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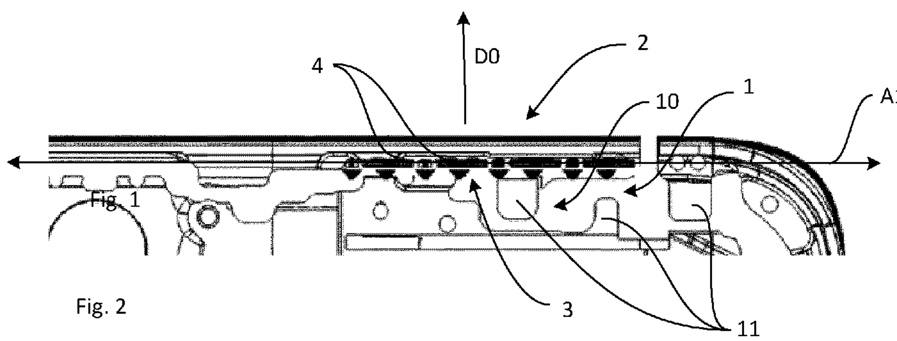

Fig. 2

(57) **Abstract:** An antenna arrangement (1) for an electronic apparatus (2) comprising an antenna array (3) comprising a plurality of antenna elements (4) generating millimeter-wave frequency radiation, and at least one radiation reflector surface (5) at least partially superimposed with the antenna array (3) and configured to reflect at least a part of the millimeter-wave frequency radiation in at least one direction. The reflector surface (5) comprises at least one of a nonconductive reflector element (5a) comprising a material having a dielectric constant of at least 10, and a plurality of parallel elongated conductive reflectors (5b). Each pair of parallel elongated conductive reflectors (5b) are separated by an elongated gap (6) filled with a dielectric solid or air. The reflector surface(s) (5) may be embedded in a display panel (7), frame (8), or substrate (9) of the electronic apparatus (2).

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ANTENNA ARRANGEMENT FOR ELECTRONIC APPARATUS

TECHNICAL FIELD

The disclosure relates to an antenna arrangement for an electronic apparatus, the antenna arrangement comprising at least one radiation reflector surface and an antenna array comprising a plurality of antenna elements arranged along an antenna array axis and configured to generate millimeter-wave frequency radiation in directions perpendicular to the antenna array axis.

BACKGROUND

Mobile apparatuses such as smartphones require omni-coverage dual-polarized millimeter-wave antennas to achieve stable communication in all directions and orientations. However, requirements on the apparatus design include providing a curved design including a sleek metal frame and a large display arranged with very small clearance since it is preferred to not have any visible openings. These design requirements are contradictory to the antenna requirements, and thus it is difficult to achieve a contemporary design and sufficient antenna coverage in one and the same apparatus.

Display side radiation is desired for millimeter-wave antennas. For millimeter-wave radiation, antennas in the form of dipoles or monopoles are commonly used. These elements provide an omnidirectional pattern, however, they might cause energy leakage or radiation towards undesired directions such as directions away from the apparatus display side. Hence, millimeter-wave antennas require reflectors, used to reflect and redirect radiation from undesired directions to desired directions. Such reflectors may, however, interfere with the performance of components of antennas outside of the millimeter-wave range, such as sub-6 GHz feeding posts.

In at least one known solution, a dielectric rod antenna is used for generating radiation towards the apparatus display side. However, the dielectric rod antenna requires a lot of free space to be available inside the apparatus, and the solution is oftentimes incompatible with sub-6 GHz feeding posts. Furthermore, this solution requires multiple apparatus layers with different permittivity, i.e. dielectric constants, as well as a notch in the display.

In a further known solution, high impedance surface spikes have been added to the metal frame. This enables modifying the radiation pattern in order to boost the directivity towards the display side. However, the spikes may intersect with the sub-6 GHz feeding posts which makes the implementation challenging. Further, there is at least some negative effect on sub-6 GHz performance due to the incompatibility with the feeding posts.

Hence, there is a need for a solution that provides good end-fire performance and directivity for apparatuses having metal frames and curved displays.

SUMMARY

It is an object to provide an improved antenna arrangement for a handheld device. The foregoing and other objects are achieved by the features of the independent claims. Further implementation forms are apparent from the dependent claims, the description, and the figures.

