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(54) **FANOUT DEVICE FOR MULTICORE FIBER CABLE**

(71) Applicant: **Chiral Photonics, Inc.**, Pine Brook, NJ (US)

(72) Inventors: **Victor Il'ich Kopp**, Fair Lawn, NJ (US); **Jing Zhang**, Union, NJ (US); **Christopher W. Draper**, Allendale, NJ (US); **Jonathan Singer**, New Hope, PA (US); **Daniel Neugroschl**, Suffern, NY (US)

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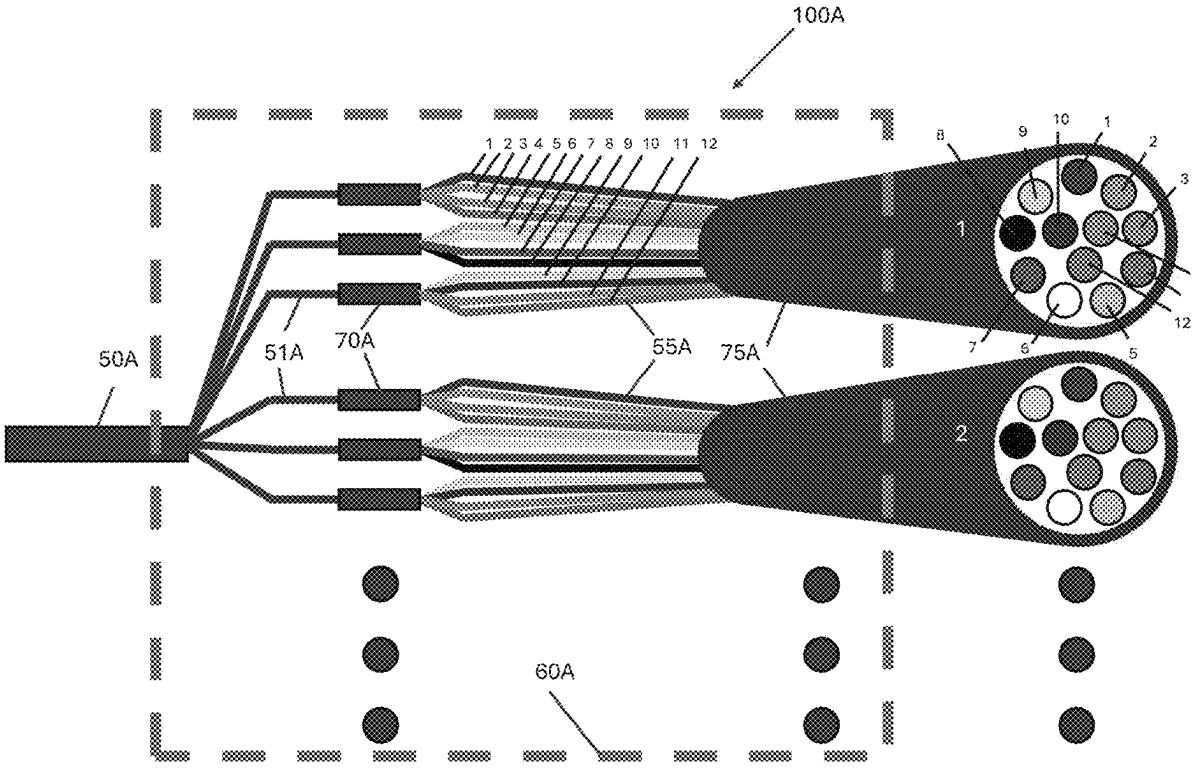
(52) **U.S. Cl.**

CPC ***G02B 6/44715*** (2023.05); ***G02B 6/02042*** (2013.01); ***G02B 6/3885*** (2013.01)

(57) **ABSTRACT**

A multicore fiber cable fanout device configured to connect a multicore fiber (MCF) cable comprising M MCFs having N cores with M×N single core fiber (SCP) pigtails is provided. The fanout device can include a housing enclosure and M MCF-to-SCF fanouts within the housing enclosure. The M×N SCF pigtails can be grouped in M×N/K SCF groups containing K SCF pigtails.



