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(54) **Coaxial cable to non-solderable material transition**

(57) An apparatus for connecting a coaxial cable (31) to a substrate (32,33), the coaxial cable (31) comprising an inner conductor (37) and an outer conductor (36), the outer conductor surrounding the inner conductor, this ap-

paratus comprising an eyelet (34,35) configured to be mounted in an opening formed in the substrate (32,33), this eyelet (34,35) being further configured to receive the coaxial cable (31) to be soldered thereto.

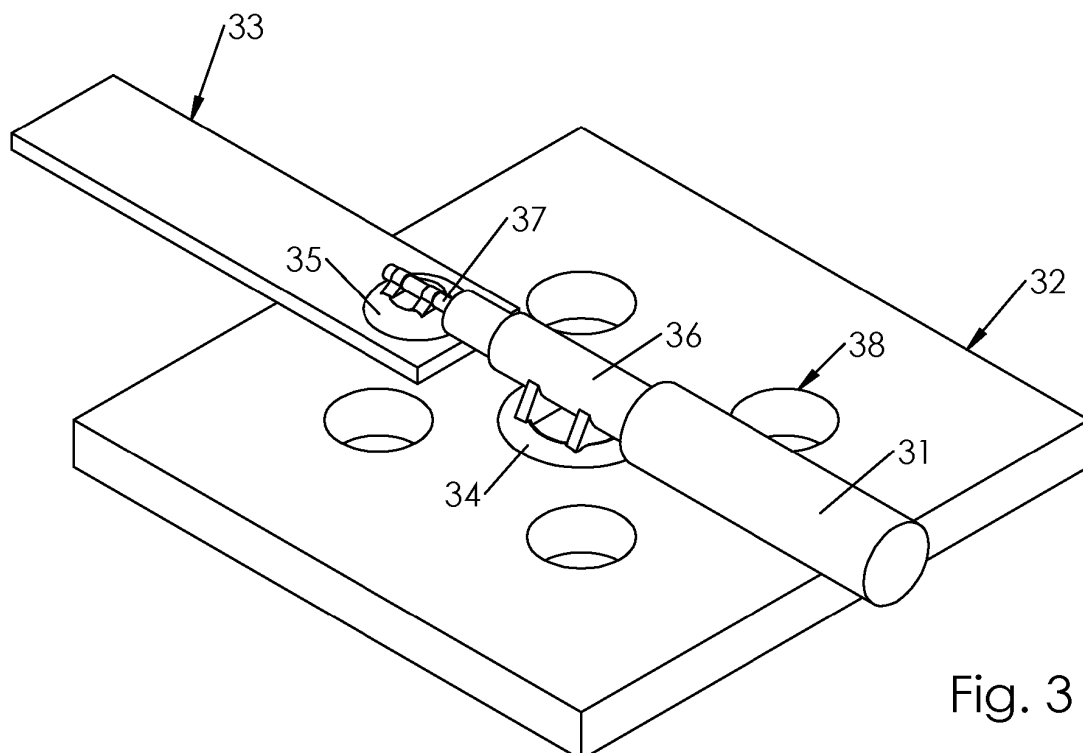


Fig. 3

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to the transition from coaxial cable to planar substrate.

BACKGROUND OF THE INVENTION

[0002] The transition from coaxial cable to electronic components is a common practice in mobile communications network base stations where receive/transmit electronics are connected to microstrips by means of coaxial cables. These microstrips usually comprise several radiating elements fed by coaxial cables.

[0003] In order to connect a coaxial cable to a microstrip, the first solution to come to mind is generally tin soldering. In fact, once a substrate (e.g. the microstrip ground plane or the microstrip track) is made of good soldering capability material (e.g. copper, copper alloys, brass, tin) the coaxial cable can be directly soldered thereto. Accordingly, it is essential that the material of the substrate be solderable (i.e. allow a solder connection to be made thereto).

[0004] However, these materials are generally costly and unsuitable for large components at competitive cost.

