(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 976 058 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
01.10.2008 Bulletin 2008/40

(21) Application number: **07105395.3**

(22) Date of filing: **30.03.2007**

(51) Int Cl.:
H01Q 3/26 *(2006.01)* ***H01Q 9/06*** *(2006.01)*
H01Q 9/28 *(2006.01)* ***H01Q 15/24*** *(2006.01)*

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK RS

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(54) An electromagnetic reflector

(57) The invention relates to an electromagnetic reflector, comprising a pair of opposite placed electric dipoles, wherein the dipoles are interconnected via a coplanar strip, forming a reflector module. Preferably, the electromagnetic reflector comprising a second reflector module, wherein the dipoles of the first and second reflector module have substantially the same orientation, wherein the coplanar strips of the respective reflector modules are substantially mutually parallel and wherein the electromagnetic reflector further comprises an additional coplanar strip interconnecting the coplanar strips of the respective reflector modules.

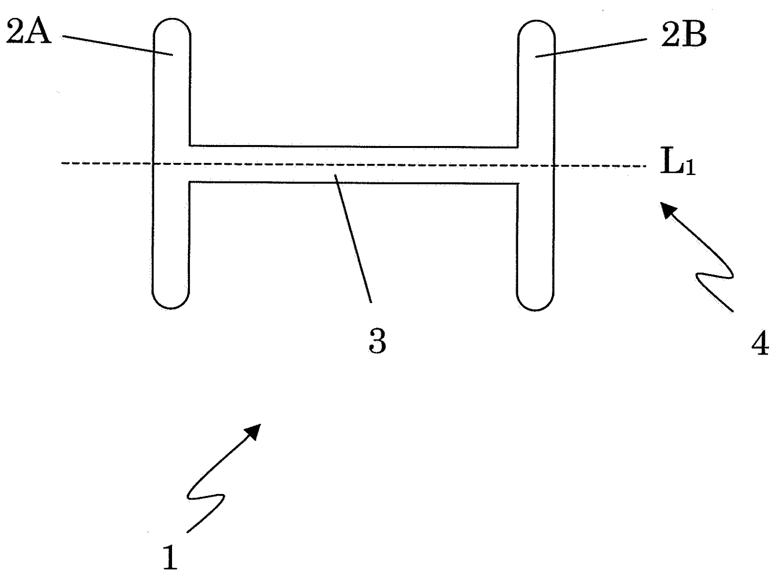

Figure 1

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Description

[0001] The invention relates to an electromagnetic reflector, comprising a pair of opposite placed electric dipoles.

[0002] Such an electromagnetic reflector, also known as an Van Atta array antenna is e.g. known from GB 1 284 747 having a multiple number of electric dipoles to receive incident electromagnetic radiation. The dipoles are substantially similarly oriented to similarly detect the radiation. Further, the dipoles are interconnected via a phase correcting network in such a way that the relative phases of the reradiated waves are reversed. As a consequence, electromagnetic energy that is incident on the Van Atta array antenna is reversed in the opposite direction of arrival. In order to achieve the desired reversal effect, at least four dipoles are needed in a linear array.

[0003] Van Attay array antenna's are applied for improving electromagnetic reflectivity, e.g. for radar detecting purposes.

[0004] It is also known to arrange electric dipoles in a two dimensional plane and to interconnect the dipoles via a phase correcting network such that an incoming electromagnetic wave is reflected back in two dimensions. It has been found that the minimal required number of electric dipoles in a planar Van Atta array is twelve.

[0005] As a disadvantage, the complexity of the phase correcting network increases significantly when the number of individual electric dipoles increases, which is in particular the case with respect to planar Van Attay arrays. Further, the phase correcting network generates undesired radiation noise due to its conducting properties, especially during reflection of irradiating waves that are incident on the electromagnetic reflector at sharp angles. In some known Van Atta arrays, the phase correcting network is shielded from incident waves by arranging a reflecting element between the network and the dipoles. However, the shielding does not work perfectly while, the complexity of the network layout may even further increase.

[0006] It is an object of the invention to provide an electromagnetic reflector according to the preamble of claim 1, wherein the disadvantages identified above are reduced. In particular, the invention aims at obtaining an electromagnetic reflector wherein undesired radiation noise is reduced. Thereto, according to the invention, the dipoles of the electromagnetic reflector are interconnected via a coplanar strip.

