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(54) **APERTURE ANTENNA ELEMENT**

APERTURANTENNENELEMENT

ELEMENT D'ANTENNE A OUVERTURE

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(56) References cited:
EP-A1- 0 777 294
WO-A1-01/41256
US-A- 4 847 625
US-A- 6 008 763
US-A- 6 054 953

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Description

Field of the invention

[0001] The present invention relates to aperture antennas, of the kind apparent from the preamble of the attached claim 1.

Background of the invention

[0002] Aperture antennas, such as for example slots, horns and aperture coupled patch antennas, are quite different in nature compared to dipole antennas. For example, in an aperture antenna, the electromagnetic radiation may be viewed as emanating from an aperture in a conducting enclosure. In the case of an aperture-coupled patch antenna the radiating patches are not conductively connected to the feeding arrangement, but excited by fields from an aperture.

[0003] In contrast to this, a dipole antenna consists of two dipole arms conductively connected to the feedline, often via a balun. Furthermore, the radiation from an aperture antenna and a dipole, respectively, is totally different in their characteristics.

[0004] The use of aperture antenna and dipole antennas, respectively, thus entails altogether different problems, and entails in particular totally different construction design aspects.

[0005] Basically, a typical aperture antenna, or aperture radiator, comprises a waveguide (antenna feed line) at the end of which an aperture is placed. A reflector may be used to accentuate certain desired radiation characteristics. An example of an antenna based on the aperture antenna technique is an aperture coupled patch antenna.

[0006] In accordance with the state of the art, a typical aperture coupled patch antenna comprises a dielectric laminate, for example a PCB (Printed Circuit Board). A feeding network, including an aperture feed feeding the antenna elements, is provided on one side of said PCB, typically by means of etching. The laminate is further provided with an electrically conductive layer on the opposite side serving as a ground plane for the aperture feed. The conductive layer may also serve as the ground plane for the antenna. The distance between the feeding network and the ground plane is thus fixed, whereby the antenna characteristics are reliable and predictable.

[0007] US 6,054,953 shows an example of a state of the art aperture-coupled antenna. The antenna described in this patent comprises a ground layer made of an electrically conductive material and is provided with a centrally located aperture. The aperture is etched on a substrate layer placed underneath the ground plane layer, and radiating patches are fed with microwave power from a feed network.

[0008] US 4,847,625 shows another example of an state of the art aperture coupled antenna. Again, the feed layer is designed from a dielectric material, such as foam or a cladded material, including an etched strip forming the feedline.

[0009] However, the use of laminate, such as PCB, is very expensive, especially considering that the laminate should be made as thin as possible in order to reduce the amount of dielectric losses. Further, the use of laminate with an etched-on feeding network requires several manufacturing steps. There is, for example, a lot of soldering steps required, which besides the laborious work, causes other problems such as giving undesired intermodulation effects. Further still, the step of attaching the ground layer to the reflector may also be a rather tedious and time-consuming manufacturing step.

[0010] Thus there exists a need for an improved aperture antenna, that is less expensive and that gives an easier and faster manufacturing method.

Summary of the invention

[0011] An object of the present invention is to provide an antenna construction that overcomes the above mentioned disadvantages. It is an object of the invention to provide a new, inventive and simpler design of an aperture antenna. In particular, it is an object of the invention to provide an aperture antenna in which the use of expensive dielectric laminates is eliminated, whereby also the laborious etching steps are eliminated, and thereby giving a less expensive antenna.

[0012] This object is achieved, according to a first aspect of the invention, by an aperture antenna as defined in the characterizing portion of claim 1.

[0013] In accordance with the invention, an aperture antenna is provided, comprising a ground plane, an aperture feed and a reflector. The aperture antenna comprises at least one aperture, provided directly on the ground plane, wherein the ground plane also is the reflector of the antenna. Further, the aperture feed is separated from the ground plane and comprises a sheet metal element, and wherein the aperture feed is fastened to the reflector by snap joint elements.

[0014] Such sheet metal element may be punched out, etched, water cut, milled or laser cut of the like. Thereby a non-expensive, but still efficient and reliable aperture feed is provided, which is easy to manufacture.

[0015] In accordance with another embodiment of the aperture antenna of the invention, the aperture feed is fastened underneath said ground plane by means of distance elements. Thereby a predetermined, fixed distance between the ground plane of the antenna and the aperture feed is achieved in a simple and non-expensive way, giving the desired antenna properties. The distance may be altered, if needed, by replacing the distance elements with elements having a different thickness, thereby providing the antenna designer a flexible design means.