[0005] In this regard, metal plating may be an alternative. Nevertheless, it remains expensive, especially for large surface areas to be plated. Further, metal plating only the areas where it is necessary to solder is both complex to implement and costly to maintain as additional process steps to realize this selective plating need to be done.

[0006] To overcome this cost problem, it is often resorted to components of non-solderable materials (i.e. made of materials which cannot be tin soldered) such as aluminum alloys which are much cheaper than copper alloys. In this case, the attachment of the coaxial cable to the non-solderable material is achieved through screw assemblies (i.e. screws, nuts, pins, bolts, studs).

[0007] Yet, just as the above solutions, screw assemblies represent additional elements, and therefore additional cost and greater complexity.

[0008] In short, known solutions for enabling the junction between a coaxial cable and microstrip structures provide adequate performance, but with limited degrees of freedom in terms of materials choice, and/or at a substantial manufacturing complexity and cost.

SUMMARY OF THE INVENTION

[0009] Various embodiments are directed to addressing the effects of one or more of the problems set forth above. The following presents a simplified summary of embodiments in order to provide a basic understanding of some aspects of the various embodiments. This summary is not an exhaustive overview of these various embodiments. It is not intended to identify key of critical el-

ements or to delineate the scope of these various embodiments. Its sole purpose is to present some concepts in a simplified form as a prelude to the more detailed description that is discussed later.

[0010] One object of various embodiments is to provide an improved junction between a coaxial cable and a plate while avoiding screw assemblies, as well as total or local plating of the microstrip substrates.

[0011] Another object of various embodiments is to provide a rapid and reliable mechanical and electric connection of a coaxial cable to a microstrip antenna.

[0012] Another object of various embodiments is to enable the design of microstrip in non-solderable materials, while being attachable to conventional coaxial cables at lower manufacturing complexity and cost.

[0013] Another object of various embodiments is to provide an arrangement for coaxial cable to microstrip transition that reduces the Passive Inter-Modulation (PIM) between the coaxial cable and different components made of non-solderable materials (such as, aluminum alloys).

[0014] Another object of various embodiments is to provide a soldering junction between a coaxial cable and a substrate made of aluminum alloys.

[0015] Various embodiments relate to apparatus for connecting a coaxial cable to a substrate, the coaxial cable comprising an inner conductor and an outer conductor, the outer conductor surrounding the inner conductor, this apparatus comprising an eyelet configured to be mounted in an opening formed in the substrate, this eyelet being further configured to receive the coaxial cable to be soldered thereto.

[0016] In accordance with a broad aspect, the coaxial cable is approximately in-line with the substrate so that the outer conductor is soldered to the outer surface of the eyelet.

[0017] In accordance with another broad aspect, the coaxial cable is approximately in-line with the substrate so that the inner conductor is soldered to the outer surface of the eyelet.

[0018] In accordance with a broad aspect, the coaxial cable is approximately perpendicular to the substrate so that the outer conductor is soldered to the inner surface of the eyelet.

[0019] In accordance with a broad aspect, the substrate is a ground plate of a microstrip.

[0020] In accordance with a broad aspect, the substrate is a microstrip line.

[0021] In accordance with a broad aspect, the substrate is of aluminum, or of an aluminum alloy.

[0022] Further, various embodiments relate to methods for connecting a coaxial cable to a substrate, the coaxial cable comprising an inner conductor and an outer conductor, the outer conductor surrounding the inner conductor, this method comprising the following steps:

- forming an opening in the substrate;
- mounting an eyelet in the formed opening;

- soldering the coaxial cable to the mounted eyelet.

[0023] While the various embodiments are susceptible to various modification and alternative forms, specific embodiments thereof have been shown by way of example in the drawings. It should be understood, however, that the description herein of specific embodiments is not intended to limit the various embodiments to the particular forms disclosed.

[0024] It may of course be appreciated that in the development of any such actual embodiments, implementation-specific decisions should be made to achieve the developer's specific goal, such as compliance with system-related and business-related constraints. It will be appreciated that such a development effort might be time consuming but may nevertheless be a routine understanding for those of ordinary skill in the art having the benefit of this disclosure.

