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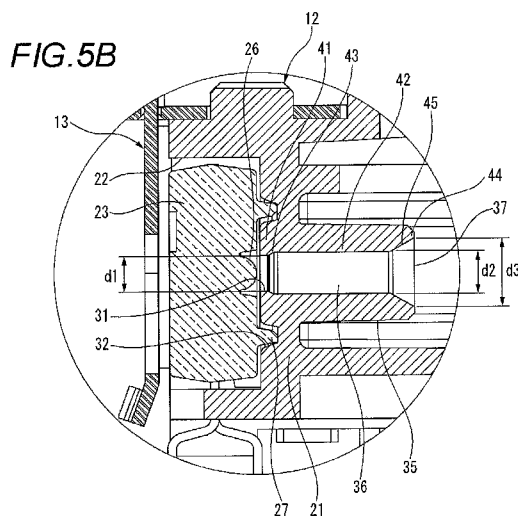
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(54) Title: OPTICAL MODULE



(57) Abstract: An optical module includes: a fiber optic transceiver which includes a light-emitting/receiving surface for transmitting light with an optical fiber; and a housing which includes a holding portion which holds the fiber optic transceiver and a cylindrical portion which has a first opening facing on the light-emitting/receiving surface and a second opening from which the optical fiber is inserted. The cylindrical portion includes a first annular portion which forms the first opening of the cylindrical portion, a second annular portion which has an inner diameter larger than an inner diameter of the first annular portion, and a first interconnecting portion which interconnects edges of the first annular portion and the second annular portion having the different inner diameters. An optical module accepts an optical connector plug with plastic optical fiber without a ferrule; and glass optical fiber or smaller diameter plastic optical fiber both with a ferrule.



DESCRIPTION

Title of the Invention :

OPTICAL MODULE

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Technical Field

[0001] The present invention relates to an optical module to which a plug attached to an optical fiber is coupled to thereby enable optical communication.

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Background Art

[0002] There is an optical module of a receptacle type constituting a part of an optical connection which is configured to be mounted on a circuit board contained within a device. The optical module includes a housing having a fixing portion to be fixed to the circuit board, and a fiber optic transceiver (FOT: Fiber Optic Transceiver) having a light-emitting element or a light-receiving element (for example, see Patent Literature 1).

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Citation List

20 Patent Literature

[0003] Patent Literature 1: JP-A-2011-59183

Summary of Invention

Technical Problem

25 [0004] Some of the optical fibers have different configurations accorded to

their standards. Since an optical fiber accorded to one of the standards can not be coupled to an optical module dedicated to an optical fiber accorded to another standard, it is necessary to prepare an optical module dedicated to the one standard for the optical fiber accorded to the one standard. For
5 example, it is necessary, as to a plastic optical fiber acceded to one standard, to prepare an optical module accorded to the configuration of the plastic optical fiber without a ferrule; and also as to an optical fiber made of glass or a smaller outside diameter (OD) plastic optical fiber both with a ferrule, to prepare an optical module accorded to the configuration of a ferrule to be
10 assembled to the glass optical fiber or a smaller OD plastic optical fiber. Thus, there arises a problem that the model number of the optical module increases.

[0005] The present invention has been made in view of the circumstances and an object of the present invention is to provide an optical module which
15 can be coupled to a plurality of optical fibers accorded to different standards.

Solution to Problem

[0006] In order to attain the object, an optical module according to each aspect of the present invention is configured by any one of the following
20 configurations (1) to (6).

(1) An optical module, including:

a fiber optic transceiver which includes a light-emitting/receiving surface for transmitting light with an optical fiber; and
a housing which includes a holding portion which holds the fiber optic
25 transceiver and a cylindrical portion which has a first opening facing on the

light-emitting/receiving surface and a second opening from which the optical fiber is inserted, wherein

the cylindrical portion includes a first annular portion which forms the first opening of the cylindrical portion, a second annular portion which
5 has an inner diameter larger than an inner diameter of the first annular portion, and a first interconnecting portion which interconnects edges of the first annular portion and the second annular portion having the different inner diameters.

(2) The optical module according to the configuration (1), wherein
10 the first interconnecting portion has a slanted surface.

(3) The optical module according to the configuration (1) or (2),
wherein

the cylindrical portion further includes a third annular portion which forms the second opening of the cylindrical portion and has an inner
15 diameter larger than the inner diameter of the second annular portion, and a second interconnecting portion which interconnects edges of the second annular portion and the third annular portion having the different inner diameters.

(4) The optical module according to the configuration (3), wherein
20 the second interconnecting portion has a slanted surface.

(5) The optical module according to any one of the configurations (1) to (4), wherein

the optical fiber to be inserted in the cylindrical portion of the housing includes a plastic optical fiber, and a glass optical fiber which is
25 provided with a ferrule at an end part of the glass optical fiber or a smaller

outside diameter plastic optical fiber which is provided with a ferrule at an end part of the smaller outside diameter plastic optical fiber, and

the inner diameter of the first annular portion is slightly larger than an outer diameter of the plastic optical fiber and smaller than an outer diameter of the ferrule, and the inner diameter of the second annular portion is larger than the outer diameter of the ferrule.

(6) The optical module according to the configuration (5), wherein an end of the ferrule has a tapered portion which abuts the first interconnecting portion when inserted in the cylindrical portion so that the first interconnecting portion prevents the end of the ferrule from being in contact with the light-emitting/receiving surface of the fiber optic transceiver.

[0007] According to the optical module in the configuration (1), the first annular portion has a cylindrical shape accorded to the shape of one type of the optical fiber. Further, the second annular portion has a cylindrical shape accorded to the shape of another type of the optical fiber. The first interconnecting portion interconnects the first and second annular portions. Thus, in the case of coupling each of the optical fibers with the different standards to the optical module, the single optical module can cope with these optical fibers and so can be coupled to each of these optical fibers of the different standards with good transmission characteristics.

Further, the first interconnecting portion guides the tip end of the one type of the optical fiber without ferrule to the first annular portion at the time of inserting the optical fiber into the cylindrical portion. Thus, the assembling procedure at the time of coupling the optical fiber to the optical

module can be facilitated.