[0016] In accordance with another embodiment of the aperture antenna of the invention, the aperture antenna is coupled to at least one apertured patch or non-apertured patch. The present invention may thus easily be implemented as an aperture-coupled patch antenna, giv-

ing a widely used aperture antenna.

[0017] In accordance with another embodiment of the aperture antenna of the invention, it further comprises a shielding case fastened underneath the reflector and enclosing the end part of the aperture feed. This prevents, or at least minimizes, the back radiation, which is highly undesired for example in sector antennas, thereby minimizing losses and yielding a higher performance of the antenna.

[0018] In accordance with another embodiment of the aperture antenna of the invention, the at least one aperture has an optional design. The aperture may be a straight slot aperture, a cross-shaped aperture consisting of perpendicular slots or an elliptic aperture. This provides an antenna that may easily be produced for its specific, intended use, and thus flexible design means.

[0019] The present invention also relates to such a aperture antenna, whereby equivalent advantages are obtained.

[0020] Further embodiments of the present invention and advantages of it will become clear in the following description.

Brief description of the drawings

[0021]

Figure 1 shows a schematic overview over the inventive aperture antenna design in accordance with the present invention.

Figure 2a shows a first exemplary embodiment of the reflector ground plane in accordance with the present invention.

Figure 2b shows a second exemplary embodiment of the reflector ground plane in accordance with the present invention.

Figures 3a and 3b show an exemplary embodiment for fastening the feeding network to the reflector ground plane.

Figure 4 shows the coupling means for coupling a distributor main to the antenna part.

Figure 5 shows an aperture antenna including the aperture antenna element in accordance with the present invention.

Detailed description of preferred embodiments

[0022] Throughout the description an aperture antenna element should be understood as comprising the parts involved directly in the radiation, unless otherwise stated. Thus, an aperture antenna element of the invention comprises an aperture feed, a reflector and at least one aperture. The aperture antenna element could optionally further include one or more patches and a shielding case preventing back radiation.

[0023] The invention will now be described with reference first to figure 1, showing an overview over the inventive aperture antenna design in accordance with the present invention. Reference numeral 1 generally designates the aperture antenna element in accordance with the present invention, and the same reference numerals are used in all drawings for designating like elements.

[0024] The aperture antenna element 1 in accordance with the present invention comprises firstly a reflector 2, which is made of an electrically conductive material, and which may have any desired shape, which may be adapted to its specific intended use. In accordance with the invention the reflector 2 also serves as the ground plane for the aperture feed. The reflector 2 comprises one or more apertures 3, which may be punched out, or water cut, laser cut or made by any other known method. Further, an aperture feed 4 is fastened to the reflector 2, for example by means of distance elements 5, made of a non-conducting material such as plastic. The aperture feed 4 should be fastened in such a way that the distance between the reflector 2 (being also the ground plane) and the aperture feed 4 is equal at all points in order to guarantee the correct and desired antenna properties. Sufficiently many distance elements 5, or other fastening means, should thus be provided in order to retain the distance. However, too many distance elements 5 should not be used either, which would give an unnecessary tedious manufacturing step for fastening the aperture feed 4 to the reflector 2, and also yielding an unnecessary high cost.

[0025] The aperture feed 4 may be any conducting element suitable for feeding power to the aperture(s) 3; it may for example be a sheet metal element or a metallized plastic. The aperture feed 4 may be produced in any suitable way; it may for example be punched out from a metal sheet, laser cut, water cut, etched or milled. The distance from the aperture feed 4 to the ground plane (i.e. the reflector 2) is determined by the thickness of the distance elements 5, and should be such that possible radiation losses from the aperture feed 4 are minimized. An exemplary distance, yielding acceptable antenna characteristics, lies within the range of 1-5 mm, for example approximatively 2,5 mm. The aperture feed 4 could be of any desired shape, examples of which are shown in figures 2a and 2b and described later.

[0026] The aperture antenna 1 may also comprise a shielding case 6, used in order to prevent back radiation. Back radiation is highly undesired for example in sector antennas where all the radiation should be directed in a specific direction, and where any back radiation from one sector antenna could interfere with the radiation from another sector antenna. The shielding case 6 could be fastened to the reflector 2 by means of conducting adhesive tape, by means of rivets, or in any other suitable manner, in such a way that a conducting or non-conducting (capacitive coupling) fastening means is provided between

the shielding case 6 and the reflector 2.