DESCRIPTION OF THE DRAWING

[0025] The objects, advantages and other features of various embodiments will become more apparent from the following disclosure and claims. The following non-restrictive description of preferred embodiments is given for the purpose of exemplification only with reference to the accompanying drawing in which

- FIG.1 is a schematic diagram illustrating a coaxial cable;
- FIG.2 is a schematic diagram illustrating a substrate configured to receive a coaxial cable to be soldered thereto;
- FIG.3 is a schematic diagram illustrating an arrangement for coaxial cable to a microstrip transition;
- FIG.4 and FIG.5 are schematic diagrams illustrating a variant arrangement for coaxial cable to a microstrip transition.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0026] With reference to figure 1, there is shown a coaxial cable **1** configured for transmitting an electrical signal. This coaxial cable **1** includes an outer conductor **12** surrounding an inner conductor **11**.

[0027] The coaxial cable **1** further includes a dielectric layer **13** (i.e. a layer made of dielectric material) placed between the inner conductor **11** and the outer conductor **12**. The coaxial cable **1** may further include a jacket **14** to protect the inner transmitting parts against mechanical, chemical and environmental damage.

[0028] The inner conductor **11** is generally in the form of a solid metal wire, a stranded metal wire for improved flexibility, or a hollow metal tube for lightness/cost purposes.

[0029] The outer conductor **12** is generally in the form of a metal plated braid (woven wires), a continuous metal

structure, or a combination of a wrapped metal tape with braided wires. In variant, the outer conductor **12** may comprise both an inner braid and an outer braid. More generally, the outer conductor **12** may or may not be in a braided form so as to provide a shield for the inner conductor **11** depending on the utilization thereof.

[0030] As non-exhaustive examples of material of the inner conductor **11** and of the outer conductor **12**, one can mention: unplated copper, tinned copper, steel copper, copper plated aluminum, unplated copper, silver plated copper.

[0031] With reference now to figure 2, there is shown an eyelet **21** mounted in an opening formed in a substrate **22**. In this regard, the eyelet **21** is inserted into the hole (opening) formed for this purpose in the substrate **22**, then fixed thereon using any appropriate crimping or press insertion process.

[0032] The eyelet **21** is made of any kind of metal with good soldering capabilities, such as brass, tin plated steel, or silver plated metal (namely, the outer surface of the attachment element being solderable).

[0033] Further, the eyelet **21** may be shaped differently from that shown in figure 2, and may, for example, be in the form of a polygon instead of a circle.

[0034] As used herein, the term "eyelet" is meant broadly to include grommets, rings or more generally any attachment element of solderable material and configured to be mounted in the dedicated hole/opening formed in the substrate **22**.

[0035] As non-limitative examples, the substrate **22**, to which a coaxial cable is to be attached, may be a microstrip ground plate, or a microstrip line (i.e. the microstrip track).

[0036] Advantageously, the substrate **22** may be of a non-solderable material such as an aluminum plate, or an aluminum alloy plate (namely, non-solderable with tin).

[0037] Figure 3 depicts the mechanical and electrical attachment of a coaxial cable **31** to a microstrip antenna including a ground plate **32** and a microstrip line **33** (e.g. an aluminum center conductor). The ground plate **32** and the microstrip line **33** are of non-solderable material.

[0038] A first eyelet **34** and a second eyelet **35** are mounted in dedicated openings, respectively, formed in the ground plate **32** and in the microstrip line **33**.

[0039] As shown in figure 3, the coaxial cable to microstrip transition is achieved by

- soldering the outer conductor **36** of the coaxial cable **31** to the outer surface of the first eyelet **34** which is fixed on the ground plate **32**;
- soldering the inner conductor **37** of the coaxial cable **31** to the outer surface of the second eyelet **35** which is fixed on the microstrip line **32**.

[0040] By "coaxial cable to microstrip transition" it is intended to mean the connection, junction, and the mechanical/electrical attachment of the coaxial cable to the

microstrip.

[0041] Accordingly, the outer conductor **36** of the coaxial cable **31** is connected (i.e. attached) to the ground plate **32** through the first eyelet **34** on which is fixed, and the inner conductor **37** of the coaxial cable **31** is extended up to the second eyelet **35** fixed on the microstrip line **33**, and soldered thereto.