According to a first aspect, there is provided an antenna arrangement for an electronic apparatus comprising an antenna array comprising a plurality of antenna elements arranged along an antenna array axis and configured to generate millimeter-wave frequency radiation in directions perpendicular to the antenna array axis, and at least one radiation reflector surface at least partially superimposed with the antenna array and extending parallel to the antenna array axis, the reflector surface being configured to reflect at least a part of the millimeter-wave frequency radiation towards at least one of the directions. The

reflector surface comprises at least one of a nonconductive reflector element comprising a material having a dielectric constant of at least 10, and a plurality of parallel elongated conductive reflectors, wherein each pair of the parallel elongated conductive reflectors are separated by an elongated gap, longitudinal axes of the parallel reflectors and longitudinal axes of the gaps extending perpendicular to the antenna array axis, the gaps being filled with a dielectric solid or air.

This solution allows millimeter-wave frequency radiation to be redirected using a reflector surface which can be arranged closer to the millimeter-wave antenna elements, allowing a larger distance to be maintained between the reflector surface and signal elements of other antennas, e.g. sub-6 GHz feeding posts, than in conventional solutions. Such an antenna arrangement has a highly efficient radiation field with omni-coverage, while freeing up space within the apparatus for, e.g., the battery. Furthermore, the antenna arrangement can be used together with highly curved display elements, since the reflector surface allows correct radiation steering regardless of the small distances involved. Using a nonconductive reflector element removes the need for grounding, while using a plurality of parallel elongated conductive reflectors is easier to use in planar implementations.

In a possible implementation form of the first aspect, the longitudinal axes extend within a main plane of the reflector surface, such than an as thin reflector surface as possible is provided.

In a further possible implementation form of the first aspect, at least one of the antenna elements is an end-fire antenna element configured to generate millimeter-wave frequency radiation having a main beam direction, a first polarization and a second polarization, the first polarization extending perpendicular to the main beam direction, the reflector surface being configured to reflect millimeter-wave frequency radiation having the first polarization. This allows radiation having a first polarization to be improved without affecting or degrading radiation having a second polarization.

In a further possible implementation form of the first aspect, the antenna arrangement comprises a plurality of reflector surfaces configured to reflect the millimeter-wave frequency radiation in different directions, providing maximum flexibility and adaptability to the arrangement.

In a further possible implementation form of the first aspect, the reflector surface is configured to be arranged at a distance ≤ λ/2 from the antenna element, λ being a wavelength of the millimeter-wave frequency radiation. By placing the reflector surface close to the antenna element, the overall required volume is reduced and design freedom increased.

In a further possible implementation form of the first aspect, the reflector surface is configured to be arranged at a distance between λ/4 and λ /10 from the antenna element. By placing the reflector surface close to the antenna element, the overall required volume is reduced and design freedom increased.

In a further possible implementation form of the first aspect the reflector surface is arranged within a near-field region of the antenna element, the near-field region being a region located at a distance < $\frac{2D^2}{\lambda}$ from the antenna element, D being a maximum outer dimension of the antenna element, such that antenna performance is sufficient while still providing a very compact antenna arrangement.

In a further possible implementation form of the first aspect, the reflector surface forms an impedance discontinuity in the antenna arrangement, reflecting the radiation such that it adds constructively towards the desired direction of radiation.

In a further possible implementation form of the first aspect, the nonconductive reflector element comprises ceramic or plastic material, allowing the dielectric constant to be offset to robustness and manufacturability.

In a further possible implementation form of the first aspect, the nonconductive reflector element has a thickness, in a direction perpendicular to a main plane of the reflector element, which is ≤ λ/4, λ being a wavelength of the millimeter-wave frequency radiation, allowing maximum radiation reflection while avoiding parasitic resonances.

In a further possible implementation form of the first aspect, the thickness is between λ/8 and 3λ /8, facilitating maximum reflectivity.

In a further possible implementation form of the first aspect, the nonconductive reflector element has a thickness, in a direction perpendicular to a main plane of the reflector element, which is an odd multiple of λ/4, facilitating maximum reflectivity.

In a further possible implementation form of the first aspect, the thickness is ≤ 1 mm, allowing an as thin antenna arrangement as possible.