[0027] The shown aperture antenna 1 may be used as an aperture-coupled patch antenna, in which case patches 7 should be included. The patches 7 may be of any known kind. The shape of the patches may be any suitable, such as rectangular, square, circular etc. The patches 7, if more than one, may be of different lengths, governing the characteristics of the antenna. Patches for compensating for the asymmetrical form of the ground plane may for example be provided. Further, apertured or non-apertured patches may be used, and such patches may also be combined in any desired manner. As is realised by a person skilled in the art, parasitic elements could also be included if desired, as is well known.

[0028] With reference now to figures 2a and 2b, examples of possible configurations of apertures 3 and aperture feeds 4 are shown. The aperture 3 may thus be of any suitable form, and comprises in its simplest embodiment just a simple, straight slot, as is shown in figure 2b. The aperture feed 4 may then also, as is shown in figure 2b, be of an equally simple design, namely just a straight conductor 4. However, an aperture 3 comprises more commonly, as is shown in figure 2a, a pair of rectilinear slots 3 oriented at right angles to each other, so as to provide for double polarization operation. In this case the aperture feed 4 may be fork-shaped, in order to be able to feed both aperture 3 slots in an efficient manner. It is also possible to provide for circular polarization operation, in which case, for example, a hybrid coupler could be used to accomplish the circular polarization operation, but as is well known within the art, there are other ways to accomplish the circular polarization such as by means of polarizers. As is outlined in figure 2a, the aperture feeds 4, 4' are placed on top of each other, however without being in contact to each other. The uppermost aperture feed 4 should thus have a shape permitting such configuration; more specifically, the aperture feed 4 that is placed on top of another aperture feed 4' should have some kind of curvature so that the bottom aperture feed 4' find room underneath the uppermost aperture feed 4, without them being in contact with each other. Although only two examples of the aperture configuration are shown, a person skilled in the art realizes that various embodiments are possible. The aperture slots could be designed in such way that the coupling there between is minimized. The design of the aperture(s) 3 may thus be such that the desired antenna characteristics are achieved.

[0029] With reference now to figures 3a and 3b an exemplary way for fastening the aperture feed 4 to the reflector 2 is shown. In the illustrated embodiment the reflector 2 is provided with holes into which a part of a snap joint element 5a is placed. The aperture feed 4, also provided with holes, is then placed between said snap joint element 5a and a complementary snap joint element 5b, whereby a very easily attachable fastening means is provided. The aperture feed 4 may also be removed in an easy manner, if desired. The assembly of the aperture antenna is thus greatly simplified compared to prior art antenna designs. The snap joint elements 5a, 5b should be of a non-conducting material, such as plastic, and the thickness H of the snap joint elements 5a, 5b be dimensioned so that optimal antenna characteristics are provided. Since the snap joint elements 5a, 5b may be disassembled, they may easily be replaced, whereby the thickness H may conveniently be altered, if desired, by replacing the snap joint elements 5a, 5b with snap joint elements of a different thickness H. Other fastening means are of course also possible, for example rivets, screws etc.

[0030] With reference now to figure 4, the feeding network, comprising feeding means 11, for example cables, for feeding the aperture antenna element 1 in accordance with the present invention, is shown. Each aperture antenna element 1 is feed by the feeding network, and thus connected to it by some suitable coupling means 12. The feeding network may be a conventional feeding network well known within the art.

[0031] With reference finally to figure 5, an aperture antenna 10 in accordance with the present invention is shown. The aperture antenna 10 comprises one or several aperture antenna elements 1 in accordance with the present invention. The aperture antenna 10 further preferably comprises equally many patches 7, for providing an aperture-coupled wide-band antenna.

[0032] To summarize, the present invention provides an improved aperture antenna element, having a simpler design and a less expensive production compared to the prior art aperture antennas. Although the present invention has been shown and described by specific embodiments, many alterations and modifications are possible, as would be obvious to a person skilled in the art.

Claims

1. An aperture antenna element comprising a ground plane, an aperture feed and a reflector, wherein at least one aperture (3) is provided directly in said ground plane, said ground plane also being said reflector (2), and wherein said aperture feed (4) is separated from said ground plane, **characterized in that** said aperture feed (4) comprises a sheet metal element and is fastened to said reflector (2) by snap joint elements (5a, 5b).

2. Aperture antenna element as claimed in claim 1, wherein said aperture feed (4) is fastened underneath said ground plane by means of distance elements (5).

