers include:

a first ribbon cable end connected to said first inside portion of said first optical connector;

a second ribbon cable end connected to said second inside portion of said second optical connector;

a central bundle portion of loosely packaged fibers;

a first breakout portion connecting said first ribbon cable end to said central bundle portion; and

a second breakout portion connecting said second ribbon cable end to said central bundle portion.

4. The optical trunkline as defined in claim 3 wherein at least one fiber in said bundle is disconnected from said second connector and connected to said at least one breakout connector.

5. A method for providing optical circuit in service breakouts for an existing aircraft optical trunkline including:

providing a container having:

an inside;

an outside; and

an access port extending from the inside to the outside;

providing a first optical connector attached to the container extending from the inside to the outside of the container, the first optical connector having:

a first outside portion adapted to removably connect to a plug at an end of a first multi-fiber optical cable forming a portion of the optical trunkline; and

a first inside portion adapted for permanent optical connection to a plurality of optical fibers;

providing a second connector attached to the container extending from the inside to the outside of the container, the second optical connector having:

a second outside portion adapted to removably connect to a plug at an end of a second multi-fiber optical cable forming a portion of the optical trunkline; and

a second inside portion adapted for permanent optical connection to a plurality of optical fibers;

providing at least one breakout optical connector having:

a third outside portion adapted to removably connect to at least one optical fiber; and

a third inside portion adapted for permanent optical connection to at least one optical fiber;

providing a plurality of optical fibers positioned within the container, at least one optical fiber of the plurality of optical fibers being permanently connected between the first and second inside portions of the first and second optical connectors;

cutting the at least one optical fiber at a location between the first and second inside portions of the first and second optical connectors to form two ends thereon; and

permanently connecting at least one end of the at least one optical fiber to the third inside portion of the breakout optical connector.

6. The method for providing optical circuit breakout for an aircraft optical trunkline as defined in claim 5 wherein the providing of a plurality of optical fibers includes:

providing first and second ribbon cable portions for connection to the first and second inside portion;

providing a loose fiber bundle portion to provide the cutting location; and

providing a first transition portion between the first ribbon cable portion and the loose fiber bundle portion; and

providing a second transition portion between the second ribbon cable portion and the loose fiber bundle portion.

7. The method for providing optical circuit breakout for an aircraft optical trunkline as defined in claim 5 wherein said cutting the at least one optical fiber at a location between the first and second inside portions of the first and second connectors to form two ends thereon, includes:

cutting the at least one optical fiber at a central location between the first and second optical connectors, and wherein permanently connecting at least one end of the at least one optical fiber to the third inside portion of the breakout optical connector includes:

permanently connecting both ends to the third inside portion of the breakout optical connector.

8. The method for providing optical circuit breakout for an aircraft optical trunkline as defined in claim 7 further:

removably connecting an optical loop to the third

outside portion of the at least one breakout connector.

9. The method for providing optical circuit breakout for an aircraft optical trunkline as defined in claim 5 further including:

providing a second container having:

an inside;

an outside;

an access port extending from the inside to the outside; and

a cover for closing the access port;

providing a second first optical connector attached to the second container extending from the inside to the outside of the second container, the second first optical connector having:

a first outside portion adapted to removably connect to a plug at an end of the second multi-fiber optical cable forming a portion of the optical trunkline; and

a first inside portion adapted for permanent optical connection to a plurality of optical fibers;

providing a second second connector attached to the second container extending from the inside to the outside of the second container, the second second optical connector having:

a second outside portion adapted to removably connect to a plug at an end of a third multi-fiber optical cable forming a portion of the optical trunkline; and

a second inside portion adapted for permanent optical connection to a plurality of optical fibers;

providing at least one second breakout optical connector having:

a third outside portion adapted to removably connect to at least one optical fiber; and

a third inside portion adapted for permanent

optical connection to at least one optical fiber;

providing a plurality of optical fibers positioned within the second container, at least one optical fiber of the plurality of optical fibers being permanently connected between the first and second inside portions of the second first and second second optical connectors;

cutting the at least one optical fiber at a location between the first and second inside portions of the second first and second second optical connectors to form two ends thereon; and

permanently connecting at least one end of the at least one optical fiber to the third inside portion of the second breakout optical connector.