In a further possible implementation form of the first aspect, the conductive reflectors and the gaps, separating the pairs of parallel reflectors, are formed in one conductive sheet material, facilitating a simplified manufacturing process.

In a further possible implementation form of the first aspect, the reflector surface has a length, in a direction perpendicular to the antenna array axis, of between λ and λ/10, λ being a wavelength of the millimeter-wave frequency radiation. This assures the end-fire radiation direction and helps avoid parasitic resonance.

In a further possible implementation form of the first aspect, the conductive reflectors and the gaps have lengths, along the longitudinal axes, within a length range of between λ and λ/10, λ being a wavelength of the millimeter-wave frequency radiation. This assures the end-fire radiation direction and helps avoid parasitic resonance.

In a further possible implementation form of the first aspect, the gaps, separating the pairs of parallel reflectors, allow millimeter-wave frequency radiation having the first polarization to propagate between adjacent pairs of parallel reflectors.

In a further possible implementation form of the first aspect, propagation of millimeter-wave frequency radiation having the second polarization is unaffected by the reflector surface.

According to a second aspect, there is provided an electronic apparatus comprising a display panel, a frame, a substrate enclosed at least by the display panel and the frame, and the antenna arrangement according to the above, wherein the antenna arrangement is configured to emit millimeter-wave frequency radiation having a first polarization propagating towards the display panel and to emit a second polarization propagating towards the frame, the antenna arrangement furthermore being configured to reflect at least part of the millimeter-wave frequency radiation having the first polarization.

This facilitates an electronic apparatus having improved antenna omni-coverage since millimeter-wave frequency radiation can be redirected using a reflector surface that is arranged closer to the millimeter-wave antenna elements, allowing a larger distance to be maintained between the reflector surface and signal elements of other antennas, e.g. sub-6 GHz feeding posts, than in conventional solutions. This, in turn, allows a smaller apparatus volume to be used for the antennas and does not require any substantial modifications to be made to existing apparatus designs.

In a possible implementation form of the second aspect, the electronic apparatus further comprises at least one antenna configured to generate radiation outside of a millimeter-wave frequency range, the reflector surface of the antenna arrangement being configured to be arranged within a volume of the electronic apparatus comprising at least one signal feed probe of the antenna, the reflector surface being arranged at a distance from the signal

feed probe(s), improving the compatibility of the antenna arrangement with non-millimeter-wave antennas and increasing design freedom.
In a further possible implementation form of the second aspect, the substrate comprises a flexible printed circuit, allowing existing components to be used as, e.g., a carrier for parts of the antenna arrangement, requiring fewer modifications to the frame of the apparatus and taking up less space within the apparatus.

In a further possible implementation form of the second aspect, the reflector surface is embedded in the display panel, frame, or substrate, facilitating assembly and freeing up additional space within the apparatus.

These and other aspects will be apparent from the embodiment(s) described below.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following detailed portion of the present disclosure, the aspects, embodiments, and implementations will be explained in more detail with reference to the example embodiments shown in the drawings, in which:

Fig. 1 shows a side view of an electronic apparatus in accordance with an example of the embodiments of the disclosure;

Fig. 2 shows a partial top view of an electronic apparatus comprising an antenna arrangement in accordance with an example of the embodiments of the disclosure;

Fig. 3 shows a cross-sectional view of an electronic apparatus comprising an antenna arrangement in accordance with an example of the embodiments of the disclosure;

Fig. 4 shows a cross-sectional view of an electronic apparatus comprising an antenna arrangement in accordance with an example of the embodiments of the disclosure;

Fig. 5 shows a cross-sectional view of an electronic apparatus comprising an antenna arrangement in accordance with an example of the embodiments of the disclosure;

Fig. 6 shows a cross-sectional view of an electronic apparatus comprising an antenna arrangement in accordance with an example of the embodiments of the disclosure;

Fig. 7 shows a partial perspective view of an electronic apparatus comprising an antenna arrangement in accordance with an example of the embodiments of the disclosure;

Fig. 8 shows a cross-sectional view of an antenna arrangement in accordance with an example of the embodiments of the disclosure;

Fig. 9 shows a partial perspective view of an antenna arrangement in accordance with an example of the embodiments of the disclosure.