According to the optical module in the configuration (2), the slanted surface of the first interconnecting portion serves as a guide for the one type of the optical fiber and also serves as a stopper for the other type of the optical fiber. Thus, in the case of coupling each of the optical fibers with the different standards to the optical module, the single optical module can cope with these optical fibers and so can be coupled to each of these optical fibers of the different standards with good transmission characteristics. Further, the assembling properties can be enhanced.

According to the optical module in the configuration (3), the tip end of the optical fiber is guided by the second interconnecting portion, whereby the assembling properties can be enhanced.

According to the optical module in the configuration (4), the slanted surface of the second interconnecting portion serves as a guide for the optical fibers, whereby the assembling properties can be enhanced.

According to the optical module in the configuration (5), the first annular portion has a cylindrical shape accorded to the shape of the plastic optical fiber. Further, the first interconnecting portion forms a slanted surface, for example, and the second annular portion has a cylindrical shape accorded to the shape of a ferrule attached to the glass optical fiber or smaller OD plastic optical fiber, both of which use a ferrule. Thus, in the case of coupling each of the optical fibers with the different standards to the optical module, the single optical module can cope with these optical fibers and so can be coupled to each of these optical fibers of the different standards with good transmission characteristics.

According to the optical module in the configuration (6), the first interconnecting portion prevents the end of the ferrule attached to the glass optical fiber from being contact with the light-emitting/receiving surface of the fiber optic transceiver. Thus, even when the optical module copes with the plurality of optical fibers accorded to different standards such as a plastic optical fiber and a glass optical fiber or smaller OD plastic optical fiber, the light-emitting/receiving surface of the fiber optic transceiver is not damaged with the end of the ferrule attached to the glass optical fiber.

10 Advantageous Effects of Invention

[0008] According to the invention, an optical module capable of coupling with a plurality of optical fibers accorded to different standards can be provided.

[0009] The invention is explained briefly. The details of the invention will be further made clear by reading an embodiment of the invention explained below with reference to drawings.

Brief Description of Drawings

[0010] Fig. 1 is a perspective view of an optical module according to an embodiment of the invention.

Fig. 2 is a perspective view of the optical module according to the embodiment of the invention seen from a side of an optical port portion.

Fig. 3 is a front view of the optical module according to the embodiment of the invention seen from the side of the optical port portion.

Fig. 4 is a perspective view of the optical module seen from a side of a

holding portion of a housing.

Fig. 5A is a sectional view showing the inner configuration of the optical module.

Fig. 5B is an enlarged sectional view of a part VB in Fig. 5A.

5 Fig. 6A is a sectional view of the optical module to which an optical fiber made of plastics is coupled.

Fig. 6B is an enlarged sectional view of a part VIB in Fig. 6A.

Fig. 7A is a sectional view of the optical module to which an optical fiber made of glass or small OD plastic optical fiber, of which both use a ferrule, is coupled.

Fig. 7B is an enlarged sectional view of a part VIIB in Fig. 7A.

Fig. 8 is a perspective view of the optical module according to a modified example seen from an optical port portion side.

15 Description of Embodiments

[0011] Hereinafter, an embodiment of the invention will be explained with reference to drawings.

[0012] Fig. 1 is a perspective view of an optical module according to the embodiment of the invention, Fig. 2 is a perspective view of the optical module according to the embodiment of the invention seen from a side of an optical port portion, Fig. 3 is a front view of the optical module according to the embodiment of the invention seen from the side of the optical port portion, Fig. 4 is a perspective view of the optical module seen from a side of a holding portion of a housing, Fig. 5A is a sectional view showing the inner configuration of the optical module and Fig. 5B is an enlarged sectional view

of a part VB in Fig. 5A.

[0013] As shown in Figs. 1 and 2, an optical module 11 according to the embodiment is an optical receptacle constituting a part of an optical connection used for the optical communication for the OA (Office

5 Automation), the FA (Factory Automation) or a vehicle-mounted device etc., for example. The optical module 11 is mounted on a circuit board contained within each of various kinds of devices and includes a housing 12 formed by resin and a shield casing 13 made of metal attached to the one end side of the housing 12.

10 [0014] As shown in Fig. 3, an optical port portion 14 is formed on the other end side of the housing 12, and an optical plug is inserted into and withdrawn from the optical port portion 14.

[0015] The shield casing 13 includes a front plate portion 13a and side plate portions 13b provided on both the side portions of the front plate portion 13a and is formed in a U-shape in its plan view. Thus, when the shield casing 15 13 is attached to the housing 12, the shield casing 13 covers the one end and the both side portions on the one end side of the housing 12. Further, in the shield casing 13, a terminal portion 13c extending to the downward side is formed at each of the portions 13b.

20 [0016] As shown in Figs. 4, 5A and 5B, a partition wall 21 for partitioning the one end side and the other end side is formed in the housing 12.

[0017] The housing 12 has two holding portions 22 each formed in a concave shape on the one end side. An FOT (Fiber Optic Transceiver) 23 as a fiber optic transceiver having a light-emitting element or a light-receiving 25 element is attached to each of the holding portions 22. The FOT 23 has an

element main body 24 and a plurality of leads 25 extended from the element main body 24. In each of the holding portions 22, a notch portion 22a is formed on the downward side of the housing 12 and the leads 25 of the FOT 23 are drawn from the notch portion 22a to the downward side of the housing 12.

[0018] Each of the FOTs 23 is provided with a light reception/emission surface 26 formed in a semispherical shape at the center of the one side surface of the element main body 24. The light reception/emission surface 26 acts as the light emission surface for emitting an optical signal when the FOT 23 includes a light-emitting element, whilst the light reception/emission surface 26 acts as the light reception surface for receiving an optical signal when the FOT 23 includes a light-receiving element.

[0019] In the FOT 23, an annular projection 27 is formed around the light reception/emission surface 26 on the one side surface of the element main body 24 where the light reception/emission surface 26 is provided.

[0020] An opening 31 is formed at the partition wall 21. An annular groove portion 32 is formed around the opening 31 on the surface of the holding portion 22 of the partition wall 21. The annular projection 27 of the FOT 23 to be received within the holding portion 22 is fit into the annular groove portion 32. When the projection 27 is fit into the groove portion 32, the light reception/emission surface 26 of the FOT 23 is disposed so as to be positioned at a position facing on the opening 31. The FOT 23 thus attached to and received within the holding portion 22 of the housing 12 is covered by the shield casing 13 attached to the housing 12.

