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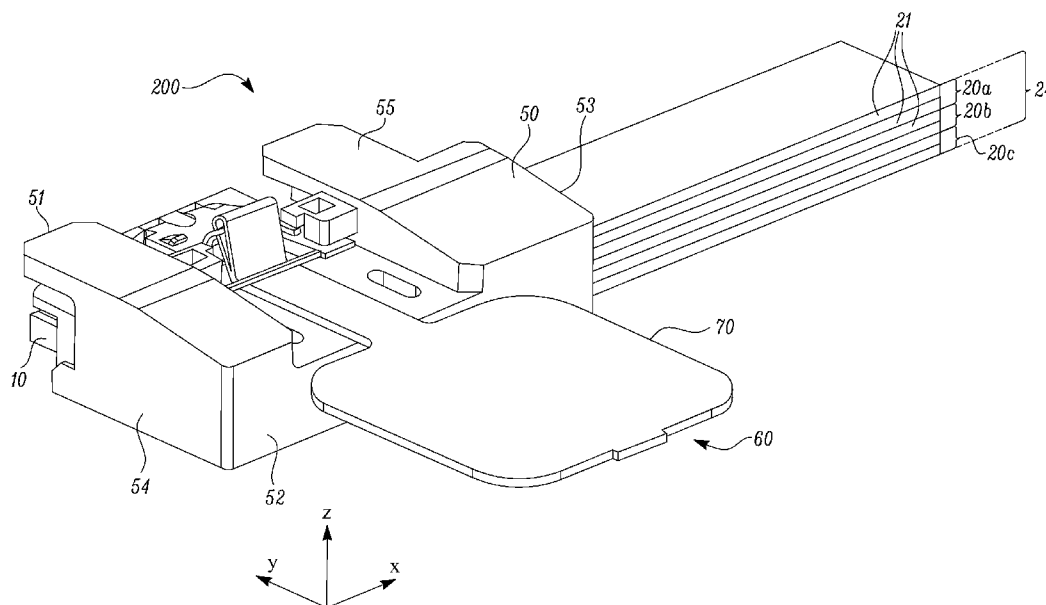


FIG. 1A

(57) Abstract: A connector assembly configured to mate with a mating connector along a mating direction is disclosed. The connector assembly includes a circuit board including a mating section including a plurality of electrically conductive mating pads and a cable section including pluralities of electrically conductive first, second, and third cable pads electrically connected to the mating pads. The connector assembly includes first, second, and third cable stacks. Each of the cable stacks is folded about a corresponding fold line of the cable stack that extends across the entire width of the cable stack to form a fold angle of less than about 30 degrees between first and second opposing portions of the cable stack at the fold line. The first portions extend along the mating direction and are arranged side-by-side in a substantially co-planar relationship to one another. The second portions extend substantially orthogonal to the mating direction.

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CONNECTOR ASSEMBLY AND CABLE ASSEMBLY FOR USE IN CONNECTOR ASSEMBLY

Technical Field

The present disclosure relates generally to a connector assembly and a cable assembly for use in the connector assembly.

Background

A connector assembly is generally used to connect a cable or a cable assembly from one device (e.g., a server, a network switching system, a client device, etc.) to another device (e.g., another server) for various applications, such as data processing, data transmission, and data reception.

Summary

In a first aspect, the present disclosure provides a connector assembly. The connector assembly is configured to mate with a mating connector along a mating direction. The connector assembly includes a circuit board. The circuit board includes a mating section including a plurality of electrically conductive mating pads for making contact with corresponding electrically conductive elements of the mating connector. The circuit board further includes a cable section including pluralities of electrically conductive first, second, and third cable pads electrically connected to the mating pads. The connector assembly further includes first, second, and third cable stacks. Each of the cable stacks includes at least two substantially planar ribbon cables stacked along a thickness direction of the cable stack. Each of the ribbon cables includes a plurality of insulated electrical conductors extending along a length, and arranged along a width, of the ribbon cable. Each of the cable stacks is folded about a corresponding fold line of the cable stack that extends across the entire width of the cable stack to form a fold angle of less than about 30 degrees between first and second opposing portions of the cable stack at the fold line. The first portions of the cable stacks extend along the mating direction and are arranged side-by-side in a substantially co-planar relationship to one another. The second portions of the cable stacks extend along a transverse direction substantially orthogonal to the mating direction and are arranged in a stack. Front ends of the insulated electrical conductors of the ribbon cables of the first portions of the first, second, and third cable stacks are substantially aligned with, and terminated at, the cable

pads of the respective pluralities of the first, second, and third cable pads in a one to one correspondence.

In a second aspect, the present disclosure provides a cable assembly for use in a connector assembly. The connector assembly is configured to mate with a mating connector along a mating direction. The cable assembly includes a circuit board. The circuit board includes a plurality of electrically conductive mating pads for making electrical and physical contact with corresponding electrically conductive elements of the mating connector. The circuit board further includes a plurality of top cable pads disposed on a top side of the circuit board. The circuit board further includes a plurality of bottom cable pads disposed on a bottom side, opposite the top side, of the circuit board. The top and bottom cable pads are electrically connected to the mating pads. The cable assembly further includes a combined stack of a plurality of individual cable stacks stacked along a common thickness direction, and extending along a common length direction, of the combined stack and the individual cable stacks. Each of the individual cable stacks includes top and bottom substantially planar ribbon cables stacked along the thickness direction. Each of the top and bottom ribbon cables includes a plurality of conductor sets. Each of the conductor sets includes two or more insulated electrical conductors substantially surrounded by an electrically conductive shield. Each of the insulated electrical conductors includes an electrically conductive central conductor surrounded by an electrically insulative material. Each of the individual cable stacks is folded about a corresponding fold line of the individual cable stack that extends across the entire width of the individual cable stack to form a fold angle of less than about 20 degrees between first and second opposing portions of the individual cable stack at the fold line. The first portions of the individual cable stacks extend along the mating direction and are arranged side-by-side in a substantially co-planar relationship to one another. The second portions of the individual cable stacks extend along the common length direction and substantially remain in the combined stack. Uninsulated top and bottom front ends of the two or more insulated electrical conductors of each of the conductor sets of each of the respective top and bottom ribbon cables are substantially aligned with, and terminated at, the corresponding cable pads of the respective top and bottom cable pads.

The details of one or more examples of the disclosure are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the disclosure will be apparent from the description and drawings, and from the claims.

Brief Description of Drawings

Exemplary embodiments disclosed herein are more completely understood in consideration of the following detailed description in connection with the following figures. The figures are not necessarily drawn to scale. Like numbers used in the figures refer to like components. However, it will be understood that the use of a number to refer to a component in a given figure is not intended to limit the component in another figure labelled with the same number.

FIG. 1A is a schematic perspective rear view of a connector assembly, according to an embodiment of the present disclosure;

FIG. 1B is a schematic perspective side view of the connector assembly mated with a mating connector, according to an embodiment of the present disclosure;

FIG. 1C is a schematic perspective rear view of a portion of the connector assembly, according to an embodiment of the present disclosure;

FIG. 2A is a schematic perspective side view of the connector assembly without a pull tab assembly, according to an embodiment of the present disclosure;

FIG. 2B is a schematic perspective top view of the connector assembly without the pull tab assembly, according to an embodiment of the present disclosure;

FIG. 3A is a schematic top view of a cable assembly for use in the connector assembly, according to an embodiment of the present disclosure;

FIG. 3B is a schematic perspective side view of a cable stack of the cable assembly, according to an embodiment of the present disclosure;

FIG. 4A is a schematic perspective side view of a ribbon cable of the cable stack without any electrically insulative jacket layer, according to an embodiment of the present disclosure;

FIG. 4B is a schematic perspective front view of the ribbon cable of the cable stack, according to an embodiment of the present disclosure;

FIG. 5A is a schematic perspective top view the cable assembly, according to an embodiment of the present disclosure;

FIG. 5B is a schematic perspective bottom view the cable assembly, according to an embodiment of the present disclosure;

FIG. 6A is a schematic perspective top view of the connector assembly with the mating connector, according to an embodiment of the present disclosure;

FIG. 6B is a schematic perspective top view of the connector assembly with the mating connector removed, according to an embodiment of the present disclosure;

FIG. 6C is a schematic perspective front view of the connector assembly with the insulative housing removed, according to an embodiment of the present disclosure; and

FIG. 6D is a schematic perspective rear view of the connector assembly, according to an embodiment of the present disclosure.

Detailed Description

In the following description, reference is made to the accompanying figures that form a part thereof and in which various embodiments are shown by way of illustration. It is to be understood that other embodiments are contemplated and may be made without departing from the scope or spirit of the present disclosure. The following detailed description, therefore, is not to be taken in a limiting sense.

In the following disclosure, the following definitions are adopted.

As used herein, “a,” “an,” “the,” “at least one,” and “one or more” are used interchangeably.

As used herein as a modifier to a property or attribute, the term “generally,” unless otherwise specifically defined, means that the property or attribute would be readily recognizable by a person of ordinary skill but without requiring absolute precision or a perfect match (e.g., within +/- 20 % for quantifiable properties).

The term “substantially,” unless otherwise specifically defined, means to a high degree of approximation (e.g., within +/- 10% for quantifiable properties) but again without requiring absolute precision or a perfect match.

As used herein, all numbers should be considered modified by the term “about.” The term “about,” unless otherwise specifically defined, means to a high degree of approximation (e.g., within +/- 5% for quantifiable properties) but again without requiring absolute precision or a perfect match.

As used herein, the terms “first” and “second” are used as identifiers. Therefore, such terms should not be construed as limiting of this disclosure. The terms “first” and “second” when used in conjunction with a feature or an element can be interchanged throughout the embodiments of this disclosure.

As used herein, when a first material is termed as “similar” to a second material, at least 90 weight % of the first and second materials are identical and any variation between the first and second materials comprises less than about 10 weight % of each of the first and second materials.