DETAILED DESCRIPTION

Figs. 3 to 8 show an antenna arrangement 1 for an electronic apparatus 2 comprising an antenna array 3 comprising a plurality of antenna elements 4 arranged along an antenna array axis A1 and configured to generate millimeter-wave frequency radiation in directions perpendicular to the antenna array axis A1, and at least one radiation reflector surface 5 at least partially superimposed with the antenna array 3 and extending parallel to the antenna array axis A1, the reflector surface 5 being configured to reflect at least a part of the millimeter-wave frequency radiation towards at least one of the directions, the reflector surface 5 comprising at least one of a nonconductive reflector element 5a comprising a material having a dielectric constant of at least 10, see Figs. 3 to 7, and a plurality of parallel elongated conductive reflectors 5b, wherein each pair of the parallel elongated conductive reflectors 5b are separated by an elongated gap 6, longitudinal axes A2 of the parallel reflectors 5b and longitudinal axes A3 of the gaps 6 extending perpendicular to the antenna array axis A1, the gaps 6 being filled with a dielectric solid or air, see Figs. 8 and 9. Figs. 1 and 2 show an electronic apparatus 2 comprising a display panel 7, a frame 8, a substrate 9 enclosed at least by the display panel 7 and the frame 8, and an antenna arrangement 1 described in more detail further below.

The frame 8 may comprise a conductive material. The substrate 9 may comprise a flexible printed circuit such as a bent LCP board (Liquid Crystal Polymer), as illustrated in Figs. 8 and 9. Cutting away a very small portion of the plastic material, e.g. crastin, is sufficient in order to place the reflector surface at the optimal position from the antenna elements.

The antenna arrangement 1 is configured to emit millimeter-wave frequency radiation having a first polarization propagating towards the display panel 7 and to emit a second polarization propagating towards the frame 8. The antenna arrangement 1 is furthermore configured to reflect at least part of the millimeter-wave frequency radiation having the first polarization.

As shown in Fig. 2, the electronic apparatus 2 may further comprise at least one antenna 10 configured to generate radiation outside of a millimeter-wave frequency range, such as radiation in the sub-6 GHz frequency range.

The reflector surface 5 of the antenna arrangement 1 is configured to be arranged within a volume of the electronic apparatus 2 comprising at least one signal feed probe 11 of the antenna 10. The reflector surface 5 is arranged at a distance from the signal feed probes 11 such that the antenna arrangement 1 is not affected by the signal of the feed probes 11.

The reflector surface 5 may be embedded in the display panel 7, frame 8, or substrate 9, or may be a separate component applied onto a surface of the display panel 7, frame 8, or

substrate 9. The reflector surface 5 may be placed between the antenna elements 4 and other internal parts of the apparatus such that leakage of radiation to any other direction than the desired direction is prevented. The reflector surface 5 may be placed, e.g., between the metals of the sub-6 GHz antennas and/or under the LCP board, the antenna elements 4 being located above the reflector surface 5.
The antenna arrangement 1 comprises an antenna array 3 and at least one radiation reflector surface 5. The antenna arrangement 1 may comprise a plurality of reflector surfaces 5 configured to reflect the millimeter-wave frequency radiation in different directions. Each reflector surface 5 may form an impedance discontinuity in the antenna arrangement 1, hence causing reflection.

The antenna array 3 comprises a plurality of antenna elements 4 arranged along an antenna array axis A1, as shown in Fig. 2, each antenna element 4 comprising at least a radiator. The antenna array 3 is configured to generate millimeter-wave frequency radiation in directions perpendicular to the antenna array axis A1.

At least one of the antenna elements 4 may be an end-fire antenna element 4. An end-fire antenna array is a linear array in which the direction of radiation is along the line of the antennas, i.e. main beam direction D0 as shown in the Figs. The end-fire antenna elements 4 are configured to generate millimeter-wave frequency radiation having a main beam direction D0, a first polarization, and a second polarization. The first polarization extends perpendicular to the main beam direction D0 and the reflector surface 5 is configured to reflect millimeter-wave frequency radiation having the first polarization. The first polarization may be vertical polarization and the second polarization may be horizontal polarization. A so-called V-pol monopole may be used to generate vertically polarized radiation and a so-called H-pol dipole may be used to generate horizontally polarized radiation.