[0021] In the housing 12, a cylindrical portion 35 protruding on a side of the

optical port portion 14 is formed at the partition wall 21. The cylindrical portion 35 has an insertion hole 36 at the center thereof. One of the openings on the side of the holding portion 22 of the insertion hole 36 is formed as the opening (or first opening) 31 facing on the light

5 reception/emission surface 26 of the FOT 23. The other opening on the opposite side of the insertion hole 36 is formed as an opening (or second opening) 37 from which the optical fiber is inserted.

[0022] The one opening 31 side of the cylindrical portion 35 is formed as a first annular portion 41 having an inner diameter d_1 slightly larger than the
10 outer diameter of a plastic optical fiber 51 described later. A second annular portion 42 having an inner diameter d_2 larger than the inner diameter d_1 of the first annular portion 41 is provided on the other opening 37 side of the cylindrical portion 35. Further, the cylindrical portion 35 has a first interconnecting portion 43 for interconnecting the first annular portion 41
15 and the second annular portion 42 having the different inner diameters.

[0023] A portion forming the other opening 37 of the cylindrical portion 35 is configured as a third annular portion 44 having an inner diameter d_3 larger than the inner diameter d_2 of the second annular portion 42. A portion for interconnecting the second annular portion 42 and the third annular portion
20 44 having the different inner diameters is formed as a second interconnecting portion 45. Each of the first interconnecting portion 43 and the second interconnecting portion 45 is configured to have a tapered shape having an inner diameter reducing toward the FOT 23 side.

[0024] The optical module 11 is mounted on the circuit board within which
25 various kinds of devices are contained. The terminal portions 13c of the

shield casing 13 and the leads 25 of the FOT 23 are inserted into through holes of the circuit board, then soldered and hence electrically coupled to a conductive pattern. The terminal portions 13c of the shield casing 13 are electrically coupled to the conduction pattern as the ground of the circuit board.

[0025] In the optical module 11, optical plugs having optical fibers of the different standards can be coupled to the optical port portion 14. The optical fibers of the different standards include a plastic optical fiber made of plastics and a glass optical fiber made of glass, for example. The plastic optical fiber is excellent in the noise withstanding properties and is a plastic optical fiber (POF), core and clad of which are made of plastics. The glass optical fiber includes one type in which core and clad are each made of glass and a hard polymer clad fiber (HPCF) in which core and clad are respectively made of glass and plastics. The glass optical fiber or smaller OD plastic optical fiber are provided and coupled with a ferrule at the end part including a tip thereof.

[0026] The optical transmission between the FOT 23 and the light reception/emission surface 26 is made possible by coupling the plastic optical fiber or the glass optical fiber to the optical module 11. Further, in the optical module 11, since the FOT 23 attached to and received within the holding portion 22 of the housing 12 is covered by the shield casing 13, good signal transmission can be realized whilst suppressing the influence of electromagnetic noise.

[0027] Next, the explanation will be made as to a case of coupling the plastic optical fiber without a ferrule and the glass optical fiber or smaller OD

plastic optical fiber both with a ferrule to the optical module 11.

[0028] (Coupling with Plastic Optical Fiber without Ferrule)

As shown in Figs. 6A and 6B, a pre-assembled optical plug 61 is attached to an end portion of the plastic optical fiber 51. The plastic optical fiber 51 is covered by a sheath 53 to thereby form an optical cable. The plastic optical fiber 51 is exposed from the sheath 53 at the end portion thereof. The optical plug 61 attached to the end portion of the plastic optical fiber 51 has a housing 63 provided with an insertion hole 62 which opens at the rear end thereof. The plastic optical fiber 51 is inserted into the strength member 67 which is press-fit into insertion hole 62 of the housing 63. In the nature of the plastic optical fiber 51, it is preferable that the tip of the plastic optical fiber 51 is close to or contact with the light-emitting/receiving surface 26 of the FOT 23.

[0029] The insertion hole 62 has a guide portion 64 having its diameter reducing gradually toward the end thereof. The plastic optical fiber 51 inserted into the strength member 67 which is press-fit into insertion hole 62 and is guided toward the center by the guide portion 64. An engagement hole 65 having an inner diameter slightly larger than the outer of the plastic optical fiber 51 is formed closer to the end side than the guide portion 64. The plastic optical fiber 51 guided by the guide portion 64 is inserted into the engagement hole 65. An engagement hole portion 66 having an inner diameter slightly larger than an outer diameter of the cylindrical portion 35 of the optical module 11 is formed at the end of the optical plug 61.

[0030] A latch portion 68 is formed at the housing 63 of the optical plug 61. When the optical plug 61 is inserted into and coupled with the optical port

portion 14 of the optical module 11, the latch portion 68 engages with the housing 12 of the optical module 11 and maintains the coupling state.

[0031] The portion of the plastic optical fiber 51 exposed from the sheath 53 is inserted into the insertion hole 62, then guided toward the center by the guide portion 64 and pushed into the engagement hole 65. Then, the plastic optical fiber 51 is protruded on the engagement hole portion 66 side from the engagement hole 65 and further protruded from the tip end surface of the optical plug 61, whereby the end surface 51a thereof is disposed at a predetermined position from the tip end surface of the optical plug 61.

10 [0032] The metal strength member 67 is press-fitted into the insertion hole 62 of the optical plug 61. The strength member 67 is fixed with a pressure crimp at section 67a of the strength member 67 to fix the end portion of the sheath 53.

[0033] When the optical plug 61 is inserted into the optical port portion 14 of the optical module 11, the end portion of the plastic optical fiber 51 is inserted from the opening 37 into the second annular portion 42 of the cylindrical portion 35 of the optical module 11. In this case, the end portion of the plastic optical fiber 51 is smoothly guided to the second annular portion 42 by the taper-shaped second interconnecting portion 45.

20 [0034] When the optical plug 61 is further inserted into the optical port portion 14 of the optical module 11, the cylindrical portion 35 is fit into the engagement hole portion 66 of the optical plug 61.