[0007] By interconnecting the dipoles via a coplanar strip a very compact reflector is obtained that radiates incident electromagnetic waves back in the opposite direction of arrival, even at sharp angles, while a complex phase correcting network is absent, so that undesired radiation noise is reduced. Surprisingly, an electromagnetic reflector is obtained wherein the structure of the known Van Atta array is simplified, while maintaining and even improving its functionality. As an additional advantage, the coplanar strip can be implemented in the same production process of the dipoles, so that production costs of the electromagnetic reflector are relatively low. In this structure, the interconnected coplanar strip and the coplanar strip form a first reflector module.

[0008] By providing a second reflector module, wherein the dipoles of the first and second reflector module have substantially the same orientation, wherein the coplanar strips of the respective reflector modules are substantially mutually parallel and wherein the electromagnetic reflector further comprises an additional coplanar strip interconnecting the coplanar strips of the respective reflector modules, in a very advantageous manner a planar electromagnetic reflector is obtained that is very compact, since it may comprise merely four dipoles, and that has a very simple and compact coplanar strip configuration causing the electromagnetic reflector to reflect an incident wave in a two dimensional plane back to the opposite direction of arrival. It is noted that it is not necessary to apply two reflector modules. It might be sufficient for some application to employ an electromagnetic reflector having a single reflector module.

[0009] In a further advantageous embodiment according to the invention, the electromagnetic reflector comprises a multiple number of reflector modules and a multiple number of coplanar strips interconnecting the coplanar strips of the respective reflectors in series, thereby obtaining a stronger focussing effect.

[0010] Further, according to the invention, an electromagnetic reflector system comprises a substrate on which a multiple number of electromagnetic reflectors are located so that by the position of the individual reflectors and their mutual orientation a focussing effect as well as an increased electromagnetic contrast might be obtained.

[0011] Other advantageous embodiments according to the invention are described in the following claims.

[0012] By way of example only, embodiments of the present invention will now be described with reference to the accompanying figures in which

Fig. 1 shows a schematic view of a first embodiment of an electromagnetic reflector according to the invention;

Fig. 2 shows a schematic view of a second embodiment of an electromagnetic reflector according to the invention;

Fig. 3 shows a schematic view of a third embodiment of an electromagnetic reflector according to the invention;

Fig. 4 shows a schematic view of a fourth embodiment of an electromagnetic reflector according to the invention; and

Fig. 5 shows a schematic view of an electromagnetic reflector system according to the invention.

[0013] The figures are merely schematic views of preferred embodiments according to the invention. In the figures, the same reference numbers refer to equal or corresponding parts.

[0014] Figure 1 shows a schematic view of a first embodiment of an electromagnetic reflector 1 according to the invention. The electromagnetic reflector 1 comprises two dipoles 2A, 2B, also called folded dipoles. The two dipoles 2A, 2B are positioned opposite with respect to each other. Further, the dipoles 2A, 2B have substantially the same orientation. The electromagnetic reflector 1 also comprises a coplanar strip 3 interconnecting the dipoles 2A, 2B. The coplanar strip 3 is substantially transverse with respect to the orientation of the electric dipoles 2A, 2B. The combination of the dipoles 2A, 2B and the coplanar strip 3 forms a first I-shaped reflector module 4. A line of symmetry L_1, oriented coaxial with respect to the coplanar strip 3 extends in a reflection plane reflecting incident electromagnetic waves. As a result, propagation components of an incident electromagnetic wave in a plane transverse with respect to the line of symmetry L_1 are retro reflected, i.e. reflected in the opposite direction of incidence.

[0015] The length of the coplanar strip 3 is preferably substantially $(n + ½) \lambda + f$, wherein n is any natural number 0, 1, 2, ... , λ represents the wavelength of an incident electromagnetic wave to be reflected, and f is an empirical correction factor.

[0016] It is noted that the orientation of the electric dipoles 2A, 2B might deviate, in stead of being oriented substantially in the same direction. Further, the coplanar strip 3 might be oriented non-transverse with respect to the orientation of one or more of the electric dipoles 2A, 2B, e.g. slightly tilted with respect to an electric dipole 2A.