10. The method for providing optical circuit breakout for an aircraft optical trunkline as defined in claim 9 wherein the multi-fiber optical cable is an optical ribbon cable.

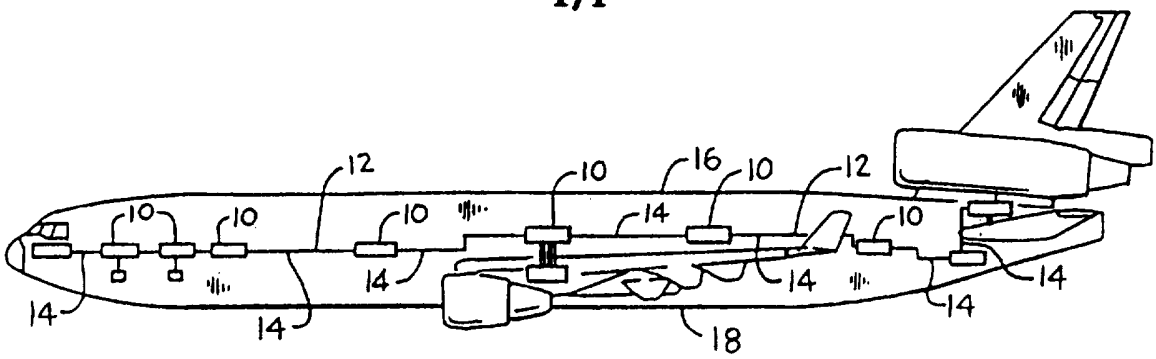

FIG. 1

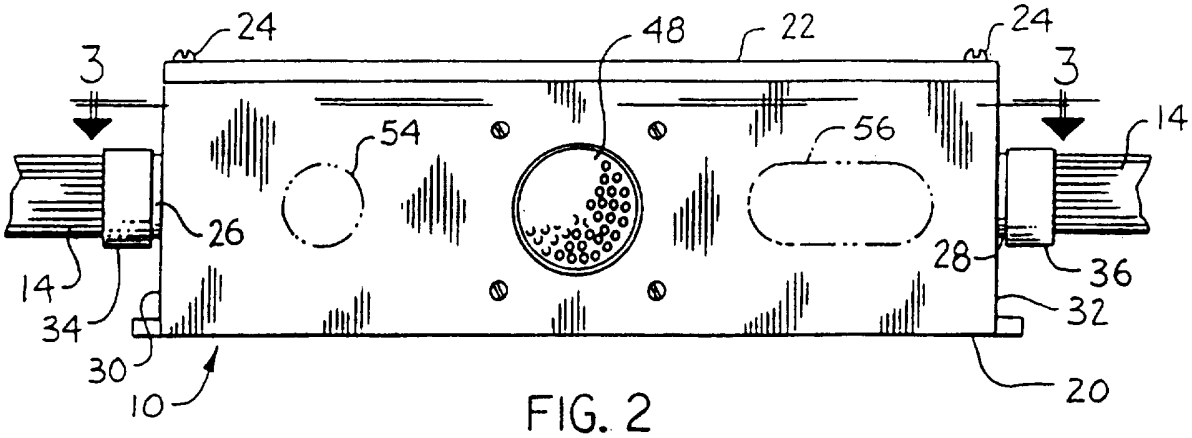

FIG. 2

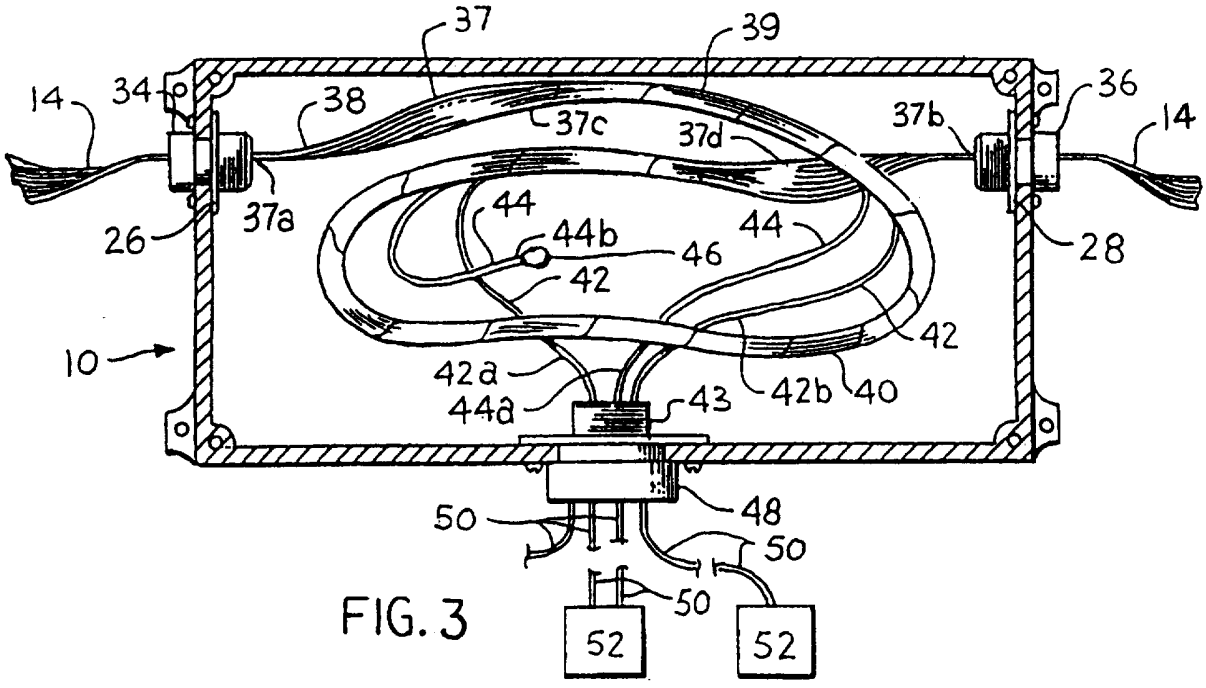

FIG. 3

INTERNATIONAL SEARCH REPORT

Internat ..al Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G02B6/44

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 G02B

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	PATENT ABSTRACTS OF JAPAN vol. 012, no. 394 (P-773), 20 October 1988 & JP 63 136007 A (FURUKAWA ELECTRIC CO LTD:THE), 8 June 1988, see abstract; figures 1-5 ---	1-10
Y	TRANSACTIONS OF THE INSTITUTE OF ELECTRONICS, INFORMATION AND COMMUNICATION ENGINEERS OF JAPAN, vol. E72, no. 11, 1 November 1989, pages 1204-1211, XP000086629 NAGASAWA S: "DESIGN AND PERFORMANCE OF SMALL-SIZE OPTICAL-FIBER FANOUT CONNECTOR FOR FIBER-RIBBON CABLE TERMINATION" see page 1204, left-hand column, line 25 - right-hand column, line 15; figures 1,12 --- -/--	1,2,4,5, 7-10

[X] Further documents are listed in the continuation of box C.

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6 August 1997	21. 08. 97

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Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	PATENT ABSTRACTS OF JAPAN vol. 010, no. 015 (P-422), 21 January 1986 & JP 60 169813 A (SUMITOMO DENKI KOGYO KK), 3 September 1985, see abstract	1,2,4,5, 7-10
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Information on patent family members

International Application No
PCT/US 97/07166

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