[0035] Thereafter, the end portion of the plastic optical fiber 51 is inserted into the first annular portion 41 of the cylindrical portion 35 of the optical module 11. In this case, the end portion of the plastic optical fiber 51 is

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smoothly guided to the first annular portion 41 by the taper-shaped first interconnecting portion 43 and is aligned at its center. Thus, the end surface 51a of the plastic optical fiber 51 is disposed at the opening 31, whereby the end surface 51a is disposed at a close position or a contact
5 position so as to oppose to the light reception/emission surface 26 of the FOT 23.

[0036] Thus, the optical module 11 is placed in a state that good optical transmission can be realized between the plastic optical fiber 51 and the light reception/emission surface 26 of the FOT 23.

10 [0037] In this state, the latch portion 68 of the optical plug 61 engages with the housing 12 of the optical module 11 to thereby maintain the coupling state of the optical plug 61 to the optical module 11.

[0038] (Coupling with Glass Optical Fiber with Ferrule or Plastic Optical Fiber with Ferrule)

15 As shown in Figs. 7A and 7B, also when the glass optical fiber 55 is to be used, the optical plug 61 is attached to the end portion of the glass optical fiber 55. The glass optical fiber 55 is covered by a buffer 56 to thereby form part of an optical cable. The glass optical fiber 55 is exposed from the buffer 56 at the end portion thereof. In the nature of the glass optical fiber 55, it is
20 necessary to adopt the configuration in which the direct contact force is avoided between the tip of the glass optical fiber 55 (and a ferrule 71) and the light-emitting/receiving surface 26 of the FOT 23.

[0039] The optical plug 61 includes a ferrule 71 that is press-fit or made as a part of a flange 69, and a compression spring 70 to urge the ferrule 71
25 forward. The ferrule 71 is typically made of zirconia ceramic, plastic, or

metal. The ferrule 71 and the flange 69 are sometimes made as one part. The front end of the compression spring 70 abuts the flange 69 and the back end of the compression spring 70 abuts the front end of the strength member 67 which is press-fit into a housing of the optical plug 61.

5 [0040] Epoxy adhesive, for example, is injected into a capillary hole 73 of the ferrule 71 and the flange 69. The capillary hole 73 is formed around the longitudinal axis of the ferrule 71. The portion of the glass optical fiber 55 exposed from the buffer 56 is inserted into capillary hole 73 of the ferrule 71. The buffer 56 is at the same time inserted into the flange 69, and the epoxy
10 adhesive is cured. The excess fiber outside of the end face of the ferrule 71 is cut; and the end face is polished to a high level finish. The glass optical fiber 55 is therefore attached inside the ferrule 71. The ferrule 71 has an outer diameter larger than the inner diameter d_1 (see Fig. 5B) of the first annular portion 41 and smaller than the inner diameter d_2 (see Fig. 5B) of
15 the second annular portion 42. The peripheral edge at the tip end portion of the ferrule is configured as a tapered portion 72 having an inner diameter reducing gradually toward the tip end thereof. In the ferrule 71, the end surface 71a thereof is protruded from the tip end surface of the optical plug 61 and disposed at a predetermined position from the tip end surface of the
20 optical plug 61.

[0041] When the optical plug 61 is inserted into the optical port portion 14 of the optical module 11, the end portion of the ferrule 71 attached to the glass optical fiber 55 is inserted from the opening 37 into the second annular
portion 42 of the cylindrical portion 35 of the optical module 11. In this case,
25 the end portion of the ferrule 71 is smoothly guided to the second annular

portion 42 by the taper-shaped second interconnecting portion 45.

[0042] When the optical plug 61 is further inserted into the optical port portion 14 of the optical module 11, the cylindrical portion 35 is fit into the engagement hole portion 66 of the optical plug 61.

5 [0043] Thereafter, when the tapered portion 72 formed at the end portion of the ferrule 71 abuts against the first interconnecting portion 43, the ferrule 71 is aligned at its center and the movement of the ferrule 71 in the insertion direction is restricted. That is, the first interconnecting portion 43 prevents the end portion of the ferrule 71 from being contact with the
10 light-emitting/receiving surface 26 of the FOT 23. Thus, the end surface 71a of the ferrule 71 is disposed at the opening 31, whereby the end surface is disposed at a close position so as to oppose to the light reception/emission surface 26 of the FOT 23.

[0044] Thus, the optical module 11 is placed in a state that good optical
15 transmission can be realized between the glass optical fiber 55 and the light reception/emission surface 26 of the FOT 23.

[0045] In this state, the latch portion 68 of the optical plug 61 engages with the housing 12 of the optical module 11 and is fixed at the mechanical plane MP (shown in Fig. 5A) to thereby maintain the coupling state of the optical
20 plug 61 to the optical module 11.

[0046] Although the description is made as to the glass optical fiber 55 which is provided with the ferrule 71, the optical module 11 can accept another plastic optical fiber which is provided with a ferrule. When a smaller outside diameter (OD) plastic optical fiber rather than the plastic
25 optical fiber 51 is used, it is usual to attach a ferrule at the end part of the

smaller OD plastic optical fiber. In this case, the smaller OD plastic optical fiber with the ferrule is received in the optical module 11, in the different way from receiving the plastic optical fiber 51 without a ferrule shown in Figs. 6A and 6B, but rather in the same way as receiving the glass optical fiber 55 with the ferrule 71, as shown in Figs. 7A and 7B.

[0047] As explained above, according to the optical module of this embodiment, the first annular portion 41 has a cylindrical shape accorded to the shape of the plastic optical fiber 51. Further, the first interconnecting portion 43 has the slanted surface against where the tip end of the ferrule 71 having a diameter reducing toward the tip abuts and the second annular portion 42 has a cylindrical shape accorded to the shape of the ferrule 71. Thus, in the case of coupling the optical module 11 to each of the plastic optical fiber 51, and the glass optical fiber 55 having the ferrule 71 or the smaller OD plastic optical fiber having the ferrule with the different standards, the single optical module 11 can cope with these optical fibers and so can be coupled to each of these optical fibers of the different standards with good transmission characteristics.