[0017] Figure 2 shows a schematic view of a second embodiment of an electromagnetic reflector 10 according to the invention. Apart from the first reflector module 4, the electromagnetic reflector 10 comprises a similar second reflector module 5, wherein the dipoles 2A, 2B, 2C, 2D of the first and second reflector module 4, 5 have substantially the same orientation. Further, the coplanar strips 3, 6 of the respective reflector modules 4, 5 are substantially mutually parallel. The electromagnetic reflector 10 comprises an additional coplanar strip 7 interconnecting the coplanar strips 3, 6 of the respective reflector modules 4, 5. The additional coplanar strip 7 is located halfway between the dipoles 2A, 2B, 2C, 2D to form a H-shaped configuration. Apart from a first and a second line of symmetry L_1, L_2 being coaxial with respect to the respective coplanar strips 3, 6 extending in reflection planes reflecting incident electromagnetic wave, the configuration also comprises a third line of symmetry L_3 transverse with respect to the first mentioned lines of symmetry L_1, L_2, and being oriented coaxial with respect to the additional coplanar strip 7. The third line of symmetry L_3 extends in a transverse reflection plane reflecting incident electromagnetic waves. As a result, also a propagation component of an incident electromagnetic wave transverse with respect to the third line of symmetry L_3 being substantially parallel with respect to the first and second line of symmetry L_1, L_2, is retro reflected, so that substantially all propagation components of incident electromagnetic waves having a component transverse with respect to plane in which the reflector 1 extends, is totally retro reflected, i.e. the direction of the reflected wave is opposite to the direction of the incidence wave.

[0018] Figure 3 shows a schematic view of a third embodiment of an electromagnetic reflector 20 according to the invention. In the third embodiment still another reflector module 8 having a further two electric dipoles 2E, 2F, is added to the configuration of the second embodiment. As a result, the electromagnetic reflector 20 comprises a multiple number of reflector modules 4, 5, 11 and a multiple number of coplanar strips 7, 9 interconnecting the coplanar strips 3, 6, 8 of the respective reflector modules 4, 5, 11, each of the modules having a line of symmetry L_1, L_2, L_4, respectively, in series. Thus a concatenated configuration is obtained. It is noted that even more reflector modules can be added to the electromagnetic reflector 20.

[0019] For detection purposes of automotive radar equipment operating at 76 GHz, the length of the electric dipoles 2A, 2B, 2C, 2D, 2E, 2F is chosen half a wavelength, i.e. approximately 2 mm. However, also other dimensions can be applied, e.g. if the operating frequency of a scanning radar is different. The length of the electric dipoles can be chosen in dependence of the operating radar signal frequency, e.g. in a range between several hundreds MHz to several hundreds GHz.

[0020] Fig. 4 shows a schematic view of a fourth embodiment of an electromagnetic reflector 21 according to the invention. The electromagnetic reflector 21 comprises a reflector module 22 that is supplemented with a further coplanar strip 23 and a further dipole 24 connected therewith. The further coplanar strip 23 is with a first end connected to a dipole 2B of the reflector module 22, opposite to the coplanar strip 3 of the reflector module 22. The further dipole 24 is connected to the second end of the further coplanar strip 23, so that a reflector 21 is obtained having three dipoles 2A, 2B, 24 being oriented parallel with each other, arranged in line with each other and being interconnected by means of two coplanar strips 3, 23 that extend on substantially the same longitudinal axis being the line of symmetry L_1. It is noted that even more coplanar strips and dipoles and/or reflector modules can be added to the electromagnetic reflector 21.

[0021] Fig. 5 shows a schematic view of an electromagnetic reflector system 30 according to the invention. The system 30 comprises a substrate 31, on which a multiple number of electromagnetic reflectors 32, 33, 34 are located, e.g. by means of a printing or etching process. In particular, three electromagnetic reflectors 32, 33, 34 according to the first embodiment are located on the substrate 31, thereby obtaining an electromagnetic reflector system, comprising simple, robust reflector units, the combination of which leads to a desired passive reflective efficiency.