As used herein, “at least one of A and B” should be understood to mean “only A, only B, or both A and B.”

As used herein, the term “between about,” unless otherwise specifically defined, generally refers to an inclusive or a closed range. For example, if a parameter X is between about A and B, then $A \leq X \leq B$.

A connector assembly is generally used to connect a cable or a cable assembly from one device (e.g., a server, a network switching system, a client device, etc.) to another device (e.g., another server) for various applications, such as data processing, data transmission, and data reception.

An increase in data processing and data storage requirements typically causes an increasing demand for facilities (e.g., server rooms) to accommodate growing numbers of servers and supporting equipment. This demand may lead to an emphasis on physical space saving in the facilities in order to accommodate more servers and more supporting equipment. Therefore, a compact and a low-profile connector assembly may be desired.

The present disclosure relates to a connector assembly. The connector assembly is configured to mate with a mating connector along a mating direction. The connector assembly includes a circuit board. The circuit board includes a mating section including a plurality of electrically conductive mating pads for making contact with corresponding electrically conductive elements of the mating connector. The circuit board further includes a cable section including pluralities of electrically conductive first, second, and third cable pads electrically connected to the mating pads. The connector assembly further includes first, second, and third cable stacks. Each of the cable stacks includes at least two substantially planar ribbon cables stacked along a thickness direction of the cable stack. Each of the ribbon cables includes a plurality of insulated electrical conductors extending along a length, and arranged along a width, of the ribbon cable. Each of the cable stacks is folded about a corresponding fold line of the cable stack that extends across the entire width of the cable stack to form a fold angle of less than about 30 degrees between first and second opposing portions of the cable stack at the fold line. The first portions of the cable stacks extend along the mating direction and are arranged side-by-side in a substantially co-planar

relationship to one another. The second portions of the cable stacks extend along a transverse direction substantially orthogonal to the mating direction and are arranged in a stack. Front ends of the insulated electrical conductors of the ribbon cables of the first portions of the first, second, and third cable stacks are substantially aligned with, and terminated at, the cable pads of the respective pluralities of the first, second, and third cable pads in a one to one correspondence.

Therefore, the connector assembly of the present disclosure may be compact and have a low profile. Specifically, the connector assembly may have the low profile since each of the cable stacks include the substantially planar ribbon cables. Further, the connector assembly may have the low profile as each of the cable stacks is folded about the corresponding fold line, such that the first portions of the cable stacks are arranged side-by-side in the substantially co-planar relationship to one another. Furthermore, the second portions of the cable stacks, which are also arranged in the stack, may result in the low profile of the connector assembly. Thus, the connector assembly may require less physical space than conventional connector assemblies.

In addition, since the second portions of the cable stacks extend substantially orthogonally to the mating direction, the cable stacks exit from one side of the circuit board of the connector assembly. Thus, the connector assembly may be suitable for mating with mating connectors which are placed in a middle portion of a circuit board. Further, the cable stacks of the connector assembly may be accommodated in a redundant space. The connector assembly may further allow easy unmating of the cable stacks of the connector assembly from the mating connector associated with a device (e.g., a networking device).

Referring now to the figures, FIGS. 1A, 1B, and 1C illustrate a connector assembly 200, according to an embodiment of the present disclosure. Specifically, FIG. 1A illustrates a schematic perspective rear view of the connector assembly 200, FIG. 1B illustrates a schematic perspective side view of the connector assembly 200 mated with a mating connector 300, and FIG. 1C illustrates a schematic perspective rear view of a portion of the connector assembly 200.

Referring to FIGS. 1A to 1C, the connector assembly 200 defines mutually orthogonal x, y, and z-axes. The x-axis is defined along a length of the connector assembly 200, while the y-axis is defined along a breadth of the connector assembly 200. The z-axis is defined along a thickness of the connector assembly 200.

The connector assembly 200 is configured to mate with the mating connector 300 along a mating direction. As illustrated in FIG. 1B, the mating direction is substantially along the y-axis.

The connector assembly 200 includes a circuit board 10. In some embodiments, the mating connector 300 is mounted on a second circuit board 310.

The connector assembly 200 includes first, second, and third cable stacks 20a, 20b, 20c (interchangeably referred to as “the plurality of individual cable stacks 20a, 20b, 20c” and “the cable stacks 20a, 20b, 20c”) stacked along a thickness direction, and extending along a length direction of the first, second, and third cable stacks 20a, 20b, 20c. As illustrated in FIG. 1A, the thickness direction is substantially along the z-axis and the length direction is substantially along the x-axis. Specifically, the connector assembly 200 further includes a combined stack 24 (interchangeably referred to as “the stack 24”) of the plurality of individual cable stacks 20a, 20b, 20c stacked along the common thickness direction and extending along the common length direction of the combined stack 24 and the individual cable stacks 20a, 20b, 20c. In the illustrated embodiment of FIG. 1A to 1C, the plurality of individual cable stacks 20a, 20b, 20c includes three individual cable stacks 20a, 20b, 20c. Further, the common thickness direction is substantially along the z-axis and the common length direction is substantially along the x-axis. In some embodiments, a total number of the individual cable stacks 20a, 20b, 20c may be varied as per desired application attributes.

Each of the cable stacks 20a, 20b, 20c includes at least two substantially planar ribbon cables 21 stacked along the thickness direction (i.e., substantially along the z-axis) of the cable stack 20a, 20b, 20c. In the illustrated embodiment of FIGS. 1A to 1C, each of the individual cable stacks 20a, 20b, 20c includes top and bottom substantially planar ribbon cables 21a, 21b stacked along the thickness direction. In some embodiments, the at least two substantially planar cables 21 may include network cables. In the illustrated embodiment of FIG. 1C, the at least two substantially planar cables 21 includes two substantially planar cables 21. In some embodiments, a total number of the substantially planar cables 21 may be varied as per desired application attributes.

In some embodiments, the connector assembly 200 further includes an insulative housing 50 (interchangeably referred to as “the housing 50”) and a pull tab assembly 60 disposed on, and removably assembled to, a top side 55 of the insulative housing 50. The pull tab assembly 60 includes a pull tab 70 configured to move relative to the insulative housing 50 along the mating direction (i.e., substantially along the y-axis).

FIGS. 2A and 2B illustrate the connector assembly 200 without the pull tab assembly 60 shown in FIG. 1A, according to an embodiment of the present disclosure. Specifically, FIG. 2A illustrates a schematic perspective side view of the connector assembly 200 without the pull tab assembly 60 and FIG. 2B illustrates a schematic perspective top view of the connector assembly 200 without the pull tab assembly 60.

The insulative housing 50 includes a front mating side 51 for mating with the mating connector 300 (shown in FIG. 1B) along the mating direction (i.e., substantially along the y-axis), a back side 52 opposite the mating side 51, and a pair of opposing first and second sides 53, 54 joining the front mating and back sides 51, 52 and substantially orthogonal to the circuit board 10. The insulative housing 50 further includes a channel 56 formed on the top side of the insulative housing 50. Further, the insulative housing 50 may be made of any suitable insulative material, such as a composite, a plastic, a dielectric material, and so forth.

FIG. 3A illustrates a schematic top view of a cable assembly 400 for use in the connector assembly 200 shown in FIG. 1A, according to an embodiment of the present disclosure. FIG. 3B illustrates a schematic perspective side view of the first cable stack 20a, according to an embodiment of the present disclosure.

Referring to FIGS. 3A and 3B, the cable assembly 400 includes the circuit board 10. Further, the cable assembly 400 includes the combined stack 24 (shown in FIGS. 1A and 1C) of the plurality of individual cable stacks 20a, 20b, 20c. Thus, the cable assembly 400 includes the circuit board 10 and the combined stack 24 of the connector assembly 200.

The circuit board 10 includes a plurality of electrically conductive mating pads 12 (interchangeably referred to as “the conductive mating pads 12” and “the mating pads 12”) for making contact with corresponding electrically conductive elements (not shown) of the mating connector 300 shown in FIG. 1B. In some embodiments, the contact may be an electrical and physical contact. In other words, the circuit board 10 includes the plurality of electrically conductive mating pads 12 for making the electrical and physical contact with the corresponding electrically conductive elements of the mating connector 300. In some embodiments, the circuit board 10 includes a mating section 11. The mating section 11 includes the plurality of electrically conductive mating pads 12 for making contact with the corresponding electrically conductive elements of the mating connector 300. In some embodiments, the conductive mating pads 12 are arranged in one or more substantially parallel rows of the conductive mating pads 12.

The circuit board 10 further includes a cable section 13. The cable section 13 includes plurality of electrically conductive cable pads 14 (interchangeably referred to as “the conductive cable pads 14” and “the cable pads 14”) electrically connected to the mating pads 12. Specifically, the cable section 13 includes pluralities of electrically conductive first, second, and third cable pads 14a, 14b, 14c electrically connected to the mating pads 12.

Further, the mating pads 12 may include an electrically conductive material, such as a metal or an alloy. Similarly, the cable pads 14 may be made of an electrically conductive material, such as a metal or an alloy. The mating pads 12 and the cable pads 14 may have a similar material and configuration or have different materials and configurations.

In some embodiments, the circuit board 10 may be a printed circuit board (PCB). In some embodiments, the circuit board 10 may further include other conductive features. In some embodiments, the other conductive features may be made of a metal or an alloy, such as copper. The mating pads 12, the cable pads 14, and the other conductive features may be disposed on at least one of a top side 15a (interchangeably referred to as “the first major side 15a” and shown in FIG. 5A) and a bottom side 15b (interchangeably referred to as “the second major side 15b” and shown in FIG. 5B), opposite the top side 15a, of the circuit board 10.

In some embodiments, each of the top side 15a and the bottom side 15b is substantially planar. Further, the top side 15a and the bottom side 15b are substantially parallel to each other. In some embodiments, the mating pads 12 and the cable pads 14 and the other conductive features may be disposed on a non-conductive substrate. In some embodiments, the non-conductive substrate may be made of a polymeric resin.