[0042] Therefore, thanks to the arrangement of the first and the second solderable eyelets, the coaxial cable can be mechanically and electrically connected to non-solderable substrates of the microstrip.

[0043] In one embodiment, the attachment elements (i.e. first and second eyelets) are two brass rings crimped into appropriate openings in the microstrip, and the outer conductor of the coaxial cable is a solderable braid.

[0044] Preferably, a plurality of holes around the eyelet or press nut (reference **23** in figure 2 and reference **38** in figure 3) are formed in the substrate in order to create thermal insulation to make soldering operation easier.

[0045] In a variant embodiment, only an eyelet **34** is provided in the ground plate **32** to which the braid **36** of the coaxial cable **31** is soldered (in other words, the microstrip line **33** may be of a solderable material to which the inner conductor **37** of the coaxial cable **31** may be directly soldered).

[0046] Preferably, the sizes of an eyelet are to be chosen so that providing sufficient surface to which the coaxial cable (namely, the inner conductor and/or the outer conductor) may be soldered.

[0047] In one embodiment shown in figures 4 and 5, the coaxial cable **41** is sensibly perpendicular to the substrate **42**, resulting in an almost right-angle transition.

[0048] In this embodiment, a free end of the inner conductor **43**, extending beyond the end of the outer conductor **45**, protrudes through the opening of the eyelet **44** which is mounted in a hole in the non-solderable substrate **42** (for example, a ground plane of a thin aluminum plate). The outer conductor **45** (i.e. the braid) of the coaxial cable **41** is soldered to inner surface of the eyelet **44** (i.e. soldered to the inside the brass ring **44**).

[0049] Advantageously, this embodiment can be used to connect an aluminum dipole, or also Zamac alloy dipole which is very common material for molded parts. This assembly may be also used to connect the inner conductor of the microstrip line if this line is made of metal which cannot be directly soldered (for example, aluminum).

[0050] Advantageously, in the above-described embodiments for coaxial cable to microstrip transition, the axis of the inner conductor of the coaxial cable can be either in-line with or orthogonal to the non-solderable substrate, while ensuring a reliable mechanical and electrical junction.

[0051] Advantageously, the above-described embodiments make production of electrical conductor assemblies easier and cheaper. In fact, they

- reduce the number of added parts;

- reduce the quantity of the required material;
- allow using lighter and cheaper material (aluminum instead of brass) for reduced weight of the final product;
- reduce the number of junctions;
- do not involve torque problems with screws;
- reduce the Passive Inter Modulation generated at the junction of the inserted eyelet and the substrate.

[0052] Further, the above-described embodiments may be adopted for any microstrip structure, including planar substrates or even curved ones (appropriate eyelet shapes may be provided so that they can be properly mounted on holes formed in these substrates).