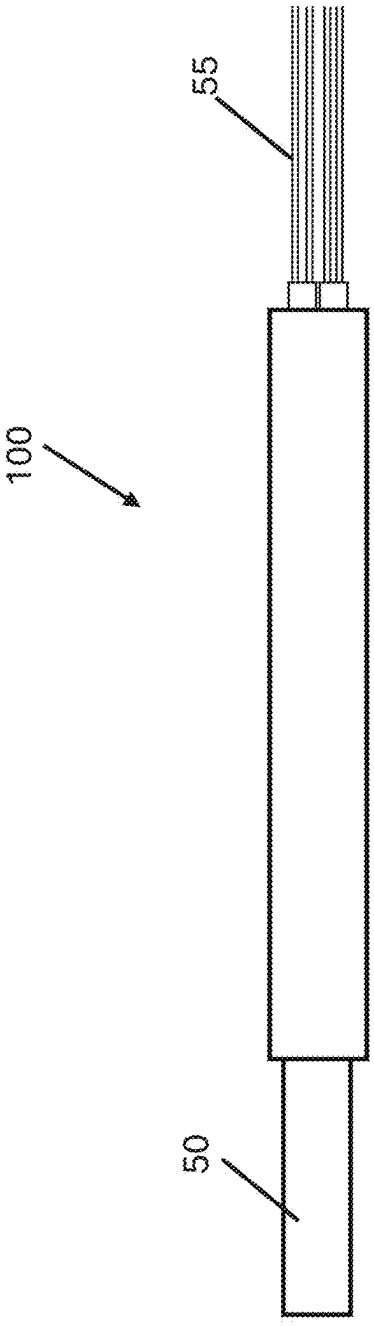


Fig. 1A

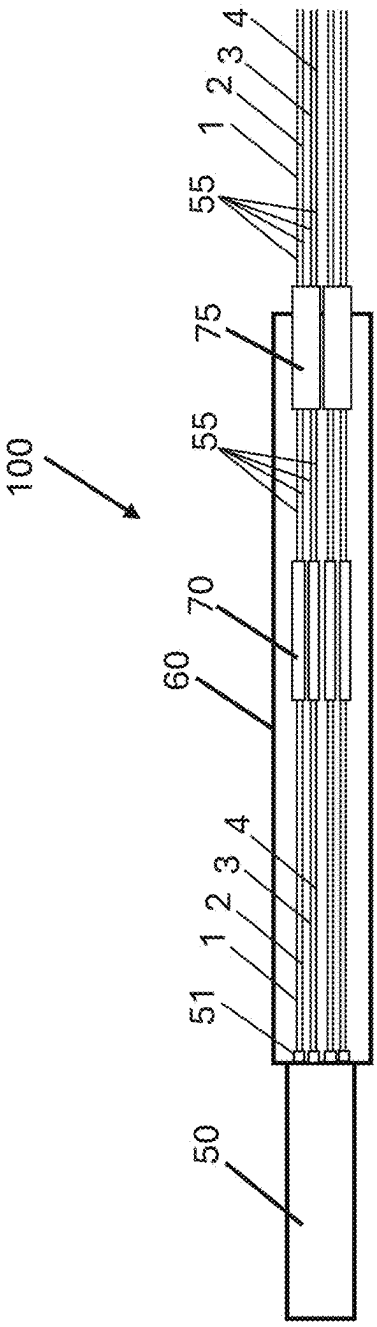


Fig. 1B

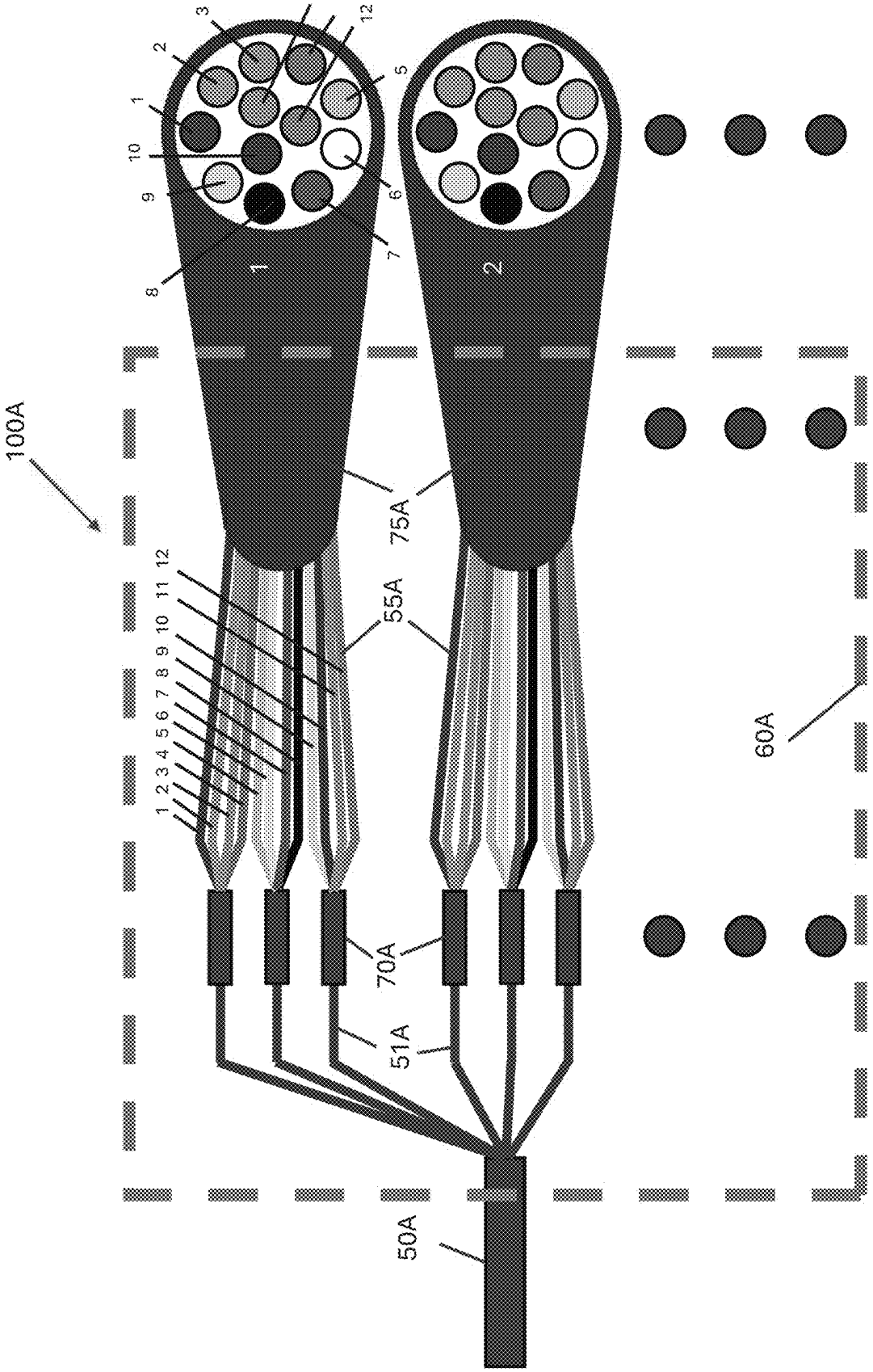


Fig. 2

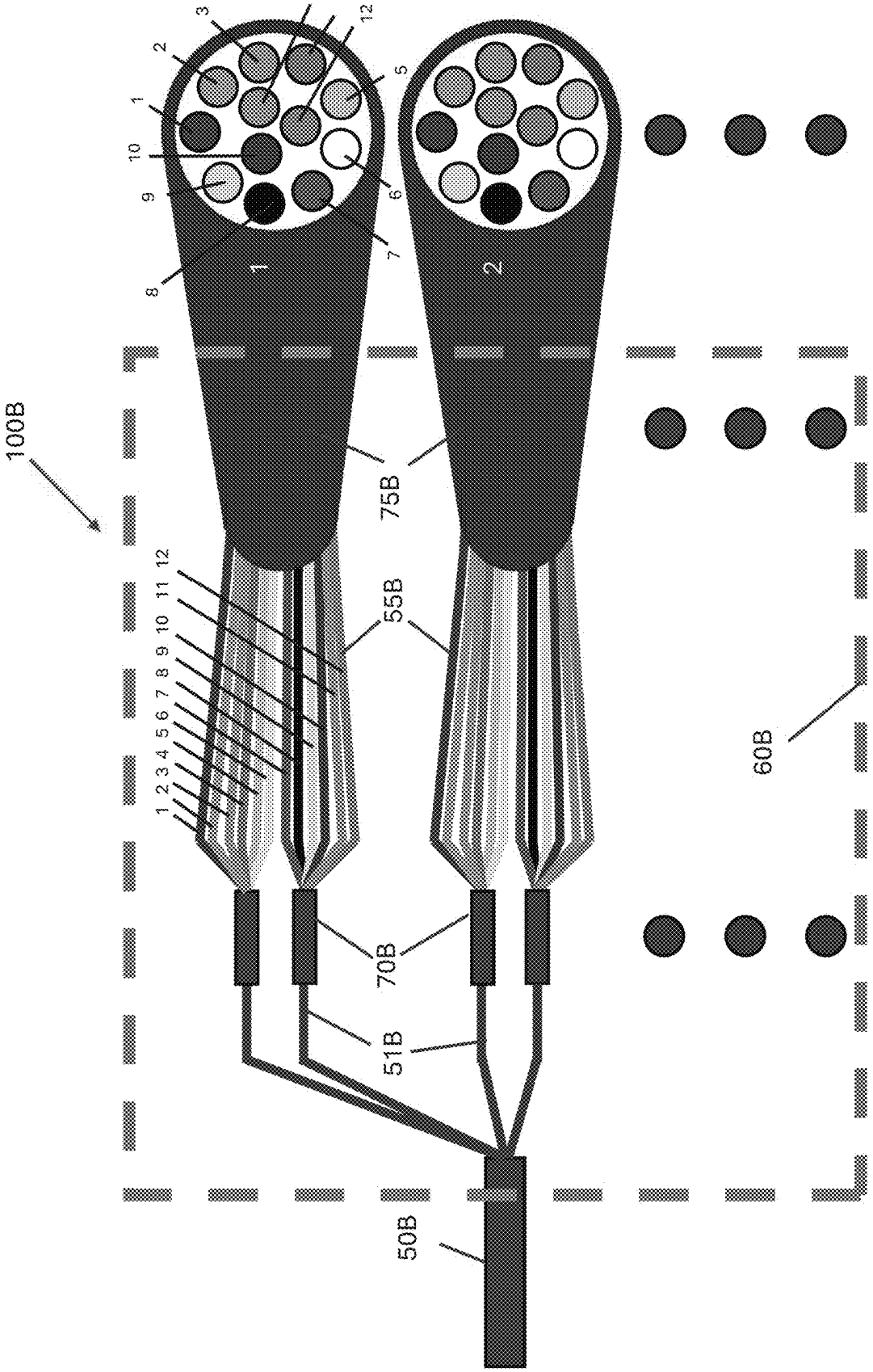


Fig. 3

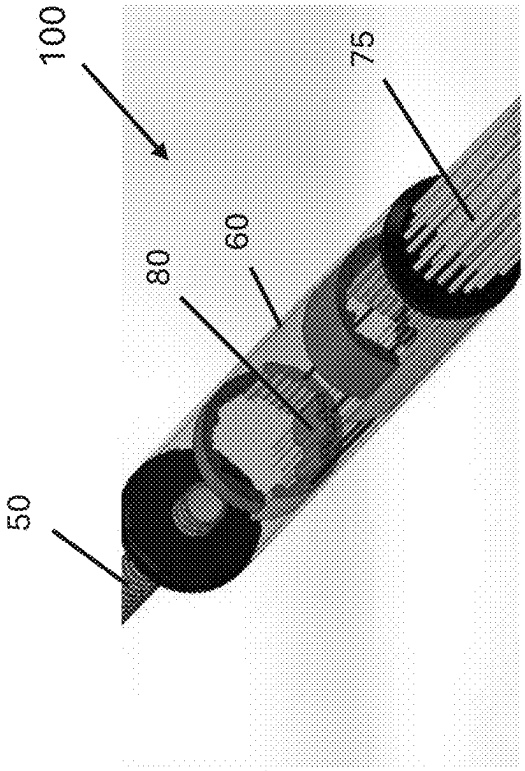


Fig. 4B

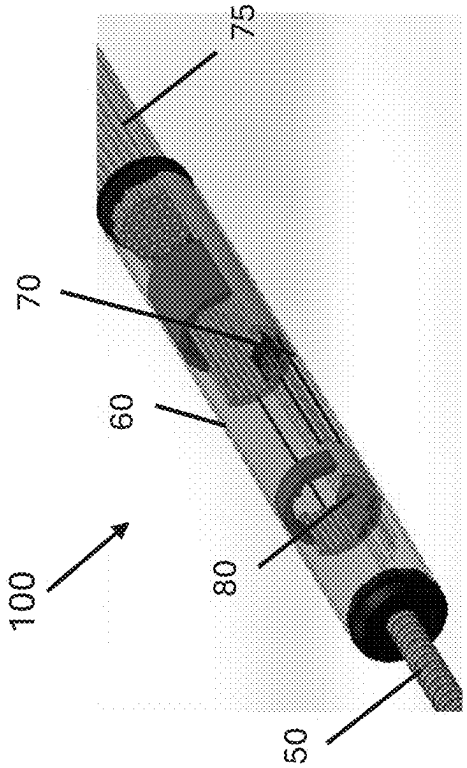


Fig. 4A

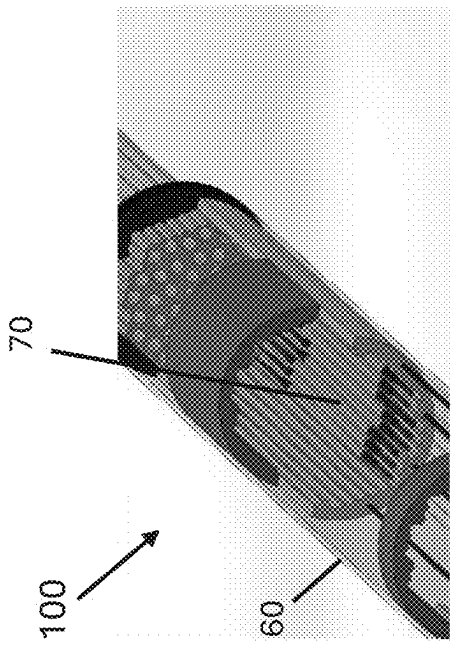


Fig.4C

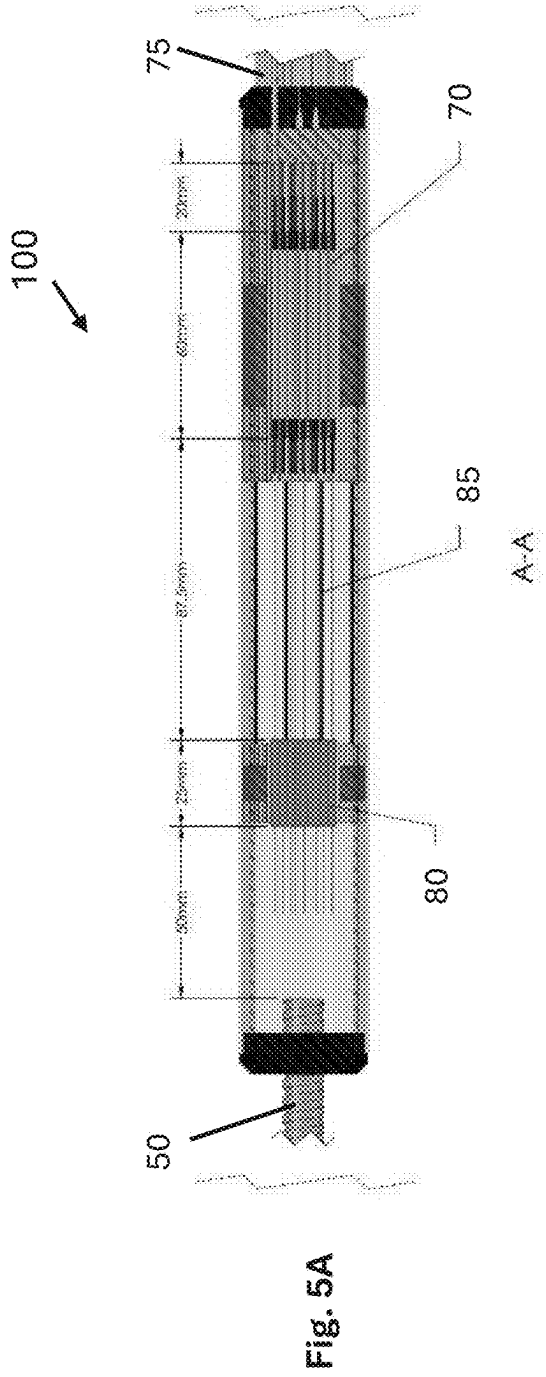


Fig. 5A

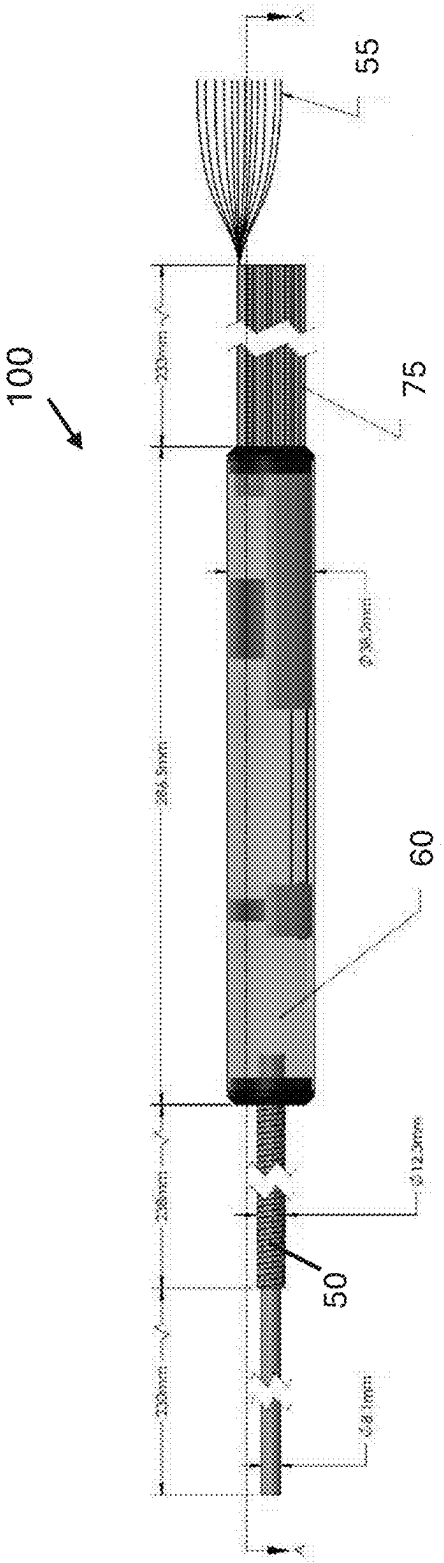


Fig. 5B

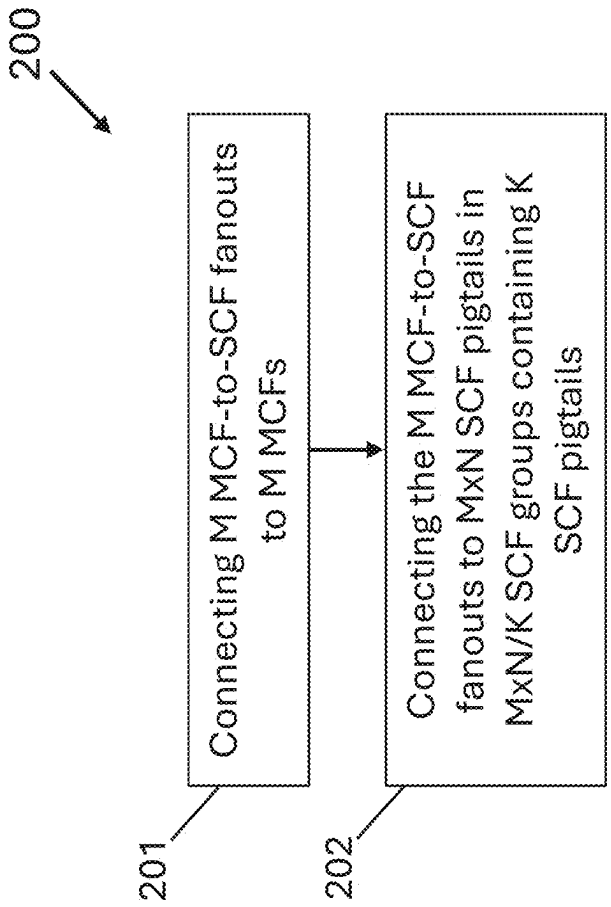

200
Connecting M MCF-to-SCF fanouts to M MCFs
Connecting the M MCF-to-SCF fanouts to MxN SCF pigtails in MxN/K SCF groups containing K SCF pigtails
201
202

Fig. 6

FANOUT DEVICE FOR MULTICORE FIBER CABLE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of priority to U.S. Provisional Application No. 63/556,285 (Attorney Docket No. CHIRA.047PR), entitled "FANOUT DEVICE FOR MULTICORE FIBER CABLE," filed Feb. 21, 2024, which is incorporated in its entirety by reference herein.

BACKGROUND

Field

[0002] This disclosure relates generally to optical components such as fanout devices for multicore fiber (MCF) cable.

Description of the Related Art

[0003] A cable fanout can refer to a device that splits the optical fibers from the cable into individual optical fibers. This can include a multicore fiber (MCF) cable, where the fanout splits the cable into individual MCFs. However, for many applications, devices that split an MCF cable to a set of single core fibers can be desirable.