3. Aperture antenna element as claimed in any of claims 1-2, wherein said aperture antenna element (1) is coupled to at least one apertured and/or non-apertured patch (7).

4. Aperture antenna element as claimed in any of the preceding claims, wherein the aperture antenna element (1) further comprises a shielding case (6) fastened underneath the reflector (2) and enclosing the aperture feed (4).

5. Aperture antenna element as claimed in any of the preceding claims, wherein said at least one aperture (3) has one of the following forms: a straight slot aperture, a cross-shaped aperture consisting of perpendicular slots or a elliptic aperture.

6. Aperture antenna element as claimed in any of the preceding claims, wherein said at least one aperture (3) is fed with more than one aperture feed (4), thus providing dual polarization operation.

7. Aperture antenna element as claimed in any of the preceding claims, wherein said aperture antenna element (1) further comprises circular polarization providing means.

8. Aperture antenna **characterized in that** it comprises one or more aperture antenna elements (1) in accordance with any of claims 1-7, said aperture antenna further comprising one or more patches (7) aperture-coupled to a respective one of said aperture antenna element(s) (1).

Patentansprüche

1. Aperturantennenelement, das eine Masseebene, eine Aperturspeisung und einen Reflektor aufweist, wobei mindestens eine Apertur (3) direkt in der Masseebene bereitgestellt ist, wobei die Masseebene auch der Reflektor (2) ist, und wobei die Aperturspeisung (4) von der Masseebene getrennt ist, **dadurch gekennzeichnet, dass** die Aperturspeisung (4) ein Metallblechelement aufweist und durch Schnappverbindungselemente (5a, 5b) am Reflektor (2) befestigt ist.

2. Aperturantennenelement nach Anspruch 1, wobei die Aperturspeisung (4) mittels Distanzelementen (5) unterhalb der Masseebene befestigt ist.

3. Aperturantennenelement nach irgendeinem der Ansprüche 1-2, wobei das Aperturantennenelement (1) mit mindestens einem Apertur- und/oder Nicht-Apertur-Feld (7) gekoppelt ist.

4. Aperturantennenelement nach irgendeinem der vorhergehenden Ansprüche, wobei das Aperturantennenelement (1) ferner ein Abschirmgehäuse (6) aufweist, das unterhalb des Reflektors (2) befestigt ist und die Aperturspeisung (4) umschließt.

5. Aperturantennenelement nach irgendeinem der vorhergehenden Ansprüche, wobei die mindestens eine Apertur (3) eine der folgenden Formen aufweist: eine gerade Schlitzapertur, eine kreuzförmige Apertur, die aus senkrechten Schlitzen besteht, oder eine elliptische Apertur.

6. Aperturantennenelement nach irgendeinem der vorhergehenden Ansprüche, wobei die mindestens eine Apertur (3) mit mehr als einer Aperturspeisung (4) gespeist wird, wodurch Zweifachpolarisationsbetrieb bereitgestellt ist.

7. Aperturantennenelement nach irgendeinem der vorhergehenden Ansprüche, wobei das Aperturantennenelement (1) ferner Zirkularpolarisations-Bereitstellungsmittel aufweist.

8. Aperturantenne, **dadurch gekennzeichnet, dass** sie ein oder mehrere Aperturantennenelemente (1) nach irgendeinem der Ansprüche 1-7 aufweist, wobei die Aperturantenne ferner ein oder mehrere Felder (7) aufweist, das/die mit einem jeweiligen des/der Aperturantennenelements/e (1) aperturgekoppelt ist/sind.

Revendications

1. Élément d'antenne à ouverture comprenant un plan de sol, une alimentation d'ouverture et un réflecteur, dans lequel au moins une ouverture (3) est prévue directement dans ledit plan de sol, ledit plan de sol étant aussi ledit réflecteur (2), et dans lequel ladite alimentation d'ouverture (4) est séparée dudit plan de sol, **caractérisé en ce que** ladite alimentation d'ouverture (4) comprend un élément en tôle et qu'elle est fixée audit réflecteur (2) par des éléments joints à pression (5a, 5b).

2. Élément d'antenne à ouverture selon la revendication 1, dans lequel ladite alimentation d'ouverture (4) est fixée en dessous dudit plan de sol au moyen d'éléments de distance (5).

3. Élément d'antenne à ouverture selon l'une quelconque des revendications 1 et 2, ledit élément d'antenne à ouverture (1) étant raccordé à au moins une plage à ouverture et/ou sans ouverture (7).