The reflector surface 5 is at least partially superimposed with the antenna array 3 and extends parallel to the antenna array axis A1. The reflector surface 5 is configured to reflect at least a part of the millimeter-wave frequency radiation towards at least one of the directions perpendicular to the antenna array axis A1.

The reflector surface 5 may be configured to be arranged at a distance ≤ λ/2 from the antenna element 4, λ being a wavelength of the millimeter-wave frequency radiation. More specifically, the reflector surface 5 may be configured to be arranged at a distance between λ/4 and λ /10 from the antenna element 4. The reflector surface 5 may be arranged within a near-field region of the antenna element 4, the near-field region being a region located at a distance < $\frac{2D^2}{\lambda}$ from the antenna element 4, D being a maximum outer dimension of the antenna element. The maximum outer dimension is the largest dimension of the antenna element, such as the length of a radiator having a rectangular surface area, or the diameter of a radiator having a circular surface area.

The reflector surface 5 may have a length, in a direction perpendicular to the antenna array axis A1, of between λ and λ/10, λ being a wavelength of the millimeter-wave frequency radiation.

The reflector surface 5 comprises at least one of a nonconductive reflector element 5a and a plurality of parallel elongated conductive reflectors 5b.

The nonconductive reflector element 5a, shown in Figs. 3 to 7, comprises a material having a so-called high dielectric constant, i.e., a dielectric constant of at least 10 such as 15, 20, or 40, enabling a broadband solution that works in a frequency range of 20-50 GHz. The nonconductive reflector element 5a may comprise ceramic or high-permittivity plastic material. High-permittivity plastic materials commonly have a dielectric constant up to 25 and are generally more flexible materials than ceramics, making them less fragile. Ceramic materials, on the other hand, are generally very rigid and thus, more fragile. Ceramics can have a dielectric constant from 15-20 up to values in the thousands.

Reflection and transmission of radiation occur due to the boundary discontinuity between two materials, resulting in a reflected wave in one of the materials and a transmitted wave in the other of the materials. If the thickness of the reflector element 5a is a multiple (i.e., positive integer) of the half-wavelength, $\lambda/2$, the reflection at the boundary will be zero at a specific frequency. This means that the reflector element 5a appears transparent to the plane wave, which undesirable, and thus, in order to achieve maximum reflectivity, the thickness of the reflector element 5a must be $\neq n\lambda/2$, where n is a positive integer.

The nonconductive reflector element 5a may, hence, have a thickness, in a direction perpendicular to a main plane of the reflector element 5a, which is $\leq \lambda/4$, λ being the wavelength of the millimeter-wave frequency radiation. The thickness may be between $\lambda/8$ and $3\lambda/8$. The nonconductive reflector element 5a may also have a thickness, in the direction perpendicular to the main plane of the reflector element 5a, which is an odd multiple of $\lambda/4$, such as $3\lambda/8$, in order to avoid the above-mentioned multiples of $\lambda/2$. Furthermore, reflector bandwidth is limited by wave impedance, i.e., the effective dielectric constant, and parasitic resonances. Parasitic resonances occur above $n\lambda/2$, limiting the highest frequency available. Therefore, the thickness of the reflector element 5a is preferably below $\lambda/4$ in order to reflect the radiation.

The thickness may be ≤ 1 mm, e.g., 0.2 mm at a dielectric constant of 40. When using a dielectric constant of 40, the reflector element 5a may be too thin and might break easily or be difficult to manufacture. Since the permittivity used is lower when the dielectric constant is 20, the thickness of the reflector element 5a has to be increased to about 0.5 mm ($\lambda/8$), which is preferable from a practical point of view. With a dielectric constant of 20, materials other than ceramics, e.g., high-permittivity plastics, can be used which may be more robust and easier to place inside the apparatus.

In an example wherein the frequency of the radiation is 30 GHZ and the thickness of nonconductive reflector element 5a is $\lambda/8$, the directivity may be around 8dBi, covering the

24-29.5 and 37-43 GHz bands, if the distance between reflector element 5a and antenna element 4 is between λ/10 and λ/5.