SUMMARY

[0004] Example implementations described herein have innovative features, no single one of which is indispensable or solely responsible for their desirable attributes. Without limiting the scope of the claims, some of the advantageous features will now be summarized.

[0005] 1. A multicore fiber cable fanout device configured to connect a multicore fiber (MCF) cable comprising M MCFs having N cores with M×N single core fiber (SCF) pigtails, the fanout device comprising:

[0006] a housing enclosure; and

[0007] M MCF-to-SCF fanouts within the housing enclosure, wherein said M×N SCF pigtails are grouped in M×N/K SCF groups containing K SCF pigtails.

[0008] 2. The multicore fiber cable fanout device of Example 1, wherein the M×N SCF pigtails are identifiable to corresponding cores of the MCFs.

[0009] 3. The multicore fiber cable fanout device of Example 1 or 2, further comprising M×N/K furcation tubes, wherein K SCF pigtails of K/N fanouts are grouped together.

[0010] 4. The multicore fiber cable fanout device of any of Examples 1-3, wherein said M×N SCF pigtails are color-coded in individual ones of said M×N/K SCF groups.

[0011] 5. The multicore fiber cable fanout device of Example 4, wherein the pigtails are identifiable using the same color-coding for different groups.

[0012] 6. The multicore fiber cable fanout device of Example 5, wherein the pigtails are identifiable using the same color-coding for each of said groups.

[0013] 7. The multicore fiber cable fanout device of any of Examples 1-6, wherein $1<M<10000$, $1<N<37$, and $1<K<48$.

[0014] 8. The multicore fiber cable fanout device of any of Examples 1-7, wherein $K=12$.

[0015] 9. The multicore fiber cable fanout device of any of Examples 1-8, wherein 12 SCF pigtails are color-coded with 12 encoding colors from blue to aqua.

[0016] 10. The multicore fiber cable fanout device of any of Examples 1-9, wherein said housing enclosure encloses MCF-MCF splices.

[0017] 11. The multicore fiber cable fanout device of any of Examples 1-10, wherein said housing enclosure is a single housing enclosure.

[0018] 12. A method of connecting a multicore fiber (MCF) cable comprising M MCFs having N cores with M×N single core fiber (SCF) pigtails, the method comprising:

[0019] connecting M MCF-to-SCF fanouts to the M MCFs; and

[0020] connecting the M MCF-to-SCF fanouts to the M×N SCF pigtails in M×N/K SCF groups containing K SCF pigtails.

[0021] 13. The method of Example 12, wherein the M×N SCF pigtails are identifiable to corresponding cores of the MCFs.

[0022] 14. The method of Example 12 or 13, wherein connecting M MCF-to-SCF fanouts to the M MCFs comprises splicing the MCF-to-SCF fanouts to the MCFs.