4. Élément d'antenne à ouverture selon l'une quelconque des revendications précédentes, cet élément d'antenne à ouverture (1) comprenant en outre un boîtier de blindage (6) fixé sous le réflecteur (2) et renfermant l'alimentation d'ouverture (4).

5. Élément d'antenne à ouverture selon l'une quelconque des revendications précédentes, dans lequel la-

dite au moins une ouverture (3) a une des formes suivantes : une ouverture à fente droite, une ouverture en forme de croix consistant en des fentes perpendiculaires ou une ouverture elliptique.

6. Élément d'antenne à ouverture selon l'une quelconque des revendications précédentes, dans lequel ladite au moins une ouverture (3) est alimentée avec plus d'une alimentation d'ouverture (4), fournissant ainsi un fonctionnement à double polarisation.

7. Élément d'antenne à ouverture selon l'une quelconque des revendications précédentes, ledit élément d'antenne à ouverture (1) comprenant en outre un moyen de fourniture de polarisation circulaire.

8. Antenne à ouverture **caractérisée en ce qu'**elle comprend un ou plusieurs éléments d'antenne à ouverture (1) selon l'une quelconque des revendications 1 à 7, ladite antenne à ouverture comprenant en outre une ou plusieurs plages (7) raccordées par ouverture à un élément respectif dudit ou desdits éléments d'antenne à ouverture (1).