[0048] In general, an optical module is not configured to be connectable to both the plastic optical fiber 51, and the glass optical fiber 55 attached to the ferrule 71 or the smaller OD plastic optical fiber with ferrule having the different standards. This is because the suitable distance between the end surface of the optical fiber and the light reception/emission surface 26 of the FOT 23 differs between these optical fibers depending on the type of the optical fiber. Thus, the plastic optical fiber 51 and the glass optical fiber 55 or the smaller OD plastic optical fiber with ferrule are coupled to different

optical modules having different structures, respectively.

[0049] In contrast, according to the optical module 11 of this embodiment, the positions of the end surfaces of the optical fibers of the different standards can be disposed at the positions separated by the suitable distances with respect to the light reception/emission surface 26 of the FOT 23 according to the position of the first annular portion 41 and the shape of the first interconnecting portion 43. Thus, the single optical module 11 can cope with the optical fibers of the different standards and can be coupled to these optical fibers with good transmission characteristics.

10 [0050] The first interconnecting portion 43 guides the tip end of the plastic optical fiber 51 to the first annular portion 41 at the time of inserting the plastic optical fiber 51 into the cylindrical portion 35. Thus, the assembling procedure at the time of coupling the plastic optical fiber 51 to the optical module 11 can be facilitated.

15 [0051] Further, the tip end of the plastic optical fiber 51 or the tip end of the ferrule 71 is guided by the second interconnecting portion 45, whereby the assembling properties can be enhanced.

[0052] Although the optical module 11 according to the embodiment is configured that the FOT 23 is covered by the shield casing 13 as the countermeasure to the electromagnetic noise, the optical module may be configured in a manner that, as shown in Fig. 8, a casing 81 made of resin is part of housing 12 to thereby cover the FOT 23 attached to and received within the holding portion 22 of the housing 12 in the casing 81.

[0053] The invention is not limited to the aforesaid embodiment and may be suitably modified and improved, for example. The material, shape, size,

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number, disposed position etc. of each of the constituent elements of the aforesaid embodiment are not limited thereto and may be arbitrary so long as the invention is attained.

CLAIMS

1. An optical module, comprising:
 - a fiber optic transceiver which includes a light-emitting/receiving
 - 5 surface for transmitting light with an optical fiber; and
 - a housing which includes a holding portion which holds the fiber optic transceiver and a cylindrical portion which has a first opening facing on the light-emitting/receiving surface and a second opening from which the optical fiber is inserted, wherein
 - 10 the cylindrical portion includes a first annular portion which forms the first opening of the cylindrical portion, a second annular portion which has an inner diameter larger than an inner diameter of the first annular portion, and a first interconnecting portion which interconnects edges of the first annular portion and the second annular portion having the different
 - 15 inner diameters.
2. The optical module according to claim 1, wherein
 - the first interconnecting portion has a slanted surface.
- 20 3. The optical module according to claim 1 or 2, wherein
 - the cylindrical portion further includes a third annular portion which forms the second opening of the cylindrical portion and has an inner diameter larger than the inner diameter of the second annular portion, and a
 - second interconnecting portion which interconnects edges of the second
 - 25 annular portion and the third annular portion having the different inner

diameters.

4. The optical module according to claim 3, wherein
the second interconnecting portion has a slanted surface.

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5. The optical module according to any one of claims 1 to 4, wherein
the optical fiber to be inserted in the cylindrical portion of the
housing includes a plastic optical fiber, and a glass optical fiber which is
provided with a ferrule at an end part of the glass optical fiber or a smaller
10 outside diameter plastic optical fiber which is provided with a ferrule at an
end part of the smaller outside diameter plastic optical fiber, and
the inner diameter of the first annular portion is slightly larger
than an outer diameter of the plastic optical fiber and smaller than an outer
diameter of the ferrule, and the inner diameter of the second annular portion
15 is larger than the outer diameter of the ferrule.

6. The optical module according to claim 5, wherein
an end of the ferrule has a tapered portion which abuts the first
interconnecting portion when inserted in the cylindrical portion so that the
20 first interconnecting portion prevents the end of the ferrule from being in
contact with the light-emitting/receiving surface of the fiber optic
transceiver.

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FIG. 1

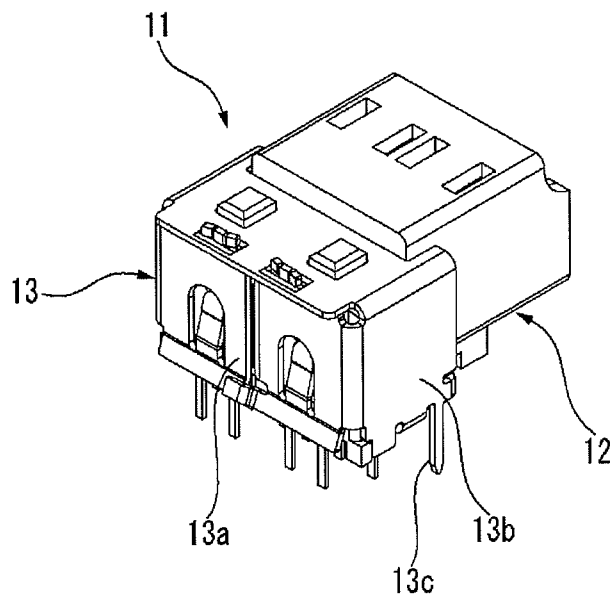
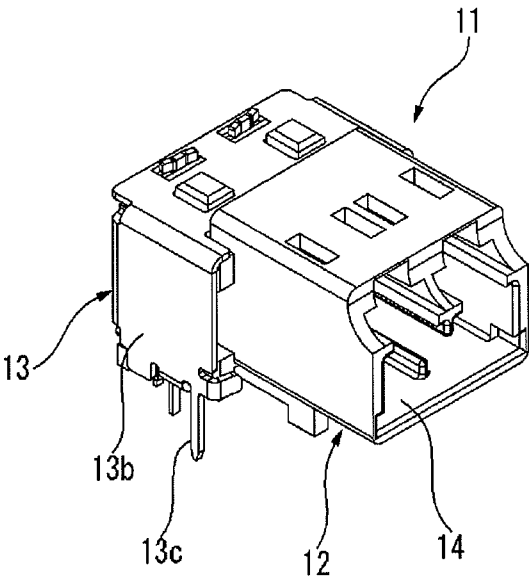
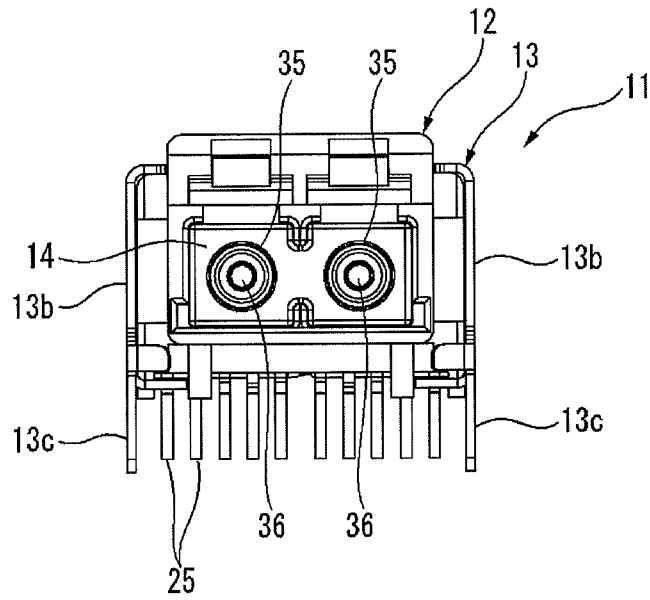