[0023] 15. The method of any of Examples 12-14, wherein connecting the M MCF-to-SCF fanouts to the M×N SCF pigtails comprises providing M×N/K furcation tubes, wherein K SCF pigtails of K/N fanouts are grouped together.

[0024] 16. The method of any of Examples 12-15, wherein said M×N SCF pigtails are color-coded in individual ones of said M×N/K SCF groups.

[0025] 17. The method of Example 16, wherein the pigtails are identifiable using the same color-coding for different groups.

[0026] 18. The method of Example 17, wherein the pigtails are identifiable using the same color-coding for each of said groups.

[0027] 19. The method of any of Examples 12-18, wherein $1<M<10000$, $1<N<37$, and $1<K<48$.

[0028] 20. The method of any of Examples 12-19, wherein $K=12$.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] FIGS. **1**A and **1**B schematically illustrate an example multicore fiber (MCF) cable fanout device.

[0030] FIG. **2** schematically illustrates an example MCF cable fanout device.

[0031] FIG. **3** schematically illustrates another example MCF cable fanout device.

[0032] FIGS. **4**A-**4**C show example internal components of an MCF cable fanout device.

[0033] FIGS. **5**A and **5**B show example dimensions of an MCF cable fanout device.

[0034] FIG. **6** illustrates an example method of connecting an MCF cable with SCF pigtails.