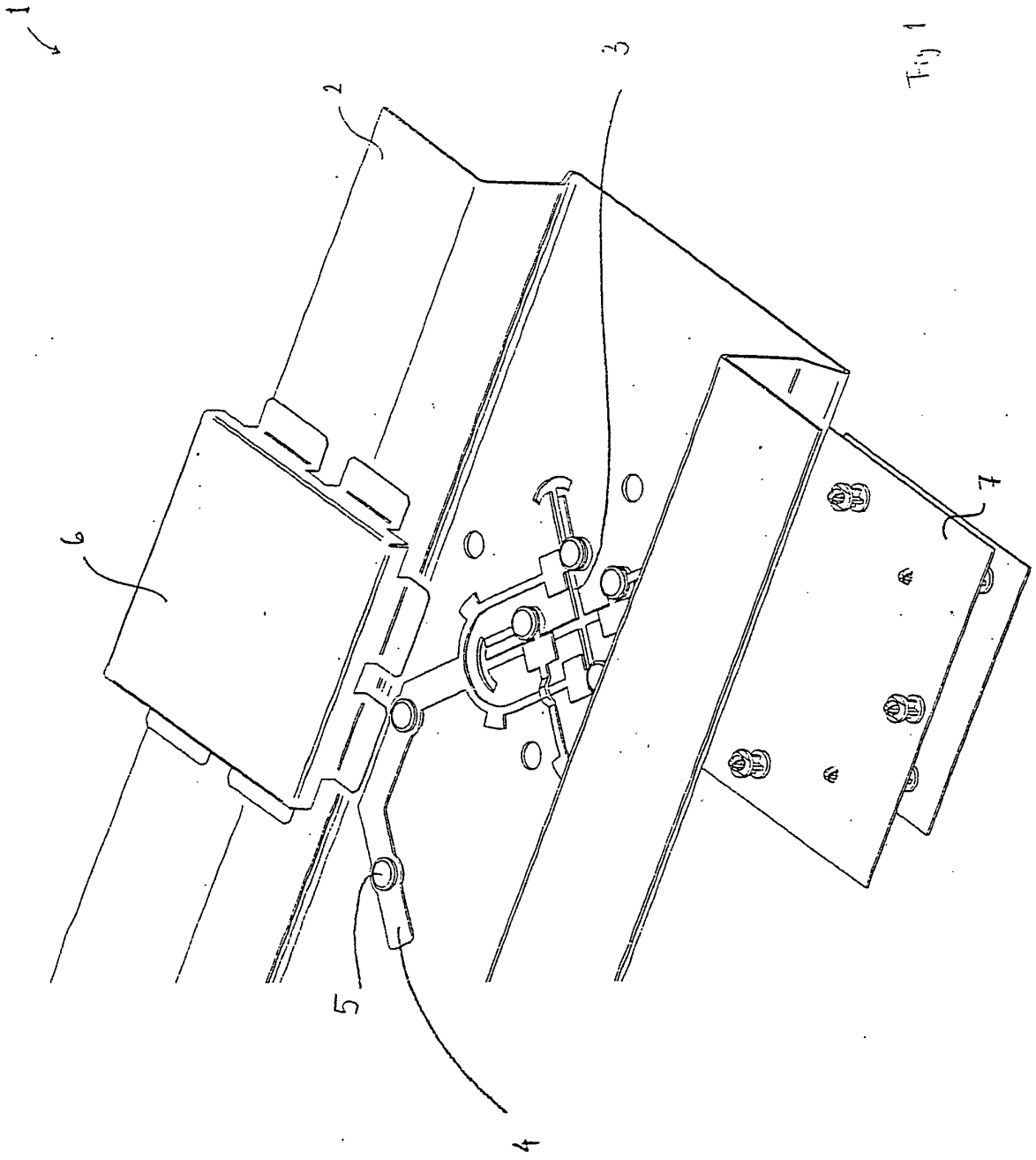

Fig 1

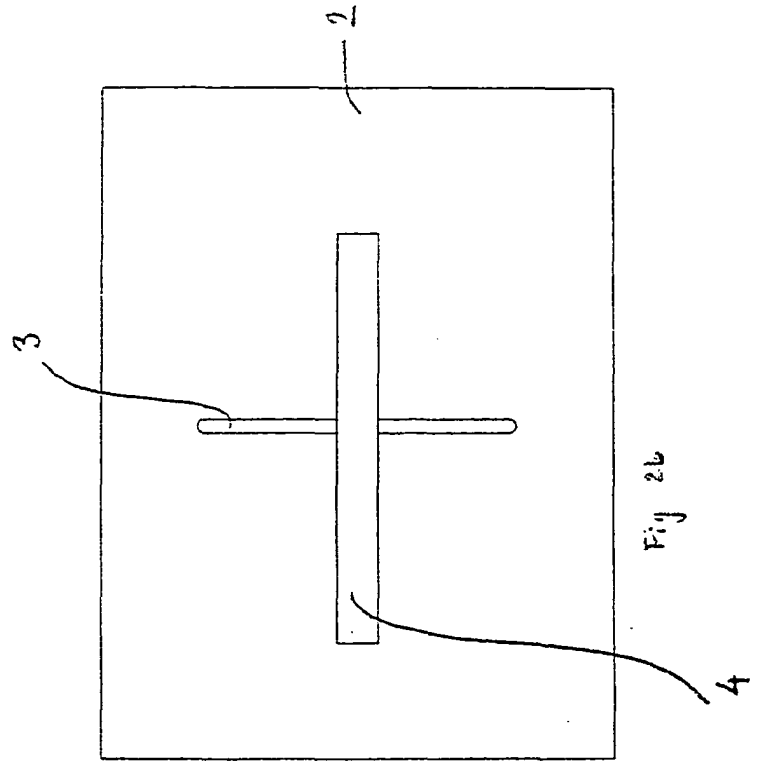

Fig 2b

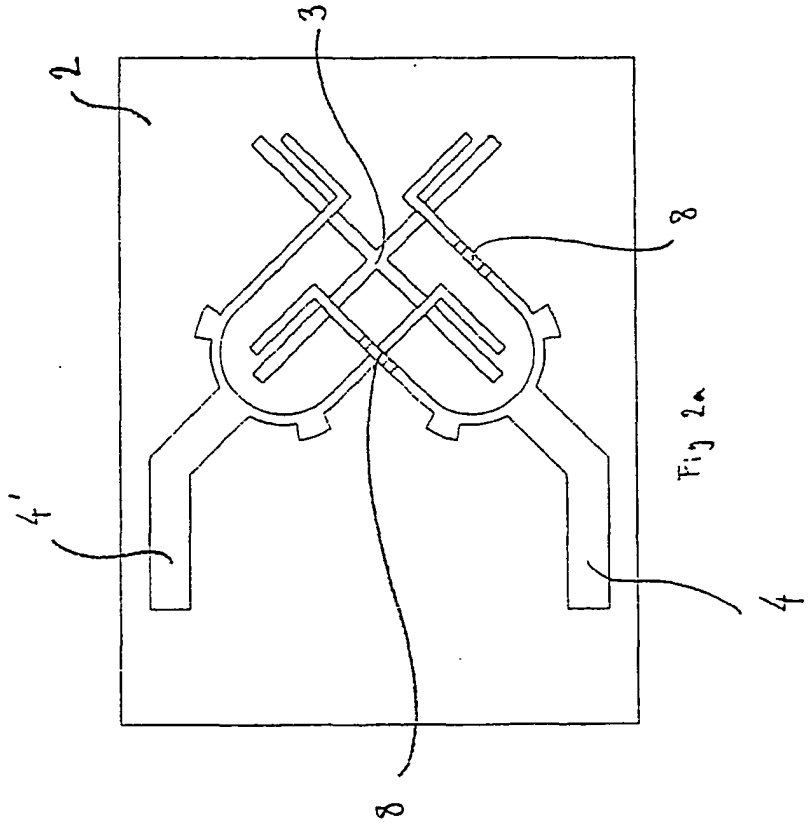

Fig 2a