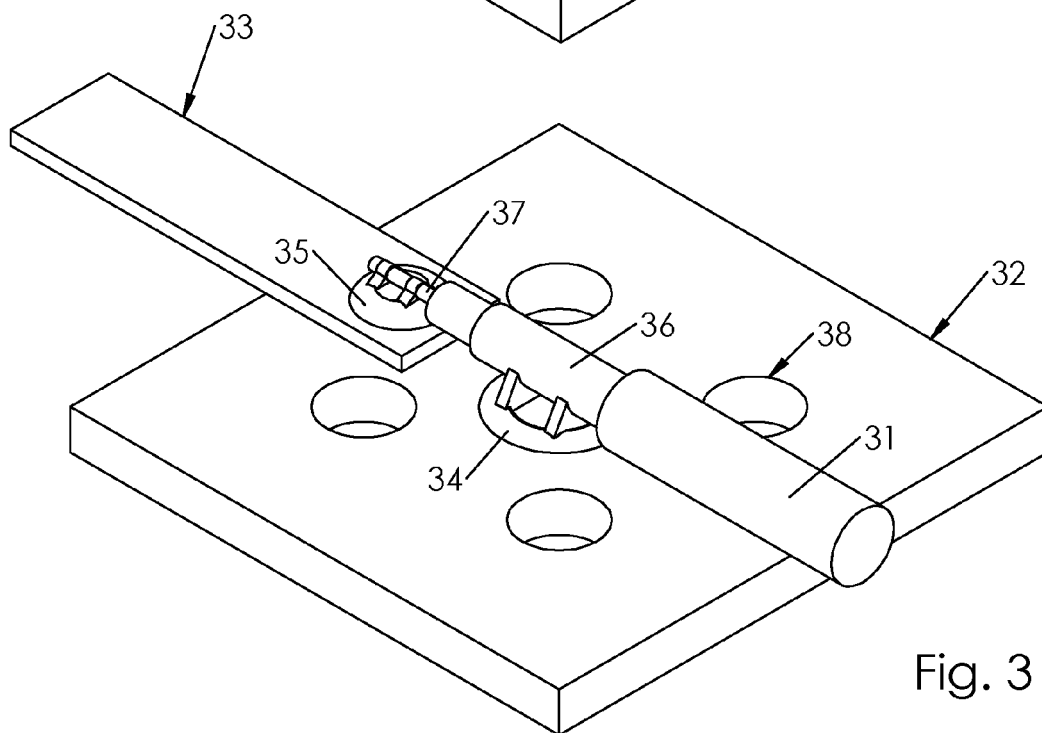
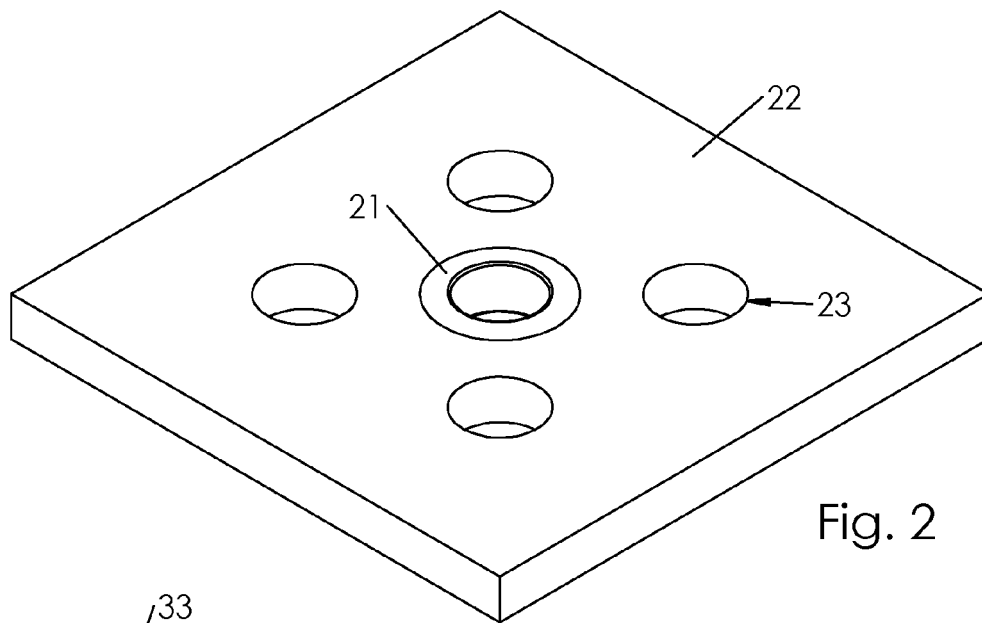
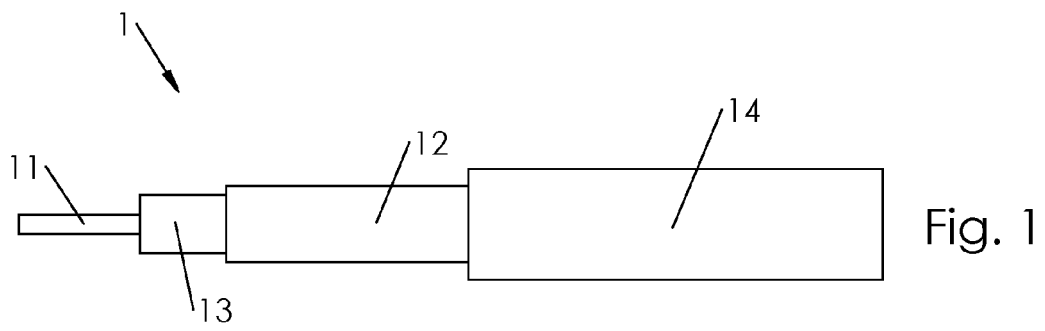
[0053] It is worth noting that while the above-described embodiments are mainly applied to microstrip connection, they may also be applied to any kind of connection between copper alloys (metals than can be tin soldered) and metals which cannot be tin soldered. Further, they may be used for connecting a coaxial cable to any electronic device operating in any frequency band.