DETAILED DESCRIPTION

[0035] In the present disclosure, a multicore fiber (MCF) cable fanout device can refer to an MCF cable connected to a set of corresponding single core fibers. Since the proper identification of the fiber leads can be useful for the MCF cable application, different ones, possibly each, of the single core fiber (SCF) leads can have one-to-one identification to the corresponding core of the appropriate MCF fiber in the cable. For this identification purpose, in fiber optic cables, optical fibers can be split into groups, either connected to

each other or combined (e.g., separately combined), for example, in a tube such as in a furcation tube. In various implementations, the MCF cable fanout device of the present disclosure, can connect a MCF cable composed of M MCFs having N cores in each fiber with M×N SCF pigtails uniquely identified in groups containing K fibers. To achieve this goal, in various embodiments, M MCF-to-SCF fanouts can be placed in a common enclosure and pigtails of a plurality (K/N) of fanouts can be grouped together.

[0036] An example MCF cable fanout device **100** is schematically illustrated in FIG. **1**A. The MCF cable fanout device **100** can be configured to connect an MCF cable **50** with SCF pigtails **55**. FIG. **1**B schematically illustrates example internal components within the housing enclosure **60** of the MCF cable fanout device **100**. FIG. **1**B is illustrated for simplicity and not drawn to scale. As shown in the example, the MCF cable fanout device **100** can include a number of MCF-to-SCF fanouts **70** within the housing enclosure **60** to connect the MCF cable **50** composed of MCFs **51** with SCF pigtails **55** that are be grouped into SCF groups **75**. Advantageously, the SCF pigtails **55** within the SCF groups **75** can be identifiable (e.g., 1, 2, 3, 4, etc.) to corresponding cores (e.g., 1, 2, 3, 4, etc.) of the MCFs **51**. An example will now be described with respect to FIG. **2**.

[0037] In the example implementation of an MCF cable fanout device **100**A illustrated in FIG. **2**, the MCF cable **50**A can include M MCFs **51**A having N cores, wherein M represents the number of MCFs **51**A and N represents the number of cores in individual ones of the MCFs **51**A. The MCF cable fanout device **100**A can include M MCF-to-SCF fanouts **70**A within the housing enclosure **60**A to connect the M MCFs **51**A with the SCF pigtails **55**A. The number of SCF pigtails **55**A can include M×N SCF pigtails **55**A, and the M×N SCF pigtails **55**A can be grouped in M×N/K SCF groups **75**A containing K SCFs **55**A, where K represents the number of SCFs **55**A in individual groups **75**A. In FIG. **2**, SCF pigtails **55**A of K/N fanouts **70**A are grouped together.

[0038] An example number M of MCFs **51**A can range from between 1 and 10000 (for example, $1<M<10000$). However, the number M of MCFs **51**A within an MCF cable **50**A is not particularly limited, and other examples are possible. The number N of cores in individual ones of the MCFs **51**A is also not particularly limited. An example number N of cores in individual ones of the MCFs **51**A can range from between 1 and 37 (for example, $1<N<37$). However, other examples, such as with a larger number of cores, are possible. In addition, the number of SCFs **55**A in individual groups **75**A can range between 1 and 48 (for example, $1<K<48$). However, other examples, such as with a larger number of SCFs **55**, are possible. Other examples, with other geometries and/or numbers of MCFs **51**, cores, fanouts **70**, SCFs **55**, groups **75**, or any combination of these, are possible.

[0039] For illustration purposes, the example MCF cable **50**A in FIG. **2** can include 144 MCFs **51**A having 4 cores (for example, M=144 and N=4). For simplicity, FIG. **2** only shows 6 of 144 MCFs **51**A. The MCF cable fanout device **100**A can include 144 MCF-to-SCF fanouts **70**A (for example, M=144) to couple the 144 MCFs **51**A of the MCF cable **50**A with the SCF pigtails **55**. For simplicity, only 6 of 144 MCF-to-SCF fanouts **70**A are shown. The 576 SCF pigtails **55**A (for example, M×N=144×4=576) are grouped in 48 SCF groups **75**A (for example, M×N/K=144×4/12=48) containing 12 SCFs **55**A (for example, K=12) in individual groups **75**A. For simplicity, only 24 of the 576 SCF pigtails and 2 of the 48 SCF groups **75**A are shown. In FIG. **2**, the SCF pigtails **55**A of 3 fanouts **70**A (for example, K/N=12/4=3) are grouped together. As described, the SCF pigtails **55**A in individual groups **75**A can be connected to each other or combined (e.g., separately combined), for example, in a tube such as in a furcation tube. In various examples, the number of furcation tubes can be equal to or less than the number of SCF groups **75**A (for example, can be equal to or less than M×N/K=48).

[0040] In this example implementation, the number of SCFs in a group can be 12. Inside the group, fibers can be identified by a fiber identifier such as by a color from blue to aqua, and/or the fiber groups can be identified by a group identified such as, for example, by a number printed either directly on the connected fiber group or on the furcation tube. In some cases, the color identifiers may comprise standard colors. For example, the color coding can follow Telecommunications Industry Association's TIA-598-C Optical Fiber Cable Color Coding. For instance, 12 SCFs can be color coded with 12 encoding colors from blue to aqua (for example, blue, orange, green, brown, slate/gray, white, red, black, yellow, violet, rose/pink, and aqua/light blue). The M×N SCF pigtails can be color-coded in individual ones of the M×N/K SCF groups. The pigtails can be identifiable using the same color-coding for different groups. In some instances, the pigtails can be identifiable using the same color-coding for each of the groups.

[0041] FIG. **3** is another example implementation using 96 MCF-to-SCF fanouts **70**B for 96 6-core MCFs **51**B instead of 144 MCF-to-SCF fanouts **70**A for 144 4-core MCFs **51**A used in FIG. **2**. The example shown in FIG. **3** can be used for a same 576-channel link as in FIG. **2** (for example, M×N=96×6=576 SCF pigtails **55**B). For simplicity, FIG. **3** only shows 4 of 96 MCFs **51**B and only 4 of 96 MCF-to-SCF fanouts **70**B. The 576 SCF pigtails **55**B are grouped in 48 SCF groups **75**B (for example, M×N/K=96×6/12=48) containing 12 SCFs **55**B (for example, K=12) in individual groups **75**B. For simplicity, only 24 of the 576 SCF pigtails and 2 of the 48 SCF groups **75**B are shown. In FIG. **3**, the SCF pigtails **55**B of 2 fanouts **70**B (for example, K/N=12/6=2) are grouped together. Other examples are possible.