As shown in FIG. 3A, each of the cable stacks 20a, 20b, 20c is folded about a corresponding fold line 30 of the cable stack 20a, 20b, 20c that extends across the entire width of the cable stack 20a, 20b, 20c to form a fold angle f1 (shown in FIG. 3B) between first and second opposing portions 22, 23 of the cable stack 20a, 20b, 20c at the fold line 30. In other words, each of the individual cable stacks 20a, 20b, 20c is folded about the corresponding fold line 30 of the individual cable stack 20a, 20b, 20c that extends across the entire width of the individual cable stack 20a, 20b, 20c to form the fold angle f1 between the first and second opposing portions 22, 23 of the individual cable stack 20a, 20b, 20c at the fold line 30.

The fold angle $f1$ is less than about 30 degrees. In some embodiments, the fold angle $f1$ is less than about 25 degrees, less than about 20 degrees, less than about 15 degrees, less than about 10 degrees, less than about 5 degrees, or less than about 2 degrees.

The first portions 22 of the cable stacks 20a, 20b, 20c extend along the mating direction and are arranged side-by-side in a substantially co-planar relationship to one another. In other words, the first portions 22 of the individual cable stacks 20a, 20b, 20c extend along the mating direction and are arranged side-by-side in the substantially co-planar relationship to one another. Specifically, the first portions 22 of the cable stacks 20a, 20b, 20c extend along the mating direction, i.e., substantially along the y-axis, and are arranged side-by-side in the substantially co-planar relationship to one another in the x-y plane. Thus, the combined stack 24 of the connector assembly 200 including the individual cable stacks 20a, 20b, 20c may have a low profile. Hence, the connector assembly 200 may occupy less physical space than conventional connector assemblies.

Further, the second portions 23 of the cable stacks 20a, 20b, 20c extend along a transverse direction substantially orthogonal to the mating direction and are arranged in the stack 24. In some embodiments, the transverse direction is along the length direction of the first, second, and third cable stacks 20a, 20b, 20c. The transverse direction is substantially along the x-axis. In other words, the second portions 23 of the individual cable stacks 20a, 20b, 20c extend along the common length direction and substantially remain in the combined stack 24. Hence, the connector assembly 200 may further occupy less physical space than conventional connector assemblies.

FIG. 4A illustrates a schematic perspective side view of one ribbon cable 21 from the at least two substantially planar ribbon cables 21 shown in FIG. 1C with some components removed, according to an embodiment of the present disclosure. Specifically, FIG. 4A illustrates a schematic perspective side view of the one ribbon cable 21 from the at least two substantially planar ribbon cables 21 without any electrically insulative jacket layer. FIG. 4B illustrates a schematic perspective front view of the ribbon cable 21, according to an embodiment of the present disclosure.

Referring to FIGS. 4A and 4B, each of the ribbon cables 21 includes a plurality of insulated electrical conductors 40 extending along a length, and arranged along a width, of the ribbon cable 21. In some embodiments, the length of the ribbon cable 21 is substantially along the x-axis and the width of the ribbon cable 21 is substantially along the y-axis. In the illustrated embodiment of FIG. 4B, each of the ribbon cables 21 includes eight insulated electrical conductors 40 extending

along the length, and arranged along the width, of the ribbon cable 21. In some embodiments, a total number of the plurality of insulated electrical conductors 40 of each of the ribbon cables 21 may be varied as per desired application attributes.

In some embodiments, each of the insulated electrical conductors 40 includes an electrically conductive central conductor 42 surrounded by an electrically insulative material 43. In some embodiments, the electrically conductive central conductor 42 may be made of a metal or an alloy, such as copper. In some embodiments, the electrically insulative material 43 may be made of any suitable material, such as a composite, a plastic, a dielectric material, and so forth.

In some embodiments, each of the ribbon cables 21 includes a plurality of conductor sets 44. Specifically, each of the top and bottom ribbon cables 21a, 21b includes the plurality of conductor sets 44. In the illustrated embodiment of FIG. 4B, each of the ribbon cables 21 includes four conductor sets 44. In some embodiments, a total number of the plurality of conductor sets 44 of each of the ribbon cables 21 may be varied as per desired application attributes. Further, in some embodiments, each conductor set 44 includes two or more of the insulated electrical conductors 40 substantially surrounded by an electrically conductive shield 45.

In some embodiments, each of the ribbon cables 21 further includes at least one electrically insulative jacket layer 47 substantially covering at least both major sides of the ribbon cable 21. In some embodiments, the at least one electrically insulative jacket layer 47 may be made of any suitable material, such as a composite, a plastic, a dielectric material, and so forth.

In the illustrated embodiment of FIG. 4B, the at least one electrically insulative jacket layer 47 of each of the ribbon cables 21 includes upper and lower electrically insulative jacket layers 47a, 47b substantially covering upper and lower major sides of the ribbon cable 21, respectively.

In some embodiments, each of the ribbon cables 21 further includes one or more uninsulated electrically conductive conductor 46. In the illustrated embodiment of FIG. 4B, each of the ribbon cables 21 further includes two uninsulated electrically conductive conductors 46. In some embodiments, a total number of the one or more uninsulated electrically conductive conductor 46 may be varied as per desired application attributes.

Referring to FIGS. 3A to 3B and 4A to 4B, front ends 41 of the insulated electrical conductors 40 of the ribbon cables 21 of the first portions 22 of the first, second, and third cable stacks 20a, 20b, 20c are substantially aligned with, and terminated at, the cable pads 14 of the respective pluralities of the first, second, and third cable pads 14a, 14b, 14c in a one to one

correspondence. Specifically, the front ends 41 of the insulated electrical conductors 40 of the ribbon cables 21 of the first portion 22 of the first cable stack 20a are substantially aligned with, and terminated at, the cable pads 14 of the first cable pad 14a in a one to one correspondence. Further, the front ends 41 of the insulated electrical conductors 40 of the ribbon cables 21 of the first portion 22 of the second cable stack 20b are substantially aligned with, and terminated at, the cable pads 14 of the second cable pad 14b in a one to one correspondence. Furthermore, the front ends 41 of the insulated electrical conductors 40 of the ribbon cables 21 of the first portion 22 of the third cable stack 20c are substantially aligned with, and terminated at, the cable pads 14 of the third cable pad 14c in a one to one correspondence.

FIG. 5A illustrates a schematic perspective top view the cable assembly 400, according to an embodiment of the present disclosure. FIG. 5B illustrates a schematic perspective bottom view the cable assembly 400, according to an embodiment of the present disclosure.

Referring to FIGS. 3A to 3B and 5A to 5B, in some embodiments, the circuit board 10 includes a plurality of top cable pads 14a1, 14b1, 14c1 (interchangeably referred to as “the first, second, and third groups 14a1, 14b1, 14c1 of the cable pads 14”) disposed on the top side 15a of the circuit board 10. In some embodiments, the circuit board 10 includes a plurality of bottom cable pads 14a2, 14b2, 14c2 (interchangeably referred to as “the fourth, fifth, and sixth groups 14a2, 14b2, 14c2 of the cable pads 14”) disposed on the bottom side 15b, opposite the top side 15a, of the circuit board 10. The top and bottom cable pads 14a1, 14b1, 14c1, 14a2, 14b2, 14c2 are electrically connected to the mating pads 12.

In other words, the uninsulated top and bottom front ends 41 of the two or more insulated electrical conductors 40 of each of the conductor sets 44 of each of the respective top and bottom ribbon cables 21a, 21b are substantially aligned with, and terminated at, the corresponding cable pads 14 of the respective top and bottom cable pads 14a1, 14b1, 14c1, 14a2, 14b2, 14c2. Specifically, the uninsulated top front ends 41 of the two or more insulated electrical conductors 40 of each of the conductor sets 44 of each of the top ribbon cables 21a are substantially aligned with, and terminated at, the corresponding cable pads 14 of the top cable pads 14a1, 14b1, 14c1. Similarly, the uninsulated bottom front ends 41 of the two or more insulated electrical conductors 40 of each of the conductor sets 44 of each of the bottom ribbon cables 21b are substantially aligned with, and terminated at, the corresponding cable pads 14 of the bottom cable pads 14a2, 14b2, 14c2.

In some embodiments, the mating section 11 includes a first mating section 11a on the first major side 15a of the circuit board 10 and a second mating section 11b on the opposite second major side 15b (shown in FIG. 5B) of the circuit board 10. The first mating section 11a includes a first group 12a of the conductive mating pads 12. Similarly, the second mating section 11b includes a second group 12b of the remaining conductive mating pads 12.

Further, in some embodiments, the cable section 13 includes a first cable section 13a on the first major side 15a of the circuit board 10 and a second cable section 13b on the opposite second major side 15b of the circuit board 10.

The first cable section 13a includes the first, second, and third groups 14a1, 14b1, 14c1 of the cable pads 14 in the respective electrically conductive first, second, and third cable pads 14a, 14b, 14c. Specifically, the first cable section 13a includes the first group 14a1 of the cable pads 14 in the first cable pad 14a, the second group 14b1 of the cable pads 14 in the second cable pad 14b, and the third group 14c1 of the cable pads 14 in the third cable pad 14c.

The second cable section 13b includes the fourth, fifth, and sixth groups 14a2, 14b2, 14c2 of the remaining cable pads 14 in the respective electrically conductive first, second, and third cable pads 14a, 14b, 14c. Specifically, the second cable section 13b includes the fourth group 14a2 of the remaining cable pads 14 in the first cable pad 14a, the fifth group 14b2 of the remaining cable pads 14 in the second cable pad 14b, and the sixth group 14c2 of the remaining cable pads 14 in the third cable pad 14c.

In some embodiments, the first portion 22 of each of the of the first, second and third cable stacks 20a, 20b, 20c includes a first segment 22a of at least one of the at least two substantially planar ribbon cables 21 of the stack 24 and a second segment 22b of at least another one of the at least two substantially planar ribbon cables 21 of the stack 24.