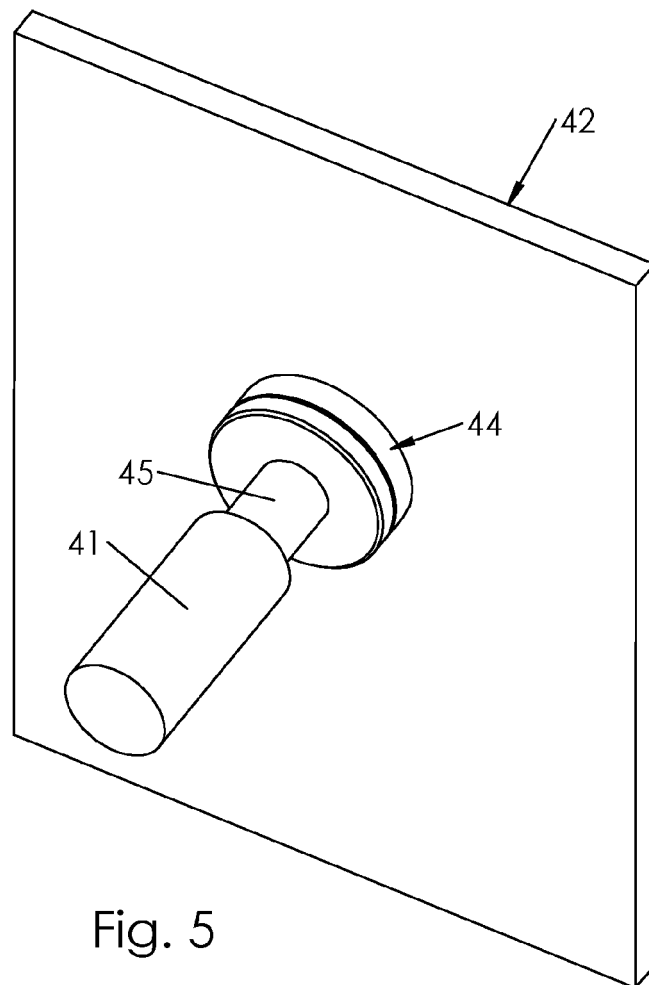
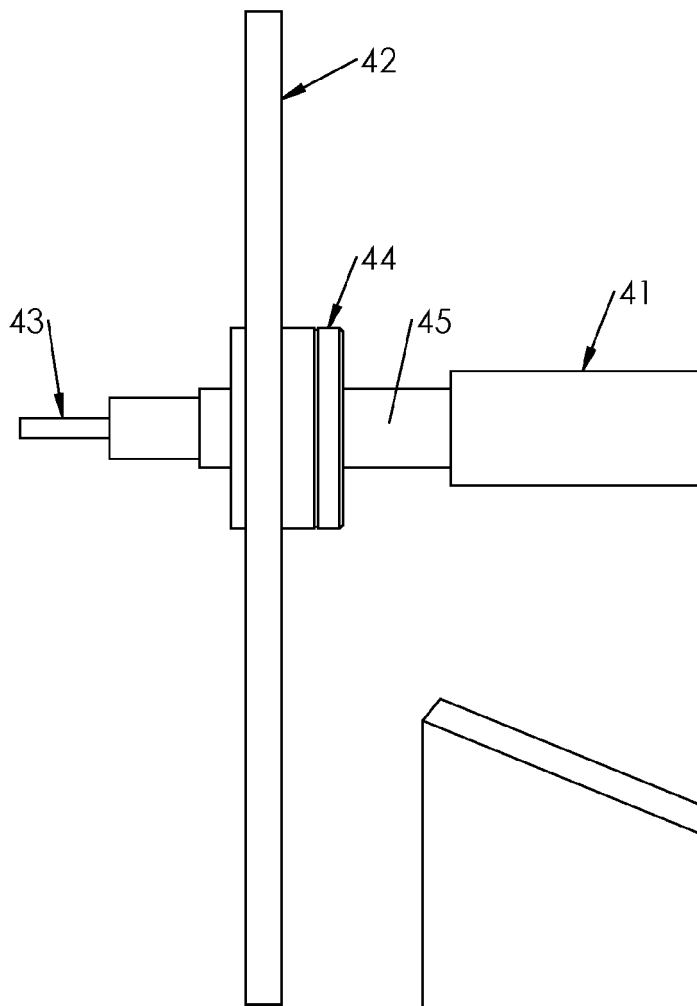
Claims