[0042] FIGS. **4**A-**4**C show example internal components of an MCF cable fanout device **100**. The MCF-to-SCF fanout **70** placement inside the housing enclosure **60** may be parallel, forming a close-packed arrangement, as shown in FIGS. **4**A-**4**C, or it may be in other parallel and/or serial configurations or other configurations. FIGS. **4**A-**4**C correspond to the example shown in FIG. **2**. For example, FIGS. **4**A-**4**C show an MCF cable fanout device **100** for an MCF cable **50** with M=144 MCFs, each having N=4 fibers. The MCF cable fanout device **100** has 144 MCF-to-SCF fanouts **70** with M×N=576 SCF pigtails grouped in the M×N/K=48 groups **75** of K=12 SCFs in each group **75**. A small number of fanouts **70** is shown for easier visibility and SCF groups **75** are represented by the 48 tubes **75** in FIGS. **4**A-**4**C.

[0043] The MCF-to-SCF fanouts **70**, shown as tubes may be fabricated directly with the MCFs of the cable **50** or may be fabricated separately and fusion-spliced to the MCFs of the cable **50**. As an example, MCF-MCF splice-protection tubes **80** are enclosed in the housing **60** as shown in FIGS. **4**A-**4**C. The fanouts **70** can be made, for example, of silica glass and/or packaged in small tubes such as metal tubes, e.g., stainless steel tubes. The MCF-MCF splice-protection

tubes **80** can be made of an inside meltable plastic tube, an outside shrink tube, and a metal pin in-between. In various instances there are M splice-protection tubes **80** (for example, M splice-protection tubes **80** protecting M splices between M MCFs and M MCF-to-SCF fanouts). As described, the SCF pigtails **55** in individual groups **75** can be connected to each other or combined (e.g., separately combined), for example, in a tube such as in a furcation tube. In some implementations, the furcation tubes can be made of a thermoplastic polyester elastomer, e.g., a Hytrel® furcation tube.

[0044] Example dimensions of a 144f-MCF cable fanout device **100** are shown in FIGS. **5**A and **5**B. In certain advantageous designs, the dimensions can be such that the cable fanout device **100** is compact for practical applications. Other dimensions are possible. In various implementations, the housing enclosure **60** can be a single housing enclosure. The housing can be made of any material, for example, one or more metals and/or one or more polymers. In some implementations, the housing enclosure **60** can comprise a tube, for example, a metal tube or a polymer tube. The housing enclosure **60** can contain the MCF-MCF splices and/or splice protectors **80** and MCF-to-SCF fanouts **70** (e.g., 144 MCF-MCF splices and/or splice protectors **80** and 144 MCF-to-SCF fanouts **70**). Spacer rods or other material **85** can be used to help space the SCFs. In various instances, on one side, the MCF cable **50** can be enclosed within an armored cable. On the other side, numbered furcation tubes **75** each containing SCFs can exit the housing enclosure **60** in this example. In this example, there are 48 numbered furcation tubes **75** each containing 12 SCFs. Only 12 of the 576 SCFs are shown for simplicity.

[0045] For increased compatibility with existing fiber networks, the SCF pigtails **55** may be part of fiber ribbons, ribbonized, or spliced to fiber ribbons. In some implementations, the number of fibers in the ribbon may be the same as K, the number of SCFs **55** in a group **75**. In some implementations, SCF to ribbon splices may be enclosed by the same common enclosure **60**, which may be longer to include SCF-ribbon splice protectors. In this case, the housing enclosure **60** can be modified such that only the SCF ribbons may be exiting the common enclosure **60**. The common enclosure **60** and enclosure's endcaps may be color-coded (or labeled) to differentiate between right or left cable ends, also known as a polarity of an MCF cable **50**. For example, a red enclosure or red end caps may identify a cable's right end and the blue color may indicate a left end. Also, the fanouts **70** themselves may be color-coded or numbered to indicate the order of the fanouts **70** in a group **75**.

[0046] FIG. **6** illustrates an example method of connecting an MCF cable comprising M MCFs having N cores with M×N SCF pigtails. In various implementations, the method can use any of the embodiments of an MCF cable fanout **100** described herein. With reference to FIG. **6**, as shown in block **201**, the method **200** can include connecting M MCF-to-SCF fanouts to the M MCFs. In some instances, connecting M MCF-to-SCF fanouts to the M MCFs can include splicing the MCF-to-SCF fanouts to the MCFs.

[0047] As shown in block **202**, the method **200** can also include connecting the M MCF-to-SCF fanouts to the M×N SCF pigtails in M×N/K SCF groups containing K SCF pigtails. In some implementations, the method **200** includes combining the SCF into separate groups. For example, in some implementations, connecting the M MCF-to-SCF fanouts to the M×N SCF pigtails can comprise providing M×N/K tubes such as furcation tubes, in which K SCF pigtails of K/N fanouts are grouped together.

[0048] As described herein, the M×N SCF pigtails can be identifiable to corresponding cores of the MCFs. As an example, the M×N SCF pigtails can be color-coded in individual ones of the M×N/K SCF groups. For instance, the pigtails can be identifiable using the same color-coding for different groups. In some cases, the pigtails can be identifiable using the same color-coding for each of the groups. In various designs, $1<M<10000$, $1<N<37$, and $1<K<48$. As an example, $K=12$. Other examples, such as with other geometries and/or numbers of MCFs **51**, cores, fanouts **70**, SCFs **55**, groups **75**, or any combination of these or other components or features, are possible.

Other Examples

[0049] 1. Multicore fiber cable fanout to connect a multicore fiber cable composed of M MCFs having N cores fibers with M×N uniquely identified single fiber core pigtails and comprising M MCF-to-SCF fanouts enclosed in a single housing enclosure, where said M×N SCF pigtails are grouped in M×N/K SCF groups containing K SCFs.