FIG. 2



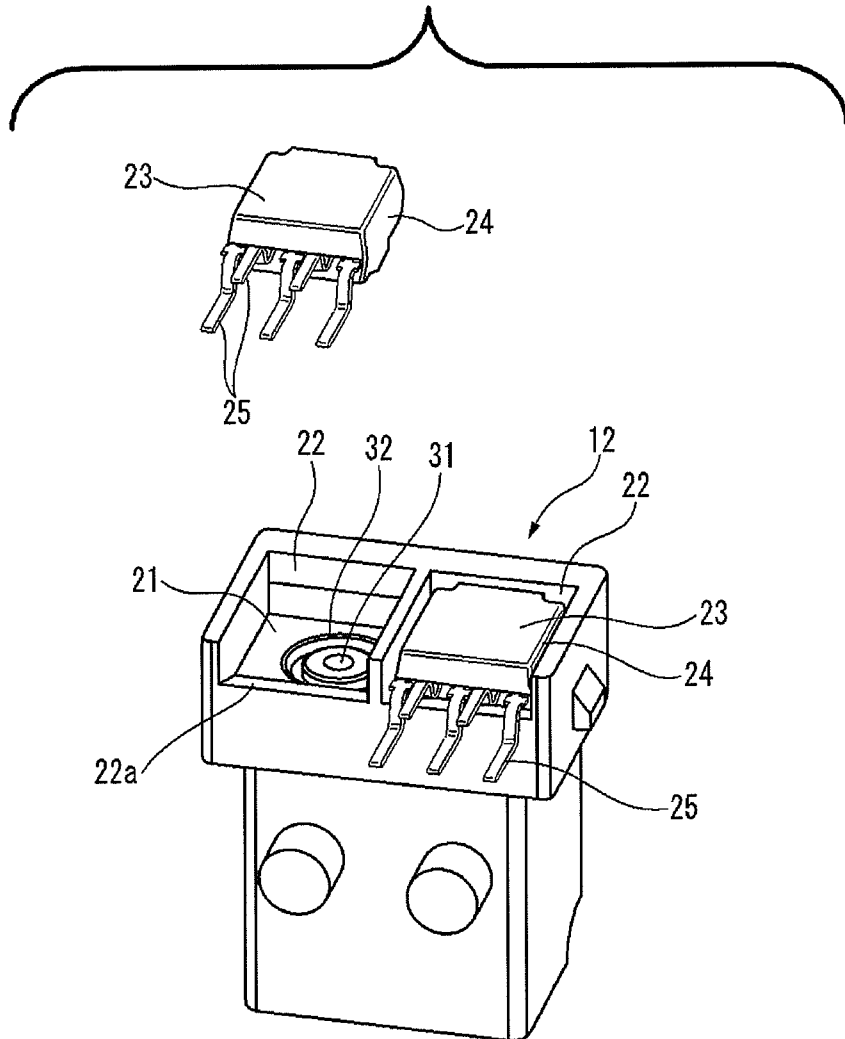
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FIG. 3