1. An apparatus for connecting a coaxial cable (31,41) to a substrate (32,33,42), the coaxial cable (31,41) comprising an inner conductor (37,43) and an outer conductor (36,45), the outer conductor surrounding the inner conductor, this apparatus comprising an eyelet (34,35,44) configured to be mounted in an opening formed in the substrate (32,33,42), this eyelet (34,35,44) being further configured to receive the coaxial cable (31,41) to be soldered thereto.
2. The apparatus of the preceding claim, wherein the coaxial cable (31) is approximately in-line with the substrate (32) so that the outer conductor (36) is soldered to the outer surface of the eyelet.
3. The apparatus of claim 1, wherein the coaxial cable (31) is approximately in-line with the substrate (33) so that the inner conductor (37) is soldered to the outer surface of the eyelet (35).
4. The apparatus of claim 1, wherein the coaxial cable (41) is approximately perpendicular to the substrate (42) so that the outer conductor (45) is soldered to the inner surface of the eyelet (44).
5. The apparatus of any of claims 1, 2, or 4, wherein the substrate (32, 42) is a ground plate of a microstrip.
6. The apparatus of claim 3, wherein the substrate (33) is a microstrip line.
7. The apparatus of claim 5 and 6, wherein the ground

plane (32) is associated to the microstrip line (33).

8. The apparatus of any of the preceding claims, wherein the substrate (32,33,42) is of aluminum. 5
9. The apparatus of any of claims 1 to 7, wherein the substrate (32,33,42) is of an aluminum alloy.
10. A method for connecting a coaxial cable (31,41) to a substrate (32,33,42), the coaxial cable (31,41) comprising an inner conductor (37,43) and an outer conductor (36,45), the outer conductor surrounding the inner conductor, this method comprising the following steps: 10
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- forming an opening in the substrate (32,33,42);
 - mounting an eyelet (34,35,44) in the formed opening;
 - soldering the coaxial cable (31,41) to the mounted eyelet (34,35,44). 20
11. The method of the preceding claim, wherein the coaxial cable (31) is approximately in-line with the substrate (32) so that the outer conductor (36) is soldered to the outer surface of the eyelet. 25
12. The method of claim 10, wherein the coaxial cable (31) is approximately in-line with the substrate (33) so that the inner conductor (37) is soldered to the outer surface of the eyelet (35). 30
13. The method of claim 10, wherein the coaxial cable (31) is approximately in-line with the substrate (33) so that the inner conductor (37) is soldered to the outer surface of the eyelet (35). 35
14. The method of claims 10 or 11, further comprising a step of forming at least an opening in the substrate configured for creating thermal insulation. 40
15. The method of any of claims 10 to 14, wherein the substrate (32,33,42) is of an aluminum alloy. 45
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 Application Number
 EP 13 30 6672

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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