[0050] 2. Multicore fiber cable fanout of Example 1 further comprising of M×N/K furcation tubes, in which pigtails of K/N fanouts are grouped together.

[0051] 3. Multicore fiber cable fanout of Example 1 where said M×N SCF pigtails are color-coded in each of said M×N/K SCF groups.

[0052] 4. Multicore fiber cable fanout of Example 1 in which $1<M<10000$, $1<N<37$, and $1<K<48$.

[0053] 5. Multicore fiber cable fanout of Example 2 where $K=12$.

[0054] 6. Multicore fiber cable fanout of Examples 3 and 5 where 12 SCFs are color-coded with a standard 12 encoding colors from blue to aqua.

[0055] 7. Multicore fiber cable fanout of Example 1 in which said single housing enclosure encloses MCF-MCF splices.

[0056] 8. A multicore fiber cable fanout configured to connect a multicore fiber (MCF) cable with M MCFs having N cores with M×N single fiber core (SCF) pigtails, the fanout comprising:

[0057] a housing enclosure; and

[0058] M MCF-to-SCF fanouts within the housing enclosure,

[0059] wherein said M×N SCF pigtails are grouped in M×N/K SCF groups containing K SCFs.

[0060] 9. The multicore fiber cable fanout of Example 8 wherein the M×N SCF pigtails are identifiable to corresponding cores of the MCFs.

[0061] 10. The multicore fiber cable fanout of Example 8 or 9, further comprising of M×N/K furcation tubes, in which pigtails of K/N fanouts are grouped together.

[0062] 11. The multicore fiber cable fanout of any of Examples 8-10, wherein said M×N SCF pigtails are color-coded in each of said M×N/K SCF groups.

[0063] 12. The multicore fiber cable fanout of Example 11, wherein the pigtails are identifiable using the same color-coding for different groups.

[0064] 13. The multicore fiber cable fanout of Example 12, wherein the pigtails are identifiable using the same color-coding for each of said groups.

[0065] 14. The multicore fiber cable fanout of any of Examples 8-13, wherein 1<M<10000, 1<N<37, and 1<K<48.

[0066] 15. The multicore fiber cable fanout of any of Examples 8-14, wherein K=12.

[0067] 16. The multicore fiber cable fanout of any of Examples 8-15, wherein 12 SCFs are color-coded with 12 encoding colors from blue to aqua.

[0068] 17. The multicore fiber cable fanout of any of Examples 8-16, wherein said housing enclosure encloses MCF-MCF splices.

[0069] 18. The multicore fiber cable fanout of any of Examples 8-17, wherein said housing enclosure is a single housing enclosure.

[0070] Thus, while there have been shown and described and pointed out fundamental novel features of the invention as applied to preferred embodiments thereof, it will be understood that various omissions and substitutions and changes in the form and details of the devices and methods illustrated, and in their operation, may be made by those skilled in the art without departing from the spirit of the invention. For example, it is expressly intended that all combinations of those elements and/or method steps which perform substantially the same function in substantially the same way to achieve the same results are within the scope of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the claims appended hereto.

What is claimed is:

1. A multicore fiber cable fanout device configured to connect a multicore fiber (MCF) cable comprising M MCFs having N cores with M×N single core fiber (SCF) pigtails, the fanout device comprising:

a housing enclosure; and

M MCF-to-SCF fanouts within the housing enclosure, wherein said M×N SCF pigtails are grouped in M×N/K SCF groups containing K SCF pigtails.

2. The multicore fiber cable fanout device of claim **1**, wherein the M×N SCF pigtails are identifiable to corresponding cores of the MCFs.

3. The multicore fiber cable fanout device of claim **1**, further comprising M×N/K furcation tubes, wherein K SCF pigtails of K/N fanouts are grouped together.

4. The multicore fiber cable fanout device of claim **1**, wherein said M×N SCF pigtails are color-coded in individual ones of said M×N/K SCF groups.

5. The multicore fiber cable fanout device of claim **4**, wherein the pigtails are identifiable using the same color-coding for different groups.

6. The multicore fiber cable fanout device of claim **5**, wherein the pigtails are identifiable using the same color-coding for each of said groups.

7. The multicore fiber cable fanout device of claim **1**, wherein 1<M<10000, 1<N<37, and 1<K<48.

8. The multicore fiber cable fanout device of claim **1**, wherein K=12.

9. The multicore fiber cable fanout device of claim **1**, wherein 12 SCF pigtails are color-coded with 12 encoding colors from blue to aqua.

10. The multicore fiber cable fanout device of claim **1**, wherein said housing enclosure encloses MCF-MCF splices.

11. The multicore fiber cable fanout device of claim **1**, wherein said housing enclosure is a single housing enclosure.

12. A method of connecting a multicore fiber (MCF) cable comprising M MCFs having N cores with M×N single core fiber (SCF) pigtails, the method comprising:

connecting M MCF-to-SCF fanouts to the M MCFs; and

connecting the M MCF-to-SCF fanouts to the M×N SCF pigtails in M×N/K SCF groups containing K SCF pigtails.

13. The method of claim **12**, wherein the M×N SCF pigtails are identifiable to corresponding cores of the MCFs.

14. The method of claim **12**, wherein connecting M MCF-to-SCF fanouts to the M MCFs comprises splicing the MCF-to-SCF fanouts to the MCFs.

15. The method of claim **12**, wherein connecting the M MCF-to-SCF fanouts to the M×N SCF pigtails comprises providing M×N/K furcation tubes, wherein K SCF pigtails of K/N fanouts are grouped together.

16. The method of claim **12**, wherein said M×N SCF pigtails are color-coded in individual ones of said M×N/K SCF groups.

17. The method of claim **16**, wherein the pigtails are identifiable using the same color-coding for different groups.

18. The method of claim **17**, wherein the pigtails are identifiable using the same color-coding for each of said groups.

19. The method of claim **12**, wherein 1<M<10000, 1<N<37, and 1<K<48.

20. The method of claim **12**, wherein K=12.

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