Referring to FIGS. 4A-4B and 5A-5B, in some embodiments, the front ends 41 of the insulated electrical conductors 40 of the first segment 22a of the first portion 22 are substantially aligned with, and terminated at, the cable pads 14 of the corresponding one of the first, second, and third groups 14a1, 14b1, 14c1 of the cable pads 14. Further, in some embodiments, the front ends 41 of the insulated electrical conductors 40 of the second segment 22b of the first portion 22 are substantially aligned with, and terminated at, the cable pads 14 of the corresponding one of the fourth, fifth, and sixth groups 14a2, 14b2, 14c2 of the cable pads 14.

Now referring to FIGS. 1A-1C to 5A-5B, in some embodiments, the insulative housing 50 is molded over and fully encapsulates at least the mating section 11 of the circuit board 10, the front ends 41 of the insulated electrical conductors 40 of the ribbon cables 21 of the first portions 22 of the first, second and third cable stacks 20a, 20b, 20c, the first portions 22 of the first, second and third cable stacks 20a, 20b, 20c, the fold lines 30 of each of the first, second and third cable stacks 20a, 20b, 20c, and a portion of the second portions 23 of the first, second and third cable stacks 20a, 20b, 20c.

Further, in some embodiments, the stack 24 of the second portions 23 of the first, second and third cable stacks 20a, 20b, 20c exits the housing 50 through, and substantially orthogonal to, the first side 53 of the housing 50. Thus, the connector assembly 200 may be suitable for mating with the mating connector 300 which is placed in a middle portion of the second circuit board 310. Further, the first, second and third cable stacks 20a, 20b, 20c of the connector assembly 200 may be accommodated in a redundant space.

FIGS 6A-6D illustrate different schematic views of the connector assembly 200 including the pull tab assembly 60, according to an embodiment of the present disclosure. Specifically, FIG. 6A illustrates a schematic perspective top view of the connector assembly 200 with the mating connector 300. FIG. 6B illustrates a schematic perspective top view of the connector assembly 200 with the mating connector 300 removed. FIG. 6C illustrates a schematic perspective front view of the connector assembly 200 with the insulative housing 50 removed. FIG. 6D illustrates a schematic perspective rear view of the connector assembly 200.

Referring to FIGS. 6A-6D, as discussed above, the connector assembly 200 includes the pull tab assembly 60 disposed on, and removably assembled to, the top side 55 of the insulative housing 50. Further, the pull tab assembly 60 includes the pull tab 70 configured to move relative to the insulative housing 50 along the mating direction (i.e., substantially along the y-axis).

The pull tab 70 includes an operating portion 71 extending beyond the housing 50. The pull tab 70 further includes an elongated section 72 extending along the mating direction from the operating portion 71. The elongated section 72 is at least partially disposed in the channel 56 (shown in FIG. 2B) formed on the top side 55 of the housing 50. The pull tab 70 further includes a coupling section 73 extending from the elongated section 72 in a direction away from the top side 55 of the insulative housing 50 and making an obtuse angle with the elongated section 72.

In some embodiments, the pull tab assembly 60 further includes a first actuating section 80. The first actuating section 80 includes a first feature 81 (shown in FIG. 6D) engaging a corresponding first feature 57 (shown in FIG. 6D) of the insulative housing 50 so that the pull tab assembly 60 is removably assembled to the insulative housing 50. This may allow easy removal, servicing, and/or replacement of the pull tab assembly 60 of the connector assembly 200. The first actuating section 80 further includes a second feature 82 engaging an end section 74 of the coupling section 73 of the pull tab 70.

In some embodiments, the pull tab assembly 60 further includes a second actuating portion 90 removably assembled to the first actuating section 80. The second actuating portion 90 includes a latch portion 91 extending through and beyond a corresponding through opening 83 in the first actuating section 80 and configured to latch onto a corresponding opening 315 (shown in FIG. 6A) in the mating connector 300 (shown in FIG. 6A).

In the illustrated embodiment of FIGS. 6A-6D, the latch portion 91 includes two projections extending through and beyond corresponding two through openings 83 in the first actuating section 80. Further, the two projections are configured to latch onto corresponding two openings 315 in the mating connector 300.

The latch portion 91 extends through and beyond the corresponding through opening 83 in the first actuating section 80 and is configured to latch onto the corresponding opening 315 in the mating connector 300, such that when the connector assembly 200 mates with the mating connector 300 and the latch portion 91 latches onto the corresponding opening 315 in the mating connector 300, a pulling of the operating portion 71 of the pull tab 70 unlatches the mating connector 300 by causing the latch portion 91 to unlatch from the corresponding opening 315 in the mating connector 300. The pull tab assembly 60 may therefore facilitate easy unmating of the connector assembly 200 and the mating connector 300. Further, the pull tab assembly 60 may also prevent accidental unmating of the mating connector 300.

Unless otherwise indicated, all numbers expressing feature sizes, amounts, and physical properties used in the specification and claims are to be understood as being modified by the term “about”. Accordingly, unless indicated to the contrary, the numerical parameters set forth in the foregoing specification and attached claims are approximations that can vary depending upon the desired properties sought to be obtained by those skilled in the art utilizing the teachings disclosed herein.

Although specific embodiments have been illustrated and described herein, it will be appreciated by those of ordinary skill in the art that a variety of alternate and/or equivalent implementations can be substituted for the specific embodiments shown and described without departing from the scope of the present disclosure. This application is intended to cover any adaptations or variations of the specific embodiments discussed herein. Therefore, it is intended that this disclosure be limited only by the claims and the equivalents thereof.

CLAIMS

What is claimed is:

1. A connector assembly configured to mate with a mating connector along a mating direction and comprising:
 - a circuit board comprising a mating section comprising a plurality of electrically conductive mating pads for making contact with corresponding electrically conductive elements of the mating connector, and a cable section comprising pluralities of electrically conductive first, second, and third cable pads electrically connected to the mating pads; and
 - first, second, and third cable stacks, each of the cable stacks comprising at least two substantially planar ribbon cables stacked along a thickness direction of the cable stack, each of the ribbon cables comprising a plurality of insulated electrical conductors extending along a length, and arranged along a width, of the ribbon cable,
 - each of the cable stacks folded about a corresponding fold line of the cable stack that extends across the entire width of the cable stack to form a fold angle of less than about 30 degrees between first and second opposing portions of the cable stack at the fold line,
 - the first portions of the cable stacks extending along the mating direction and arranged side-by-side in a substantially co-planar relationship to one another, the second portions of the cable stacks extending along a transverse direction substantially orthogonal to the mating direction and arranged in a stack,
 - front ends of the insulated electrical conductors of the ribbon cables of the first portions of the first, second, and third cable stacks substantially aligned with, and terminated at, the cable pads of the respective pluralities of the first, second, and third cable pads in a one to one correspondence.
2. The connector assembly of claim 1, wherein the conductive mating pads are arranged in one or more substantially parallel rows of the conductive mating pads.
3. The connector assembly of claim 1, wherein the mating section comprises a first mating section on a first major side of the circuit board and a second mating section on an opposite

second major side of the circuit board, and wherein the first mating section comprises a first group of the conductive mating pads and the second mating section comprises a second group of the remaining conductive mating pads.

4. The connector assembly of claim 1, wherein the cable section comprises a first cable section on a first major side of the circuit board and a second cable section on an opposite second major side of the circuit board, and wherein the first cable section comprises first, second, and third groups of the cable pads in the respective electrically conductive first, second, and third cable pads, and the second cable section comprises fourth, fifth, and sixth groups of the remaining cable pads in the respective electrically conductive first, second, and third cable pads.
5. The connector assembly of claim 4, wherein the first portion of each of the of the first, second and third cable stacks comprises a first segment of at least one of the at least two substantially planar ribbon cables of the stack and a second segment of at least another one of the at least two substantially planar ribbon cables of the stack, and wherein:
 - the front ends of the insulated electrical conductors of the first segment of the first portion are substantially aligned with, and terminated at, the cable pads of the corresponding one of the first, second, and third groups of the cable pads; and
 - the front ends of the insulated electrical conductors of the second segment of the first portion are substantially aligned with, and terminated at, the cable pads of the corresponding one of the fourth, fifth, and sixth groups of the cable pads.
6. The connector assembly of claim 1, wherein each of the insulated electrical conductors comprises an electrically conductive central conductor surrounded by an electrically insulative material.
7. The connector assembly of claim 1, wherein each of the ribbon cables comprises a plurality of conductor sets, each conductor set comprising two or more of the insulated electrical conductors substantially surrounded by an electrically conductive shield.

8. The connector assembly of claim 1, wherein each of the ribbon cables further comprises at least one electrically insulative jacket layer substantially covering at least both major sides of the ribbon cable.
9. The connector assembly of claim 1, wherein each of the ribbon cables further comprises one or more uninsulated electrically conductive conductor.
10. The connector assembly of claim 1 further comprising an insulative housing molded over and fully encapsulating at least the mating section of the circuit board, the front ends of the insulated electrical conductors of the ribbon cables of the first portions of the first, second, and third cable stacks, the first portions of the first, second, and third cable stacks, the fold lines of each of the first, second, and third cable stacks, and a portion of the second portions of the first, second, and third cable stacks.
11. The connector assembly of claim 10, wherein the insulative housing comprises a front mating side for mating with the mating connector along the mating direction, a back side opposite the mating side, and a pair of opposing first and second sides joining the front mating and back sides and substantially orthogonal to the circuit board.
12. The connector assembly of claim 11, wherein the stack of the second portions of the first, second, and third cable stacks exits the housing through, and substantially orthogonal to, the first side of the housing.
13. The connector assembly of claim 10 further comprising a pull tab assembly disposed on, and removably assembled to, a top side of the insulative housing and comprising:
 - a pull tab configured to move relative to the insulative housing along the mating direction and comprising:
 - an operating portion extending beyond the housing;
 - an elongated section extending along the mating direction from the operating portion and at least partially disposed in a channel formed on the top side of the housing; and

a coupling section extending from the elongated section in a direction away from the top side of the insulative housing and making an obtuse angle with the elongated section; and

a first actuating section comprising a first feature engaging a corresponding first feature of the insulative housing so that the pull tab assembly is removably assembled to the insulative housing and a second feature engaging an end section of the coupling section of the pull tab; and

a second actuating portion removably assembled to the first actuating section and comprising a latch portion extending through and beyond a corresponding through opening in the first actuating section and configured to latch onto a corresponding opening in the mating connector, such that when the connector assembly mates with the mating connector and the latch portion latches onto the corresponding opening in the mating connector, a pulling of the operating portion of the pull tab unlatches the mating connector by causing the latch portion to unlatch from the corresponding opening in the mating connector.