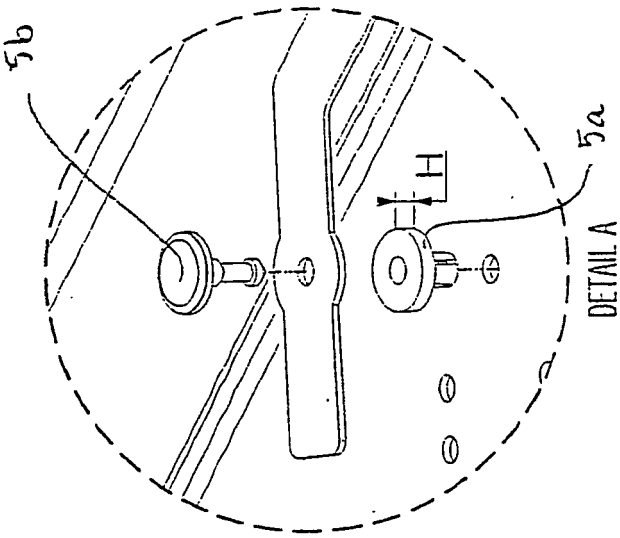

Fig 3b

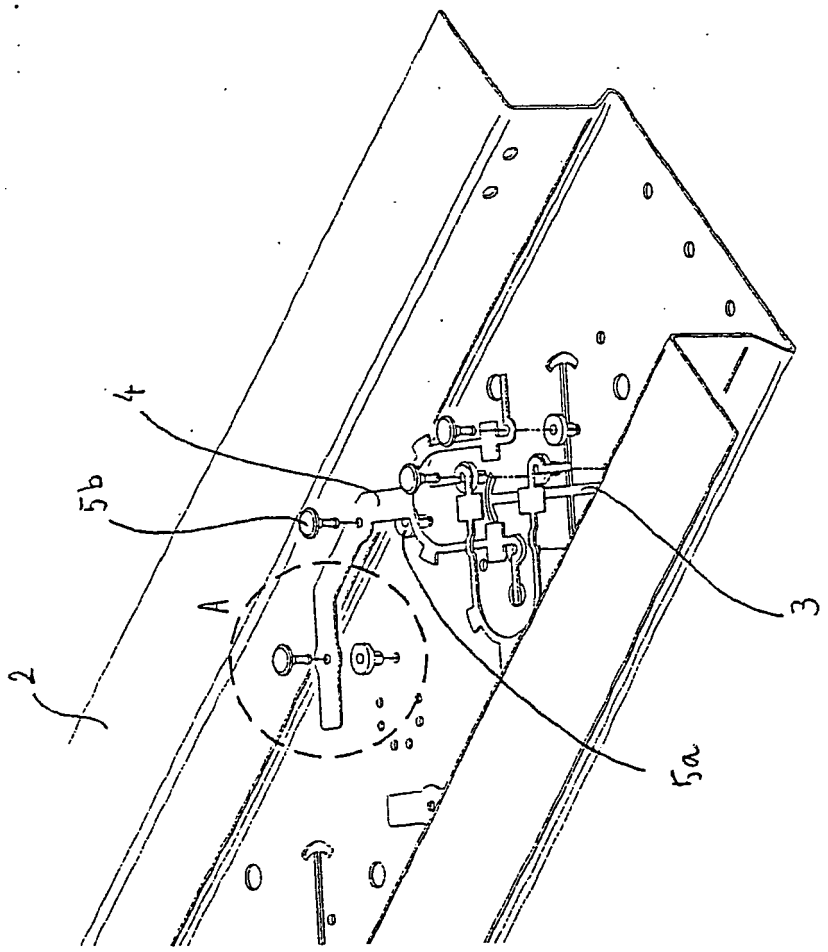

Fig 3a

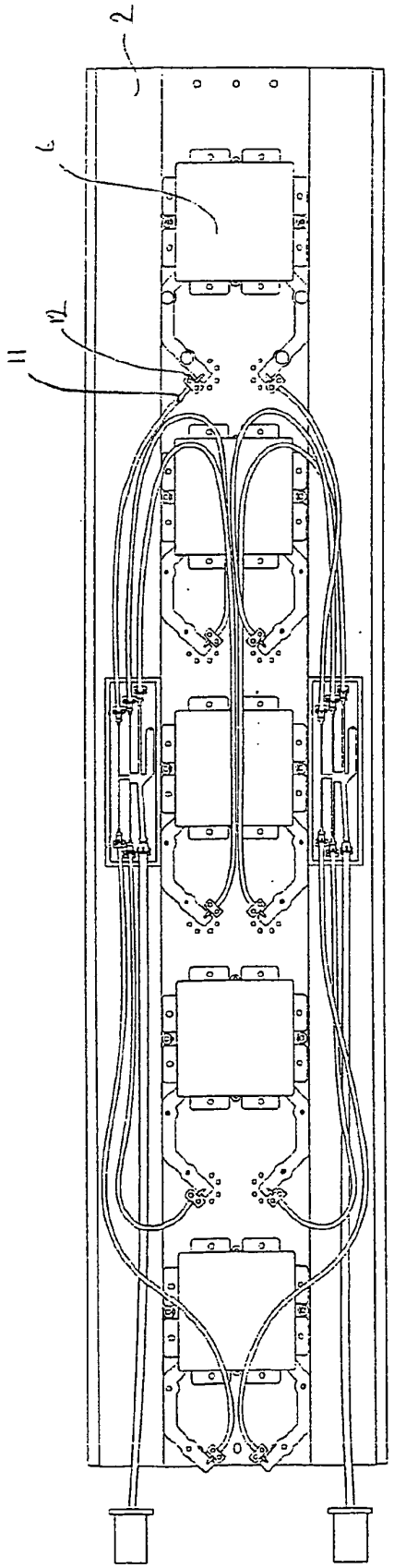

Fig. 4