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FIG. 4



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FIG. 5A

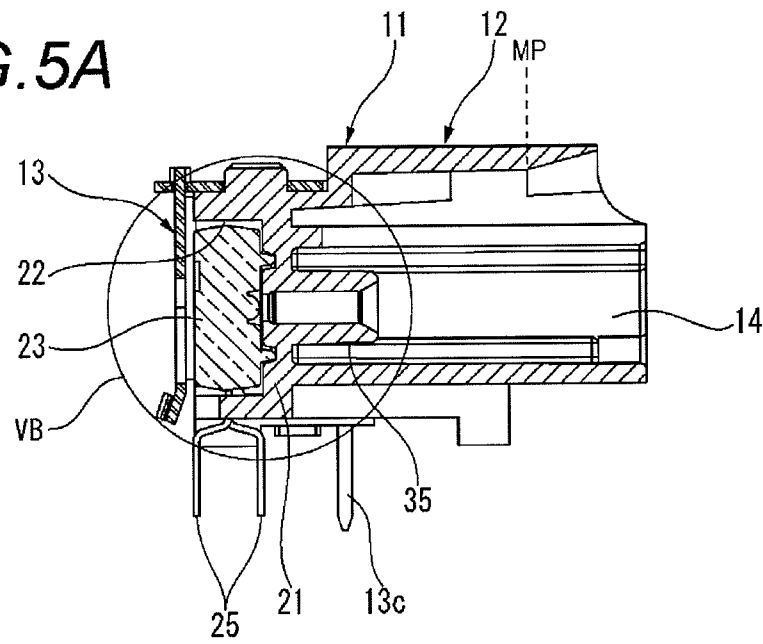


FIG. 5B

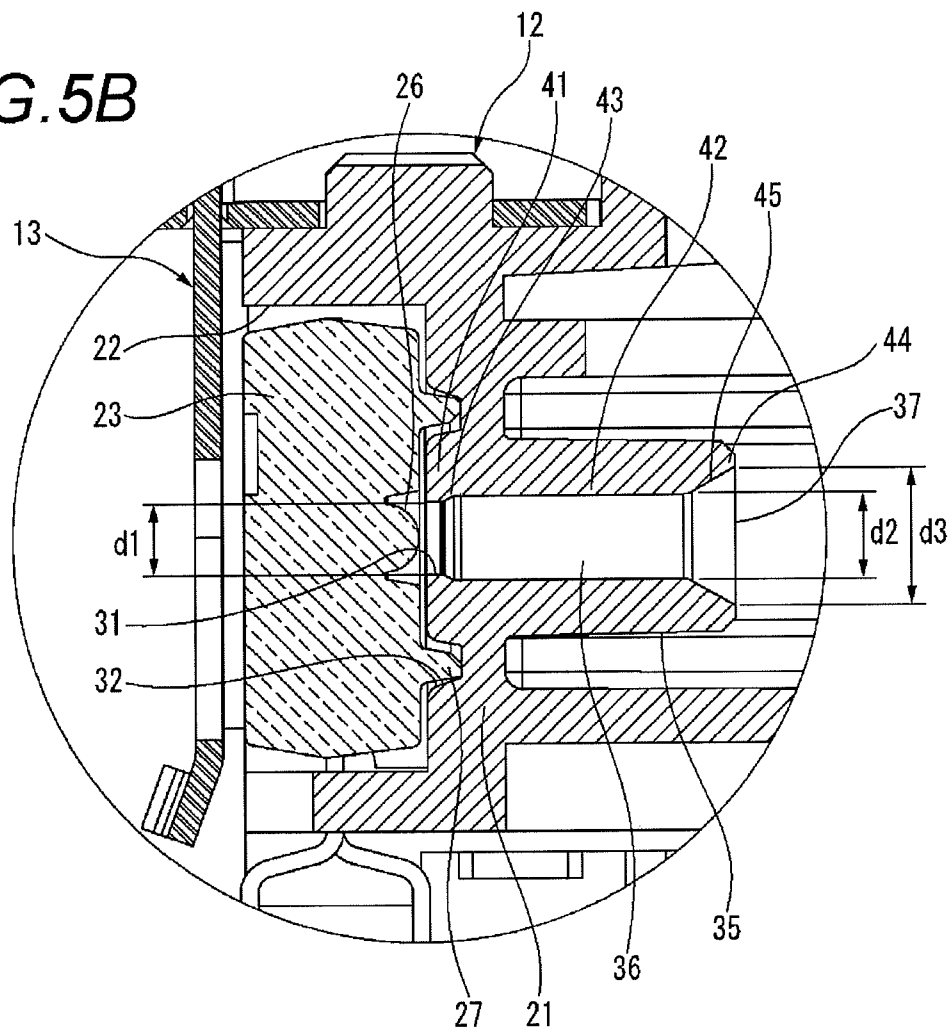


FIG. 6A

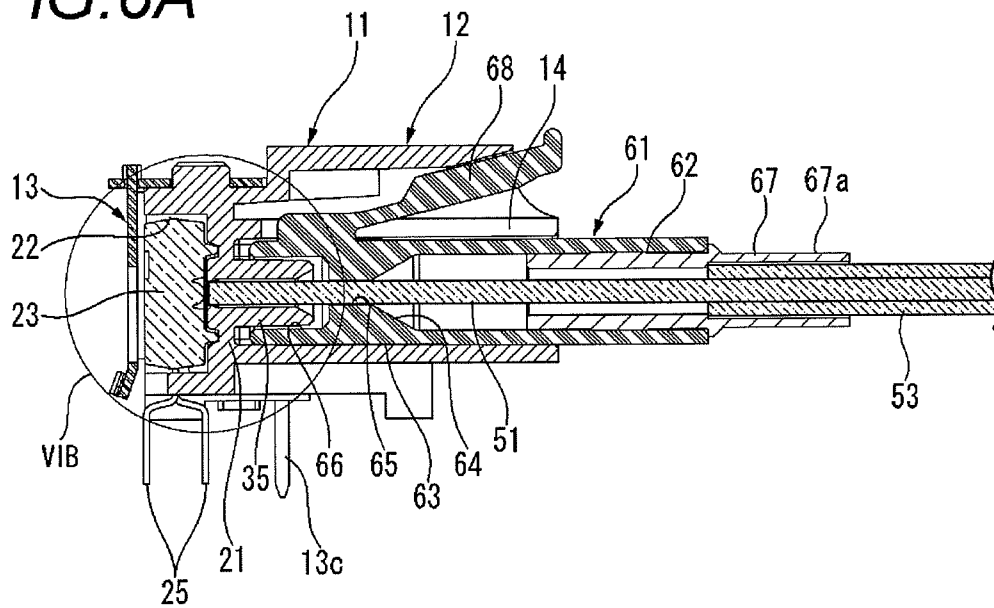


FIG. 6B

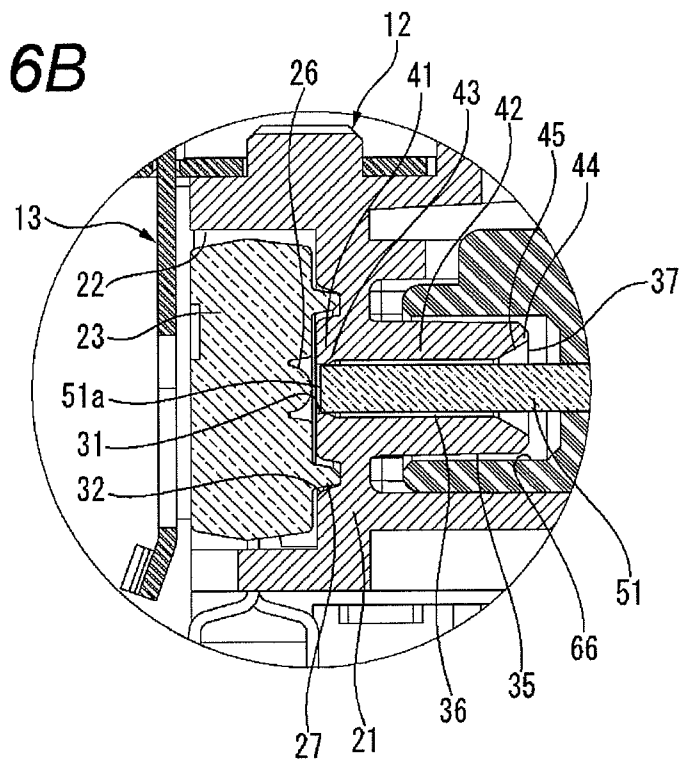


FIG. 7A

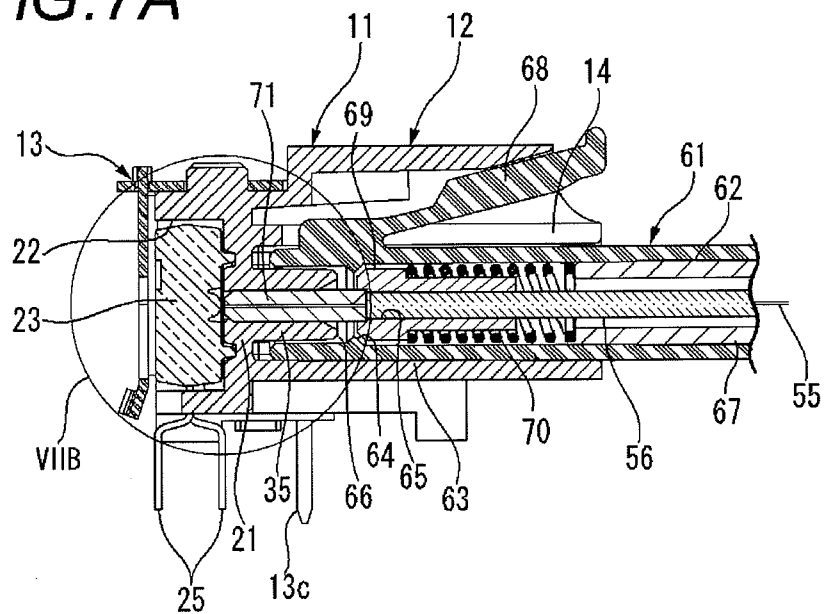
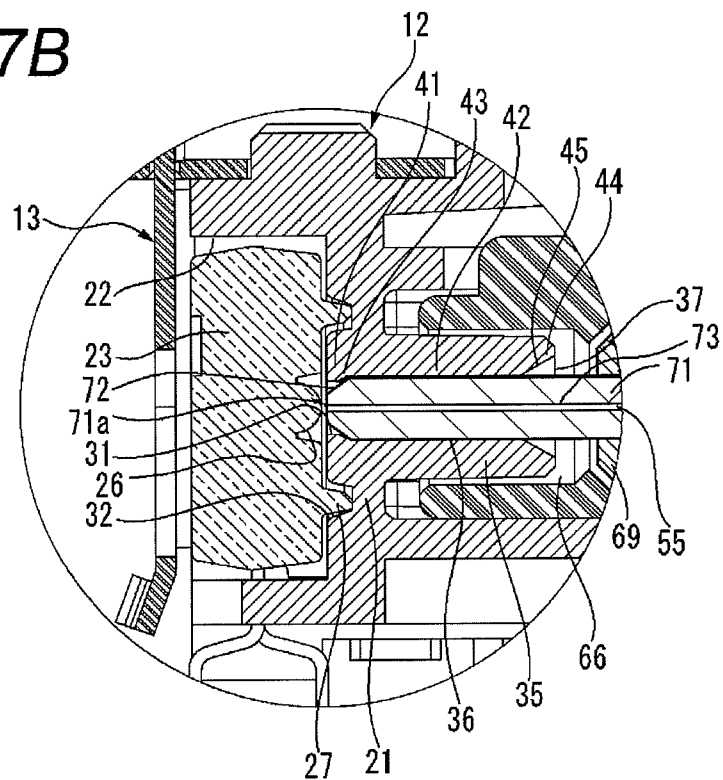
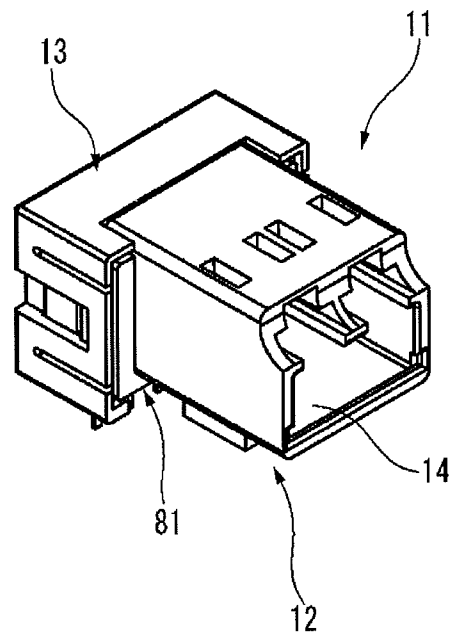


FIG. 7B



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FIG. 8



INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 11/67336

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G02B 6/36 (2012.01)**USPC - 385/78**

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(8) - G02B 6/36 (2012.01)

USPC - 385/78

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 385/15,53,55,76,77,78,85,134-137,139

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

Database Searched: PubWEST(PGPB,USPT,USOC,EPAB,JPAB), Google Scholar

Search Terms Used: Fiber, optic, transceiver, emitting, receiving, light, connector, coupler, slant, ferrule, slanted

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,936,263 A (Hashizume) 10 August 1999 (10.08.1999), entire document, especially Fig. 1A, Col. 1, lines 20-25; Col. 4, lines 19-25	1-4
X	US 5,195,156 A (Freeman et al.) 16 March 1993 (16.03.1993), entire document, especially Fig. 7; Col. 2, lines 51-55	1-2
A	US 2008/0019643 A1 (Teo et al.) 24 January 2008 (24.01.2008), para. [0028]-[0030], [0037]	1-4
A	US 5,546,212 A (Kunikane et al.) 13 August 1996 (13.08.1996), FIG. 6	1-4



Further documents are listed in the continuation of Box C.



* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"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

25 April 2012 (25.04.2012)

Date of mailing of the international search report

04 JUN 2012

Name and mailing address of the ISA/US

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents
P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-3201

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PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 11/67336

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claims Nos.: ⁵⁻⁶
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. HI Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.