14. The connector assembly of claim 1, wherein the mating connector is mounted on a second circuit board.

15. A cable assembly for use in a connector assembly configured to mate with a mating connector along a mating direction, the cable assembly comprising:

a circuit board comprising:

a plurality of electrically conductive mating pads for making electrical and physical contact with corresponding electrically conductive elements of the mating connector;

a plurality of top cable pads disposed on a top side of the circuit board; and

a plurality of bottom cable pads disposed on a bottom side, opposite the top side, of the circuit board, the top and bottom cable pads electrically connected to the mating pads; and

a combined stack of a plurality of individual cable stacks stacked along a common thickness direction, and extending along a common length direction, of the combined stack and the individual cable stacks, each of the individual cable stacks comprising top and

bottom substantially planar ribbon cables stacked along the thickness direction, each of the top and bottom ribbon cables comprising a plurality of conductor sets, each of the conductor sets comprising two or more insulated electrical conductors substantially surrounded by an electrically conductive shield, each of the insulated electrical conductors comprising an electrically conductive central conductor surrounded by an electrically insulative material,

each of the individual cable stacks folded about a corresponding fold line of the individual cable stack that extends across the entire width of the individual cable stack to form a fold angle of less than about 20 degrees between first and second opposing portions of the individual cable stack at the fold line,

the first portions of the individual cable stacks extending along the mating direction and arranged side-by-side in a substantially co-planar relationship to one another, the second portions of the individual cable stacks extending along the common length direction and substantially remaining in the combined stack,

wherein, uninsulated top and bottom front ends of the two or more insulated electrical conductors of each of the conductor sets of each of the respective top and bottom ribbon cables are substantially aligned with, and terminated at, the corresponding cable pads of the respective top and bottom cable pads.

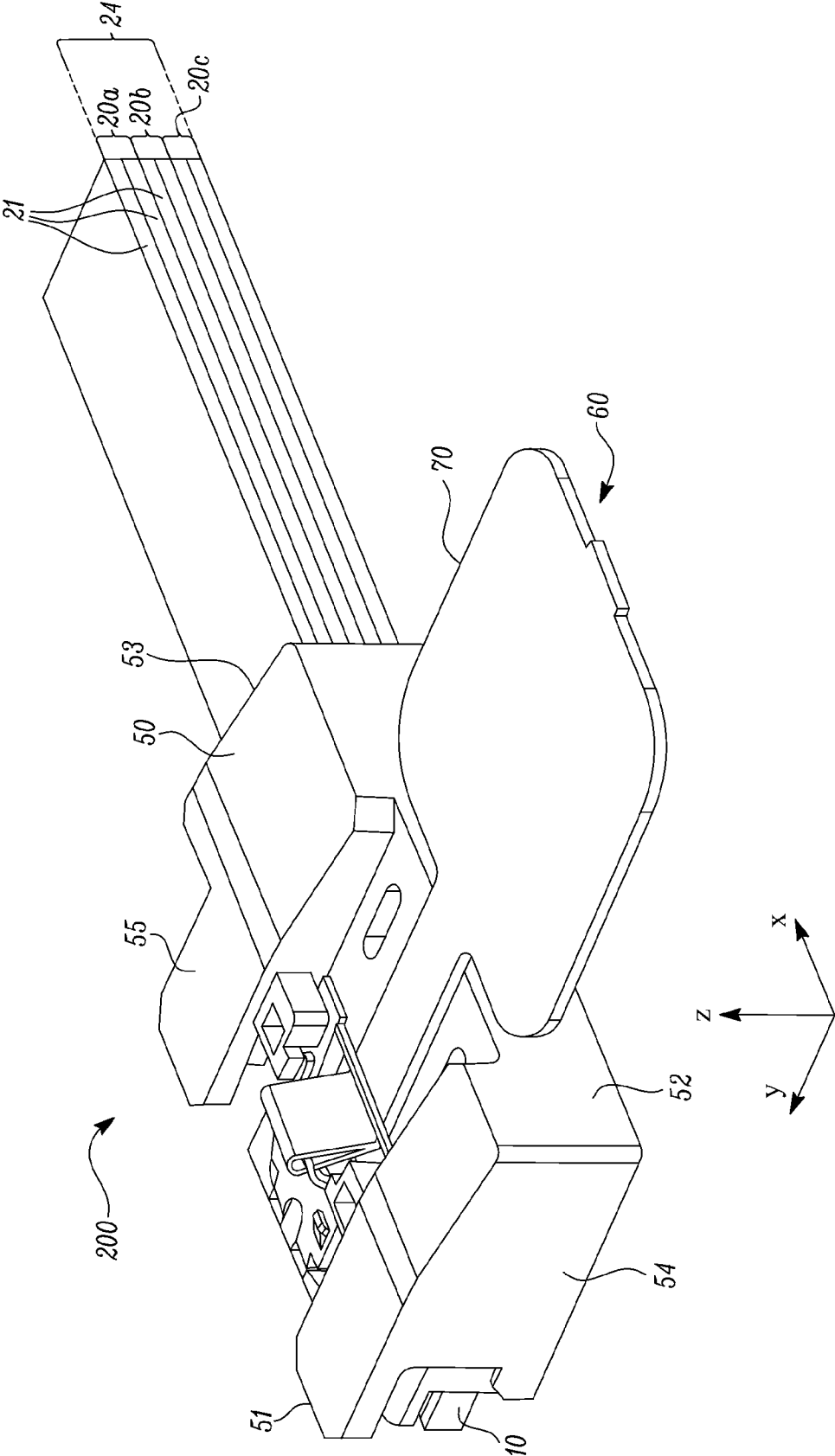


FIG. 1A

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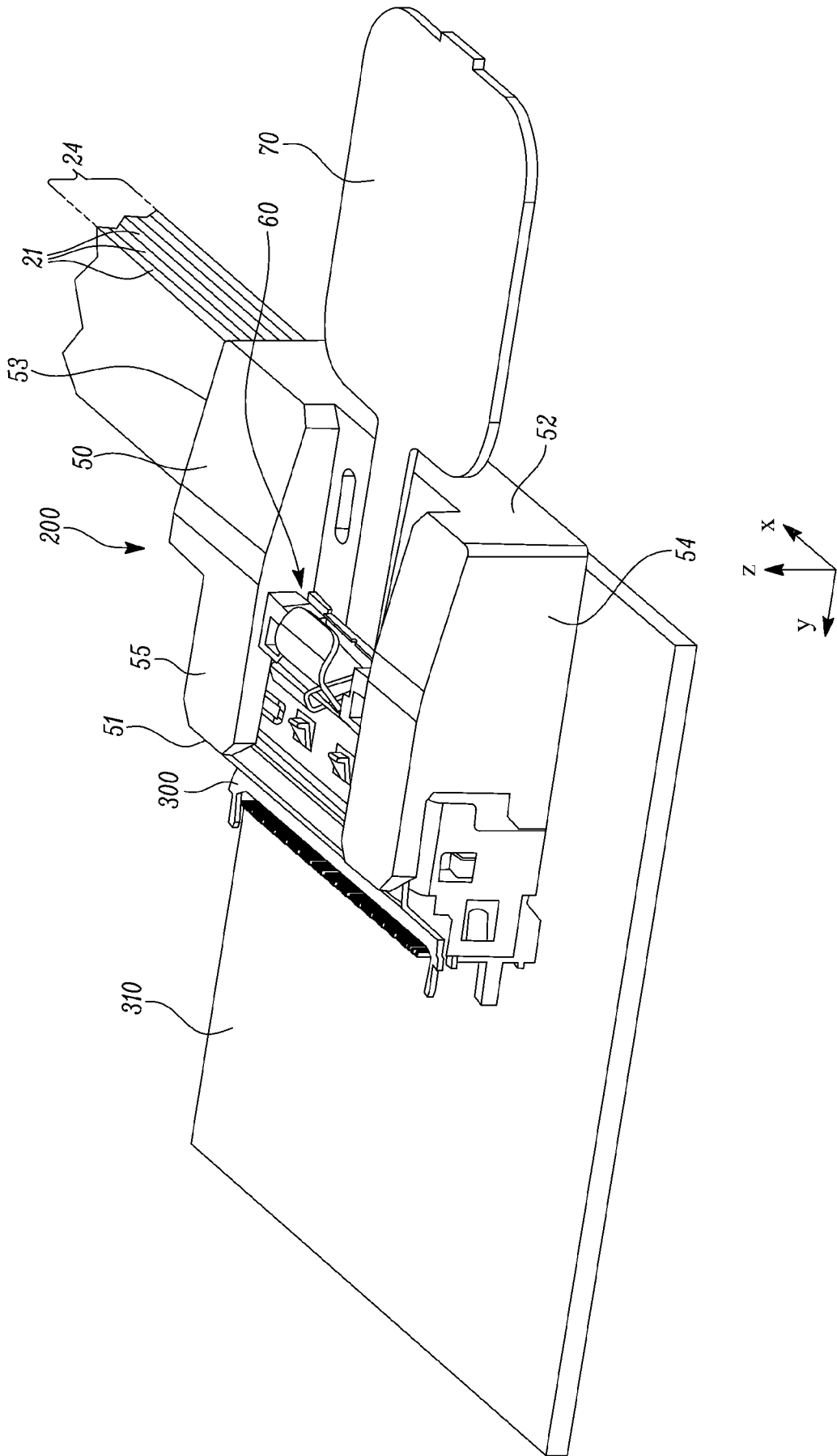