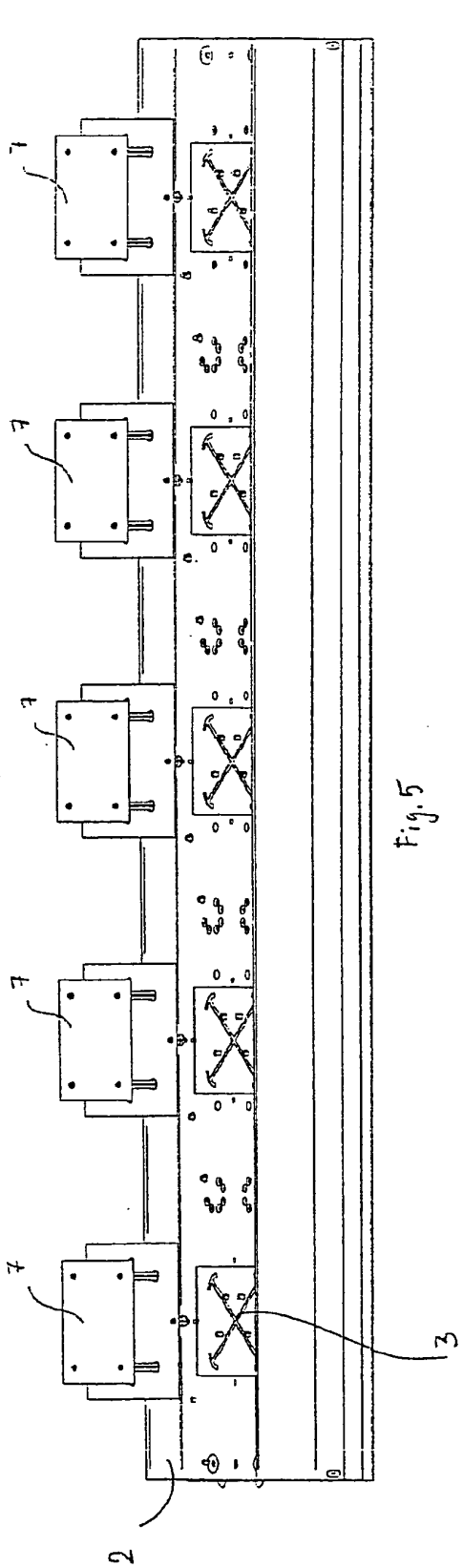

Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- US 6054953 A **[0007]**
- US 4847625 A **[0008]**