The plurality of parallel elongated conductive reflectors 5b are arranged such that each pair of parallel elongated conductive reflectors 5b are separated by an elongated gap 6. The longitudinal axes A2 of the parallel reflectors 5b and the longitudinal axes A3 of the gaps 6 extend perpendicular to the antenna array axis A1, as shown in Fig. 9. The longitudinal axes A2, A3 may extend within a main plane of the reflector surface 5. The conductive reflectors 5b and the gaps 6, separating the pairs of parallel reflectors 5b, may be formed in one conductive sheet material, as suggested in Fig. 9, The conductive sheet material may be a copper sheet. The conductive reflectors 5b/ conductive sheet material may be grounded to the frame 8 or the substrate 9.

The gaps 6 are filled with a dielectric solid or air. Air has a dielectric constant of 1, while the dielectric solid may be any suitable material having a dielectric constant generally in the range of 2-5, generally 3. The dielectric solid may be comprised by the main dielectric material of a conventional printed circuit board or liquid crystal polymer board, e.g. when the reflector surface 5, i.e. the reflectors 5b, are embedded into the board.

The conductive reflectors 5b and the gaps 6 may have lengths, along the longitudinal axes A2, A3, within a length range of between λ and λ/10, λ being a wavelength of the millimeter-wave frequency radiation.

The gaps 6, separating the pairs of parallel reflectors 5b, may allow millimeter-wave frequency radiation having the first polarization, e.g., vertical polarization to propagate between adjacent pairs of parallel reflectors 5b. Propagation of millimeter-wave frequency radiation having the second polarization, e.g., horizontal polarization, may remain unaffected by the reflector surface 5.

The various aspects and implementations have been described in conjunction with various embodiments herein. However, other variations to the disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed subject-matter, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measured cannot be used to advantage.

The reference signs used in the claims shall not be construed as limiting the scope. Unless otherwise indicated, the drawings are intended to be read (e.g., cross-hatching, arrangement of parts, proportion, degree, etc.) together with the specification, and are to be considered a portion of the entire written description of this disclosure. As used in the description, the terms "horizontal", "vertical", "left", "right", "up" and "down", as well as adjectival and adverbial derivatives thereof (e.g., "horizontally", "rightwardly", "upwardly", etc.), simply refer to the orientation of the illustrated structure as the particular drawing figure faces the reader. Similarly, the terms "inwardly" and "outwardly" generally refer to the orientation of a surface relative to its axis of elongation, or axis of rotation, as appropriate.

CLAIMS

1. An antenna arrangement (1) for an electronic apparatus (2) comprising:

-an antenna array (3) comprising a plurality of antenna elements (4) arranged along an antenna array axis (A1) and configured to generate millimeter-wave frequency radiation in directions perpendicular to said antenna array axis (A1); and

-at least one radiation reflector surface (5) at least partially superimposed with said antenna array (3) and extending parallel to said antenna array axis (A1), said reflector surface (5) being configured to reflect at least a part of said millimeter-wave frequency radiation towards at least one of said directions,

said reflector surface (5) comprising at least one of
-a nonconductive reflector element (5a) comprising a material having a dielectric constant of at least 10; and

-a plurality of parallel elongated conductive reflectors (5b), wherein each pair of said parallel elongated conductive reflectors (5b) are separated by an elongated gap (6), longitudinal axes (A2) of said parallel reflectors (5b) and longitudinal axes (A3) of said gaps (6) extending perpendicular to said antenna array axis (A1),
said gaps (6) being filled with a dielectric solid or air.

2. The antenna arrangement (1) according to claim 1, wherein at least one of said antenna elements (4) is an end-fire antenna element (4) configured to generate millimeter-wave frequency radiation having a main beam direction (D0), a first polarization, and a second polarization, said first polarization extending perpendicular to said main beam direction (D0), said reflector surface (5) being configured to reflect millimeter-wave frequency radiation having said first polarization.

3. The antenna arrangement (1) according to claim 1 or 2, wherein said reflector surface (5) is configured to be arranged at a distance $\leq \lambda/2$ from said antenna element (4), λ being a wavelength of said millimeter-wave frequency radiation.