FIG. 1B

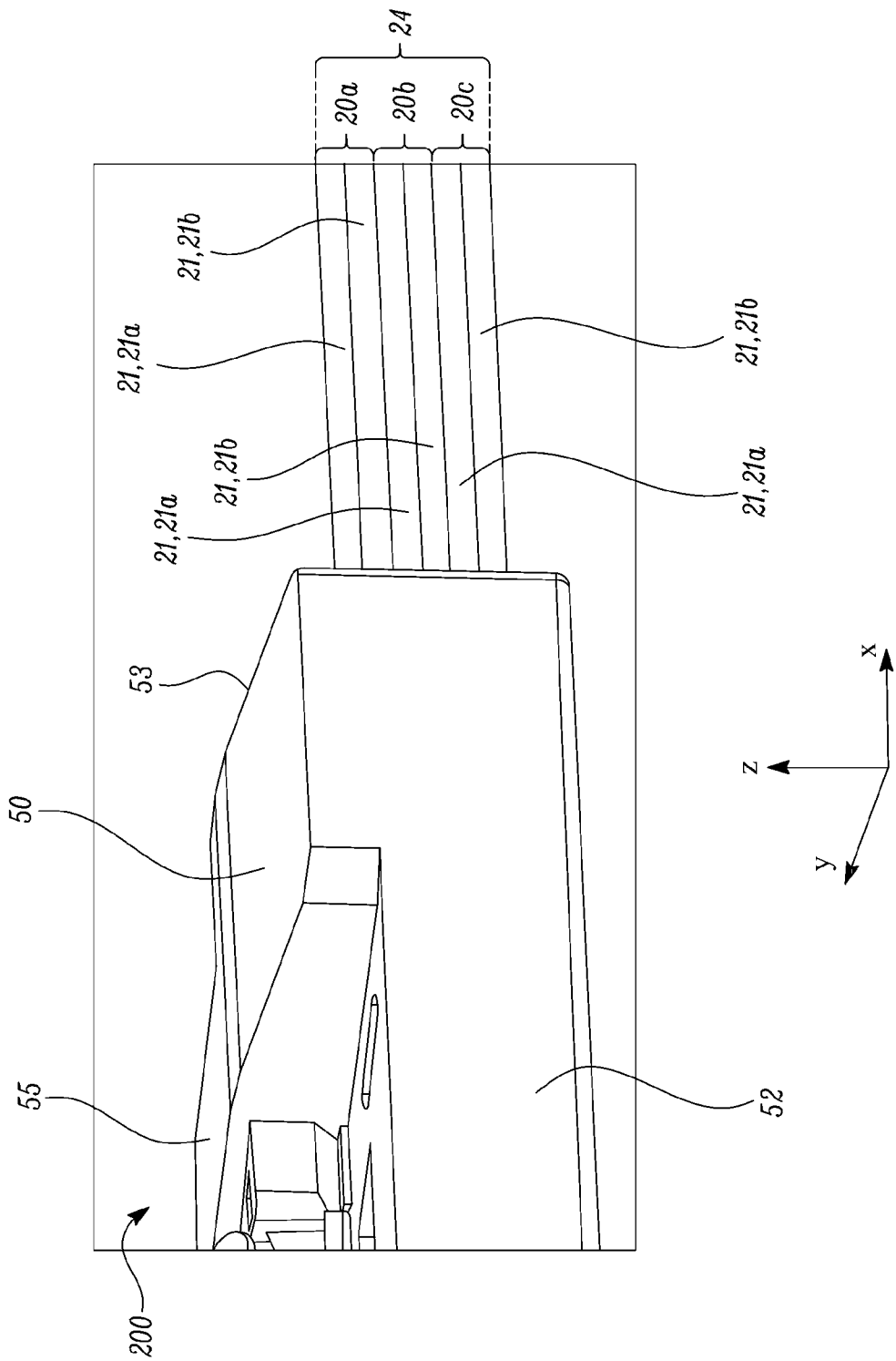


FIG. 1C

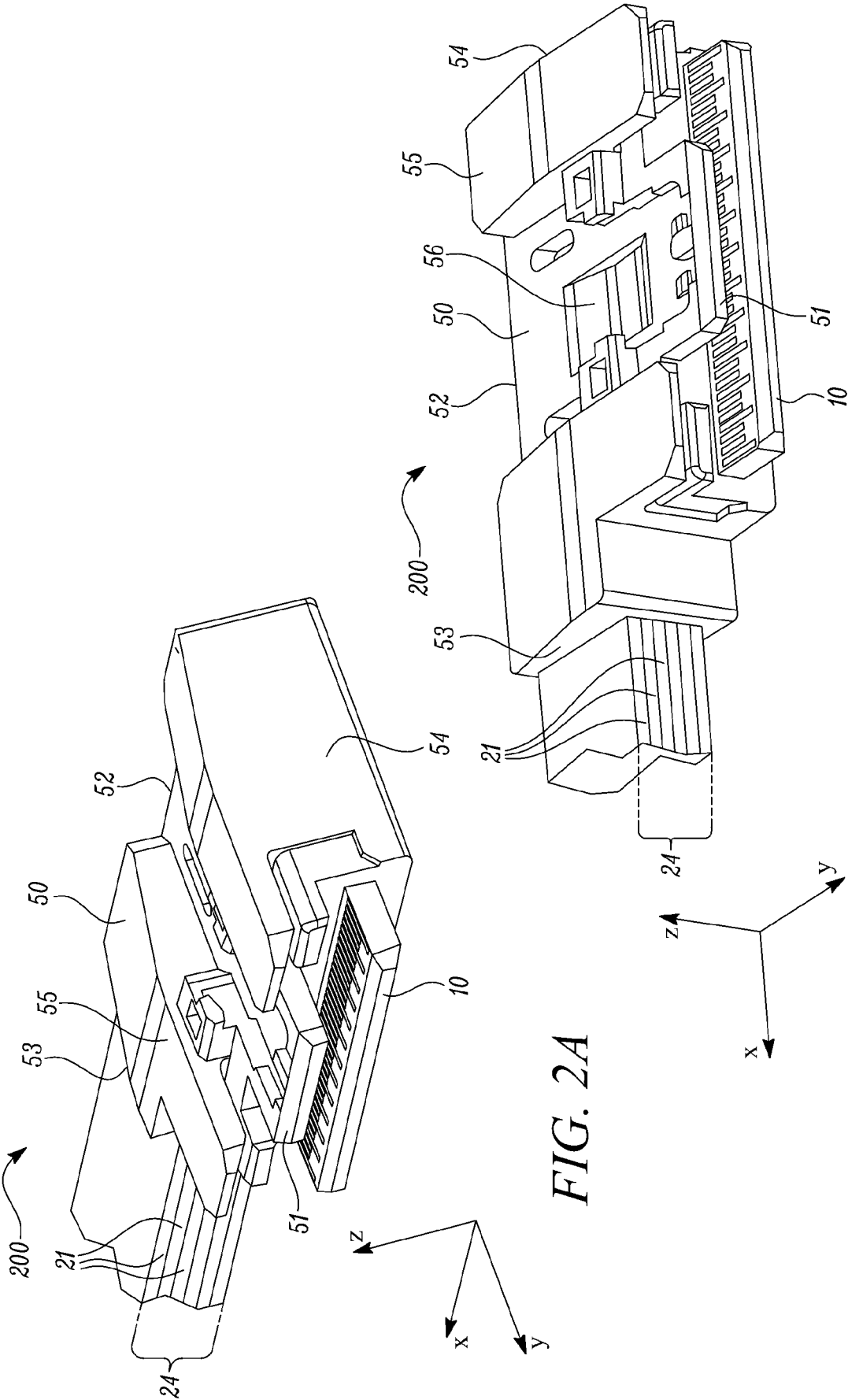


FIG. 2B

FIG. 2A

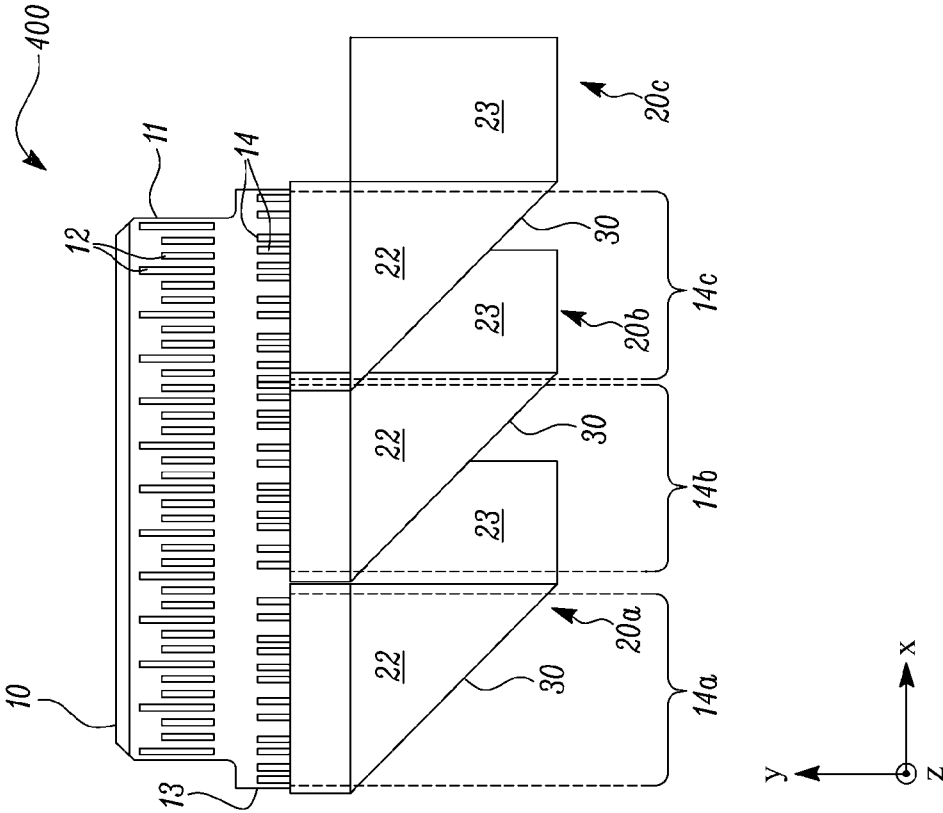


FIG. 3A

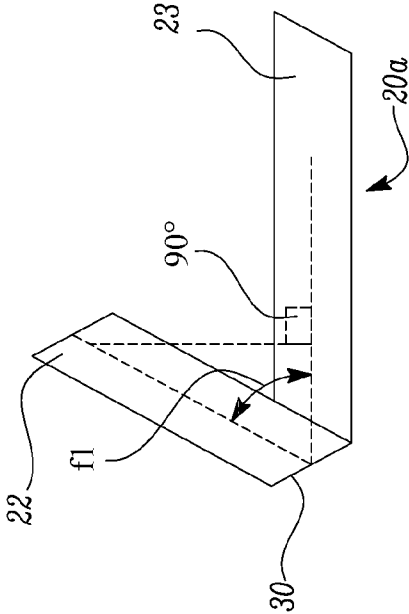


FIG. 3B

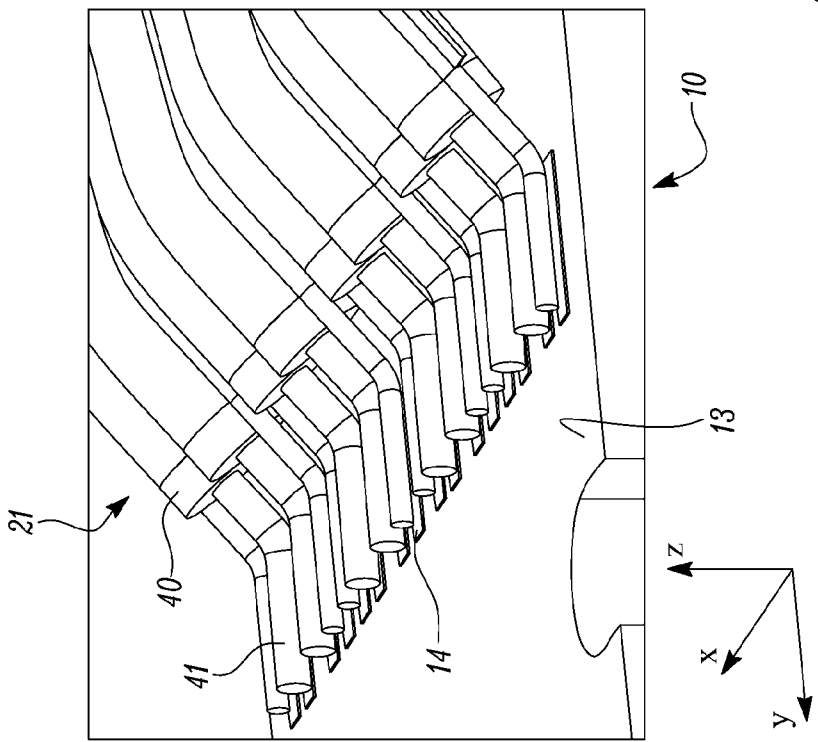


FIG. 4A

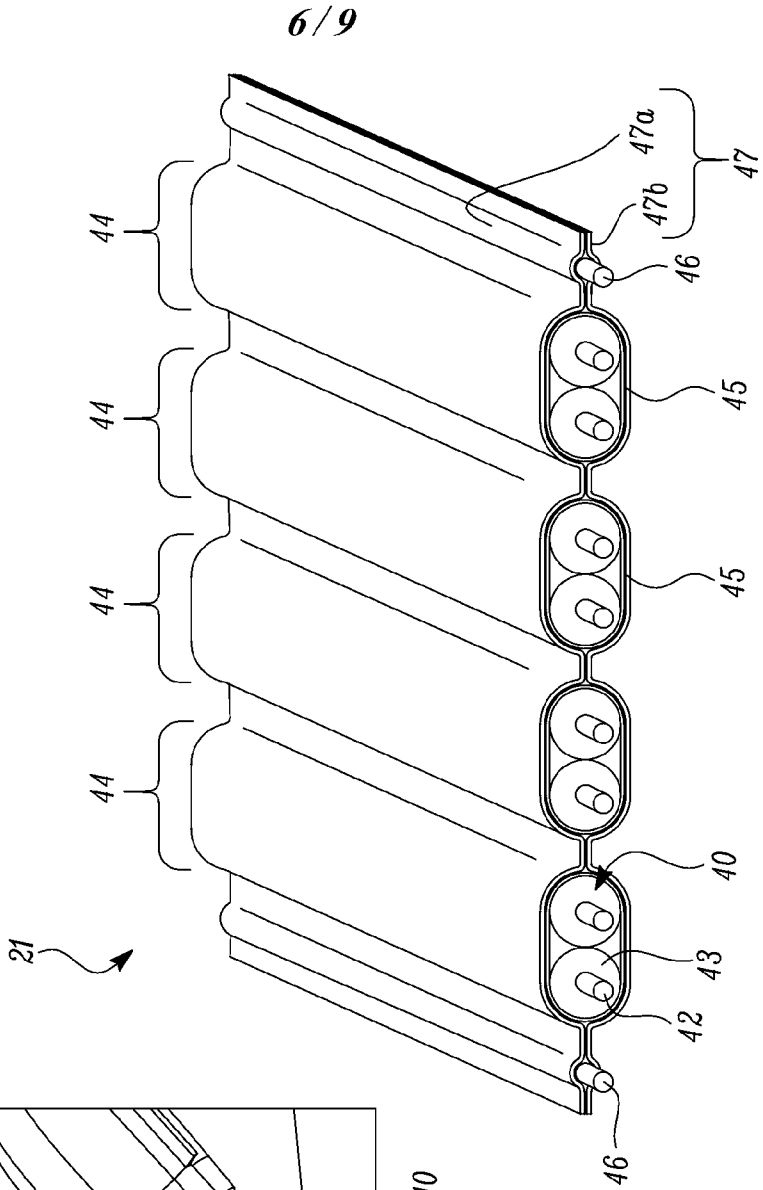


FIG. 4B

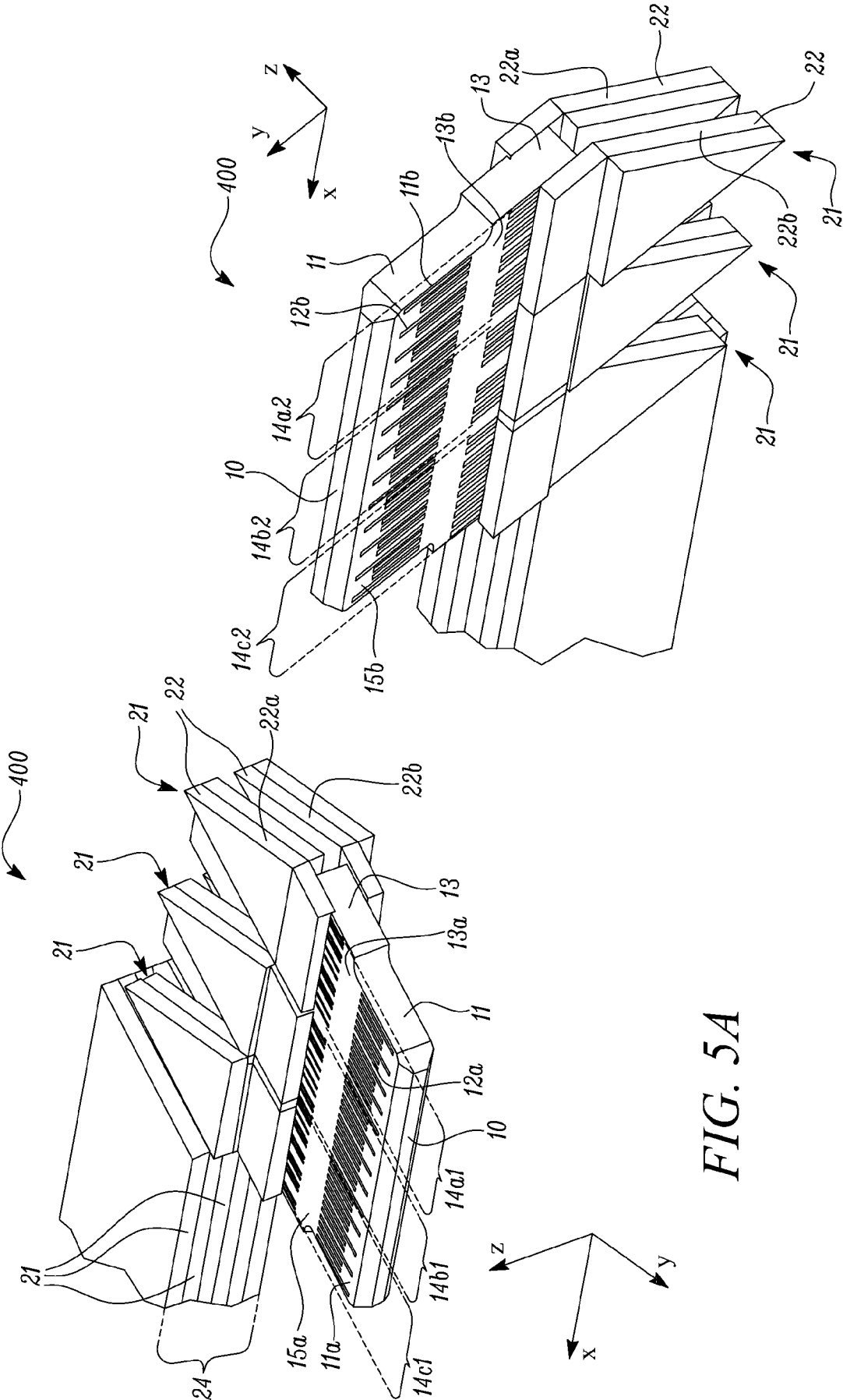


FIG. 5A

FIG. 5B

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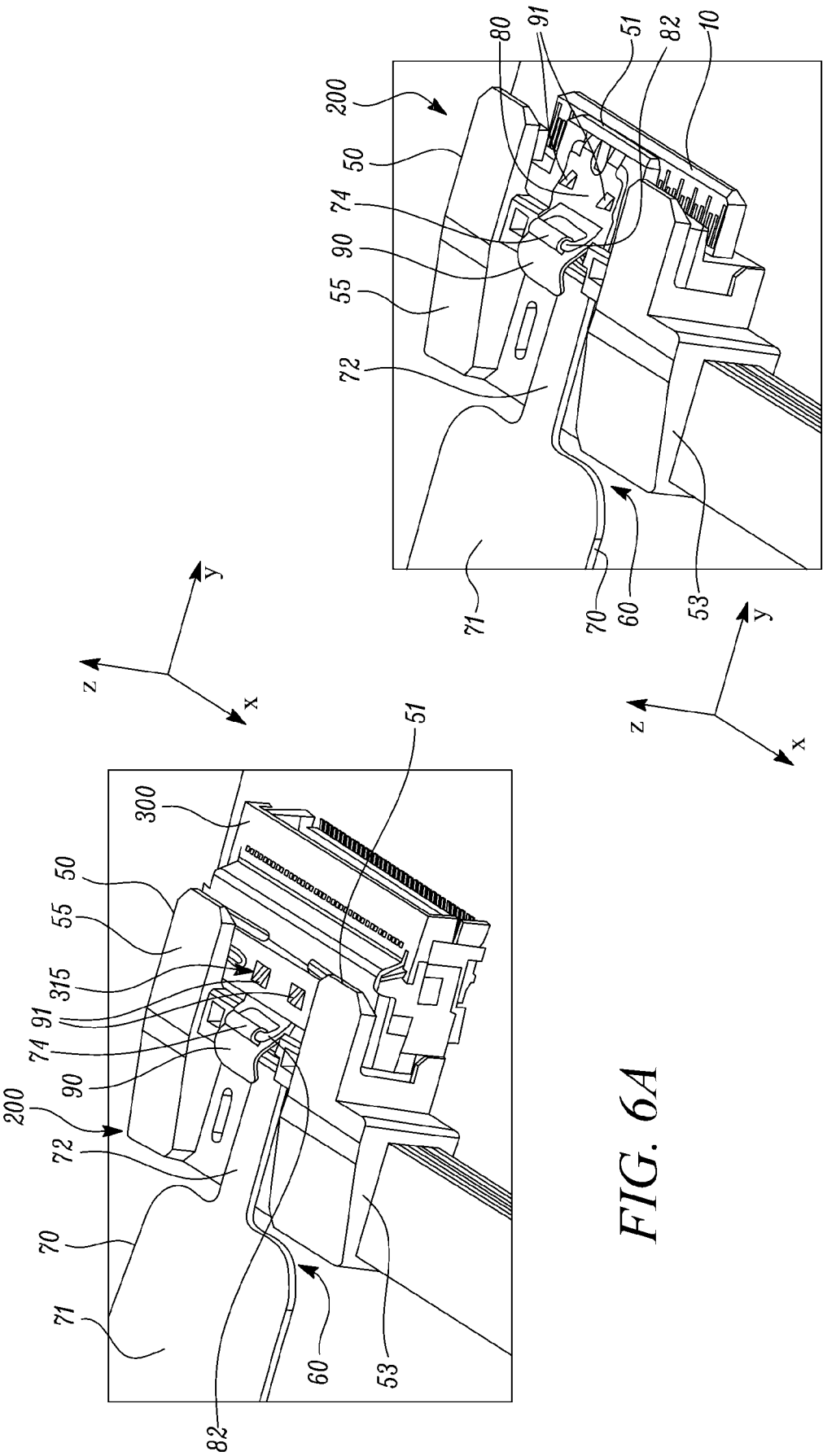
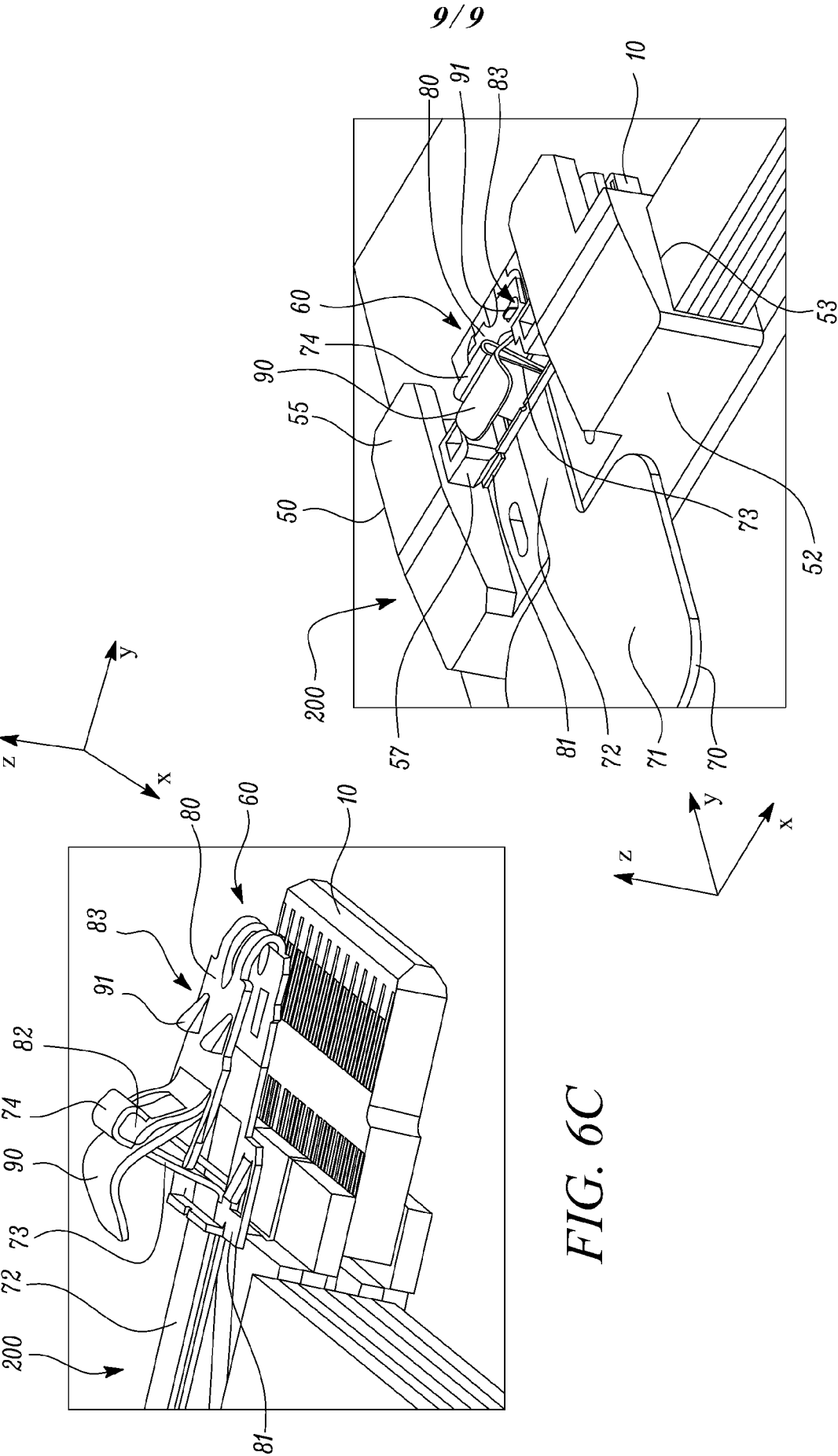


FIG. 6B

FIG. 6A



INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/113046

A. CLASSIFICATION OF SUBJECT MATTER

H01R12/50(2011.01)i; H01R12/79(2011.01)i; H01R12/72(2011.01)i; H01R12/65(2011.01)i; H01R12/62(2011.01)i