[0022] The substrate comprises flexible dielectric material, so that the electromagnetic reflector system can easily be attached to objects, such as cloths. However, in an alternative embodiment the substrate comprises a relatively rigid material, such as FR4, so that the individual electromagnetic reflectors 32, 33, 34 are less sensitive to breakage.

[0023] Further, a bottom layer of the substrate 31 comprises an adhesive layer (not shown), so that the electromagnetic reflector system 30 can even more easily be attached to objects in order to obtain a better electromagnetic contrast.

[0024] The electromagnetic reflectors described above are applicable where electromagnetic contrast is desired, e.g. in traffic situations where optical visibility is reduced and observations are mainly performed by interpreting radar data which becomes available in cars. By improving electromagnetic contrast of objects and/or persons in the direction of incident electromagnetic waves, the objects and/or the persons can more easily be detected by radar, thus improving safety conditions. Thereto, clothing of pedestrians, such as coats, could be provided with electromagnetic reflectors according to the invention.

[0025] The invention is not restricted to the embodiments described herein. It will be understood that many variants are possible.

[0026] As an example, an electromagnetic reflector according to the invention can also be used in passive radio beacons for shipping traffic and airplanes navigation purposes.

[0027] As the person skilled in the art knows, various electrical guiding materials having arbitrary thicknesses can be used to form the dipoles.

[0028] Other such variants will be obvious for the person skilled in the art and are considered to lie within the scope of the invention as formulated in the following claims.

Claims

1. An electromagnetic reflector, comprising a pair of opposite placed electric dipoles, wherein the dipoles are interconnected via a coplanar strip.

2. An electromagnetic reflector according to claim 1, wherein the interconnected dipoles and the coplanar strip form a first reflector module, the electromagnetic reflector comprising a second reflector module, wherein the dipoles of the first and second reflector module have substantially the same orientation, wherein the coplanar strips of the respective reflector modules are substantially mutually parallel and wherein the electromagnetic reflector further comprises an additional coplanar strip interconnecting the coplanar strips of the respective reflector modules.

3. An electromagnetic reflector according to claim 2, comprising a multiple number of reflector modules and a multiple number of coplanar strips interconnecting the coplanar strips of the respective reflector modules in series.

4. An electromagnetic reflector, comprising a substrate on which a multiple number of electromagnetic reflectors according to any of the previous claims are located.

5. An electromagnetic reflector system according to claim 4, wherein the substrate comprises flexible dielectric material.

6. An electromagnetic reflector system according to claim 4 or 5, wherein an bottom layer of the substrate comprises an adhesive layer.

7. An electromagnetic reflector according to any of the previous claims, wherein the electric dipoles have substantially the same orientation.

8. An electromagnetic reflector according to any of the previous claims, wherein the coplanar strip is substantially transverse with respect to the orientation of an electric dipole of the pair of electric dipoles.