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: H01R, H05K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS、VEN、CNTXT、WOTXT、EPTXT、USTXT、CNKI、IEEE: connector, circuit board, PCB, cable, pad?, stack?, fold+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2002075660 A1 (ST. JUDE CHILDREN'S RESEARCH HOSPITAL) 20 June 2002 (2002-06-20) description, paragraphs [0074]-[0094],[0152] and figures 1-6	1-15
A	US 2020295486 A1 (3M INNOVATIVE PROPERTIES COMPANY) 17 September 2020 (2020-09-17) the whole document	1-15
A	US 2019199021 A1 (3M INNOVATIVE PROPERTIES COMPANY) 27 June 2019 (2019-06-27) the whole document	1-15
A	US 2009314516 A1 (AU OPTRONICS CORPORATION) 24 December 2009 (2009-12-24) the whole document	1-15
A	CN 209981521 U (3M INNOVATIVE PROPERTIES COMPANY) 21 January 2020 (2020-01-21) the whole document	1-15

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

16 April 2024

Date of mailing of the international search report

24 April 2024

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/113046

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

International application No.

PCT/CN2023/113046

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				DE	212012000216	U1	17 July 2014
				US	2014302694	A1	09 October 2014
				US	9595787	B2	14 March 2017
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				CN	103988374	B	24 August 2016