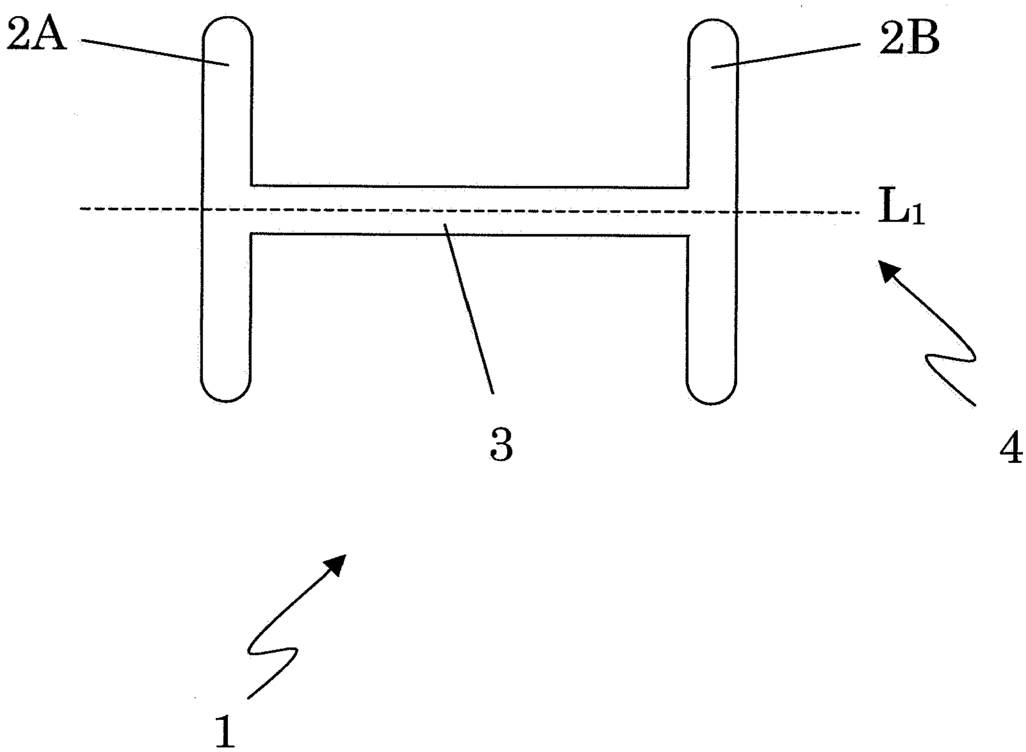

Figure 1

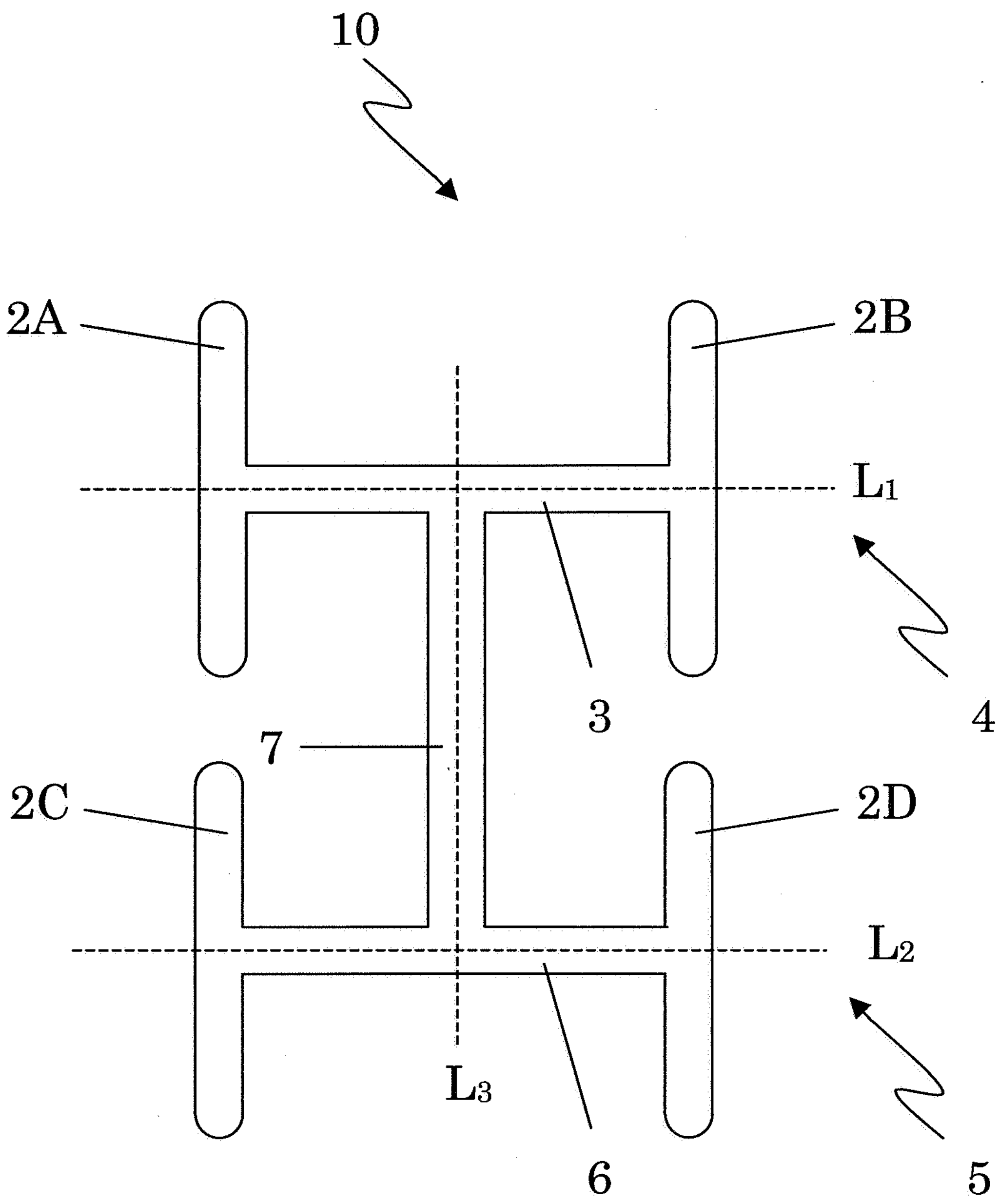

Figure 2

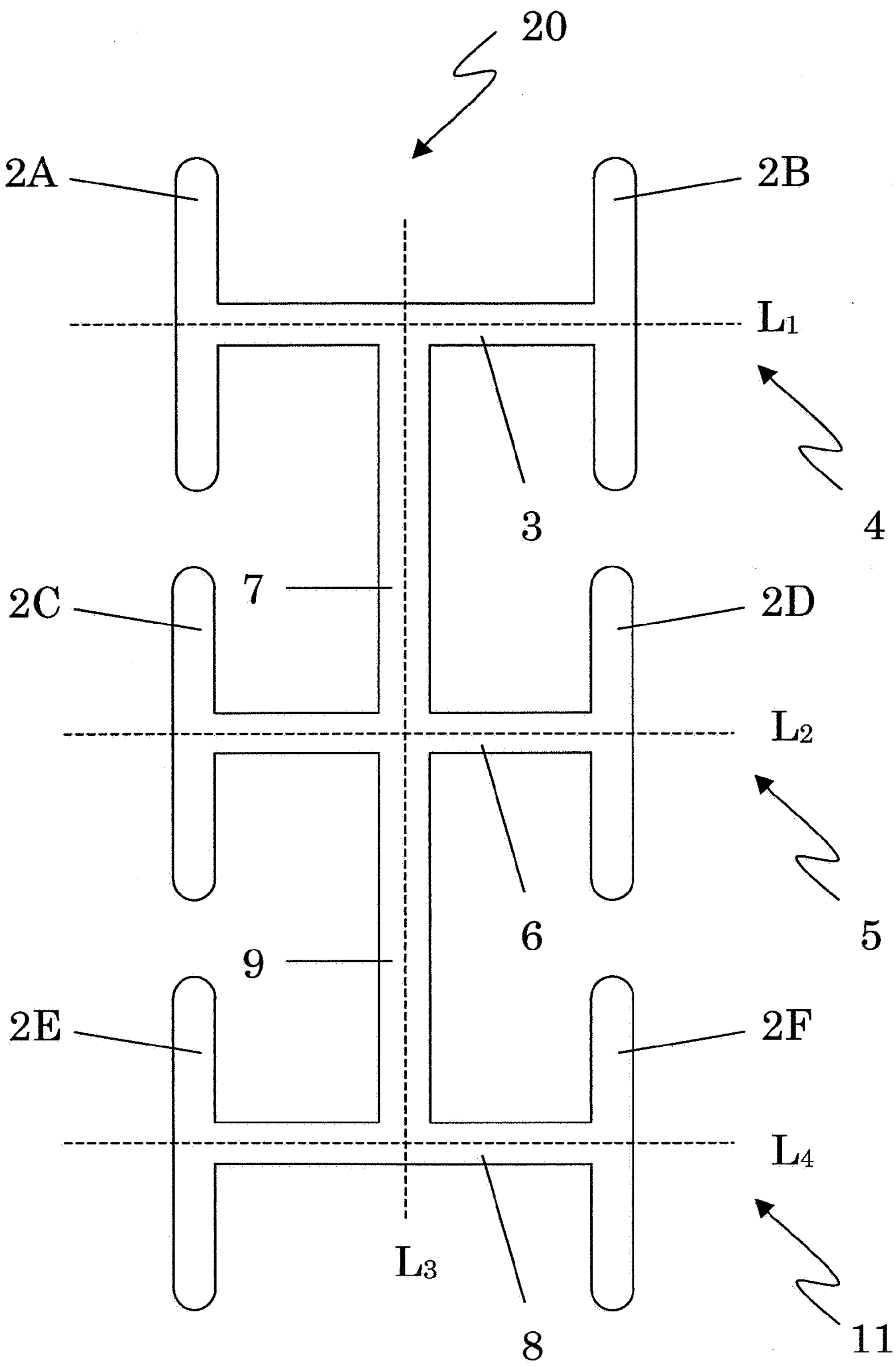

Figure 3

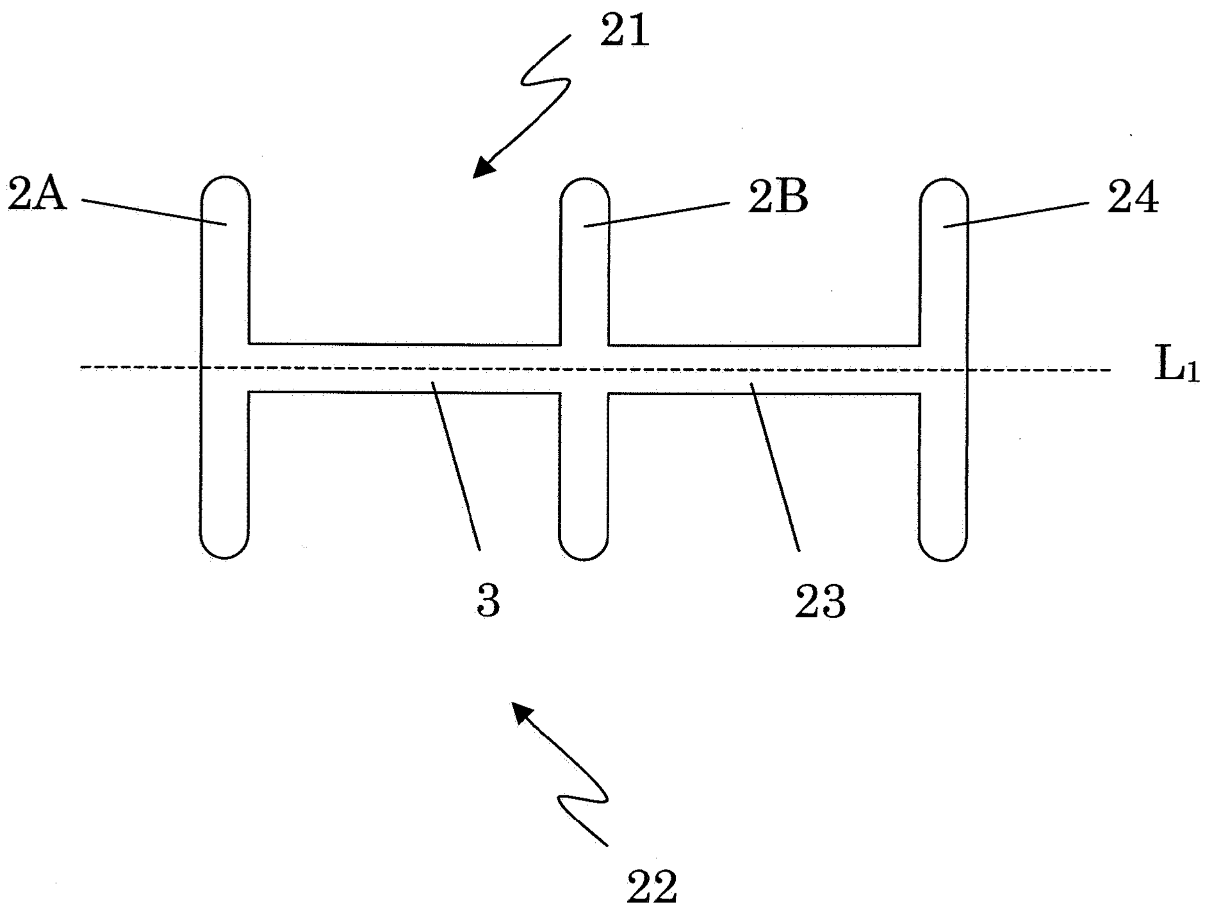

Figure 4

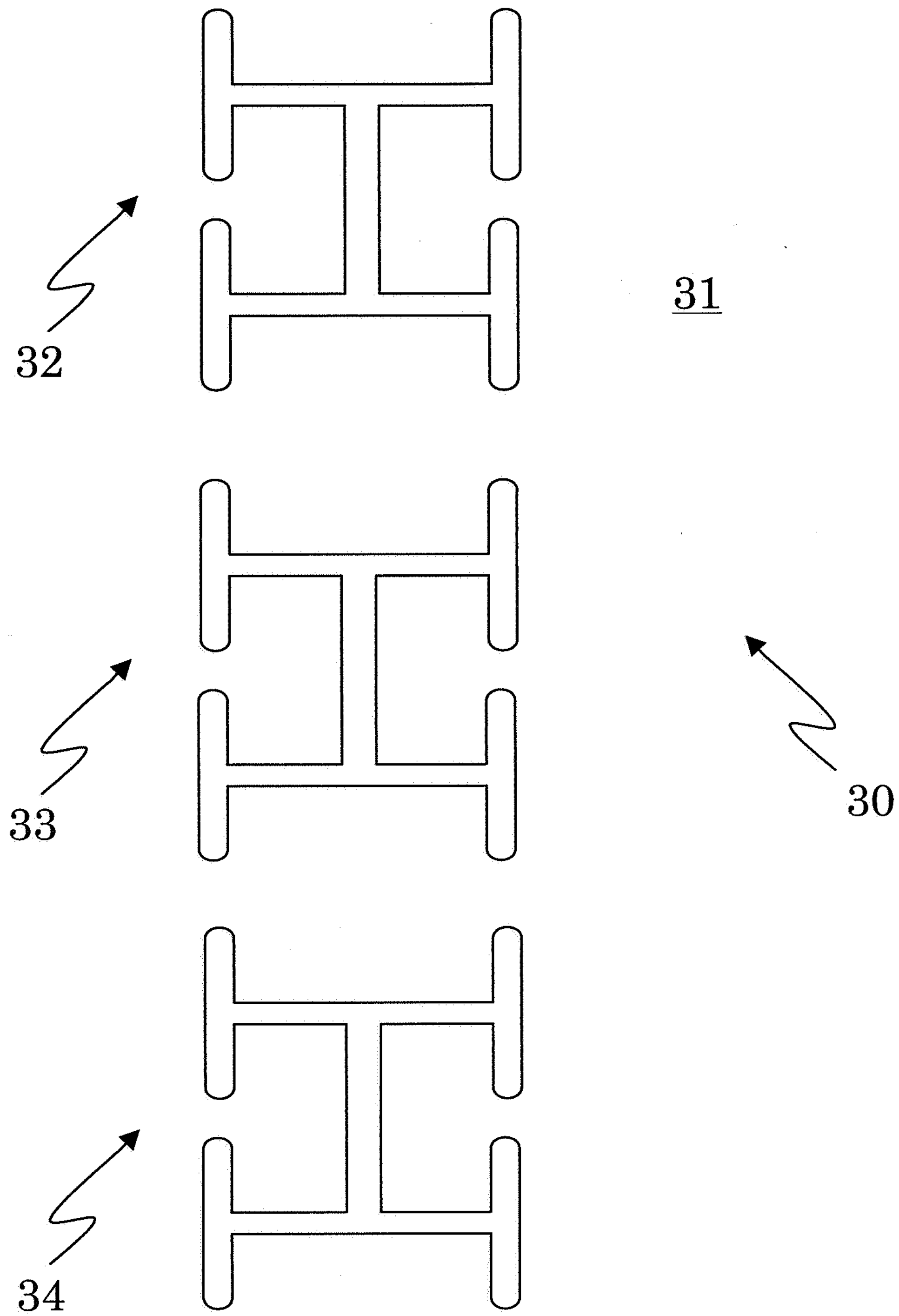

Figure 5

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EUROPEAN SEARCH REPORT

Application Number
EP 07 10 5395

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	18 April 2007	Van Dooren, Gerry

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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