4. The antenna arrangement (1) according to claim 3, wherein said reflector surface (5) is configured to be arranged at a distance between $\lambda/4$ and $\lambda/10$ from said antenna element (4).

5. The antenna arrangement (1) according to any one of the previous claims, wherein said reflector surface (5) is arranged within a near-field region of said antenna element (4), said near-field region being a region located at a distance < $\frac{2D^2}{\lambda}$ from said antenna element (4), D being a maximum outer dimension of the antenna element.

6. The antenna arrangement (1) according to any one of the previous claims, wherein said nonconductive reflector element (5a) comprises ceramic or plastic material.

7. The antenna arrangement (1) according to any one of the previous claims, wherein said nonconductive reflector element (5a) has a thickness, in a direction perpendicular to a main plane of said reflector element (5a), which is $\leq \lambda/4$, λ being a wavelength of said millimeter-wave frequency radiation.

8. The antenna arrangement (1) according to claim 7, wherein said thickness is between $\lambda/8$ and $3\lambda/8$.

9. The antenna arrangement (1) according to any one of the previous claims, wherein said nonconductive reflector element (5a) has a thickness, in a direction perpendicular to a main plane of said reflector element (5a), which is an odd multiple of $\lambda/4$.

10. The antenna arrangement (1) according to any one of claims 1 to 5, wherein said conductive reflectors (5b) and said gaps (6), separating said pairs of parallel reflectors (5b), are formed in one conductive sheet material.

11. The antenna arrangement (1) according to any one of claims 1 to 5 or 10, wherein said reflector surface (5) has a length, in a direction perpendicular to said antenna array axis (A1), of between λ and λ/10, λ being a wavelength of said millimeter-wave frequency radiation.

12. The antenna arrangement (1) according to claim 11, wherein said conductive reflectors (5b) and said gaps (6) have lengths, along said longitudinal axes (A2, A3), within a length range of between λ and λ/10, λ being a wavelength of said millimeter-wave frequency radiation.

13. The antenna arrangement (1) according to any one of claims 2 to 5 or 10 to 12, wherein said gaps (6), separating said pairs of parallel reflectors (5b), allow millimeter-wave frequency radiation having said first polarization to propagate between adjacent pairs of parallel reflectors (5b).

14. The antenna arrangement (1) according to one of claims 2 to 13, wherein propagation of millimeter-wave frequency radiation having said second polarization is unaffected by said reflector surface (5).

15. An electronic apparatus (2) comprising a display panel (7), a frame (8), a substrate (9) enclosed at least by said display panel (7) and said frame (8), and the antenna arrangement (1) according to any one of claims 1 to 14,
wherein said antenna arrangement (1) is configured to emit millimeter-wave frequency radiation having a first polarization propagating towards said display panel (7) and to emit a second polarization propagating towards said frame (8),

said antenna arrangement (1) furthermore being configured to reflect at least part of said millimeter-wave frequency radiation having said first polarization.

16. The electronic apparatus (2) according to claim 15, further comprising at least one antenna (10) configured to generate radiation outside of a millimeter-wave frequency range, the reflector surface (5) of said antenna arrangement (1) being configured to be arranged within a volume of said electronic apparatus (2) comprising at least one signal feed probe (11) of said antenna (10), said reflector surface (5) being arranged at a distance from said signal feed probe(s) (11).

17. The electronic apparatus (2) according to claim 15 or 16, wherein said substrate (9) comprises a flexible printed circuit.

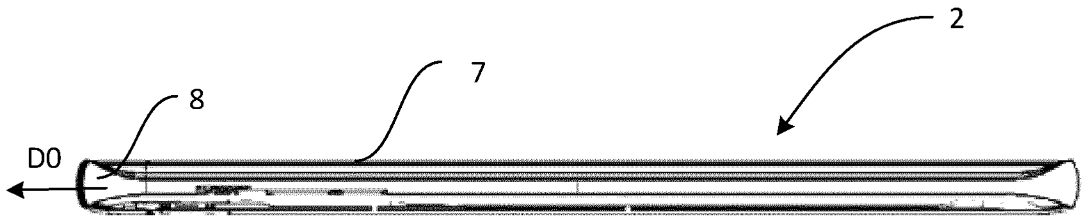

Fig. 1

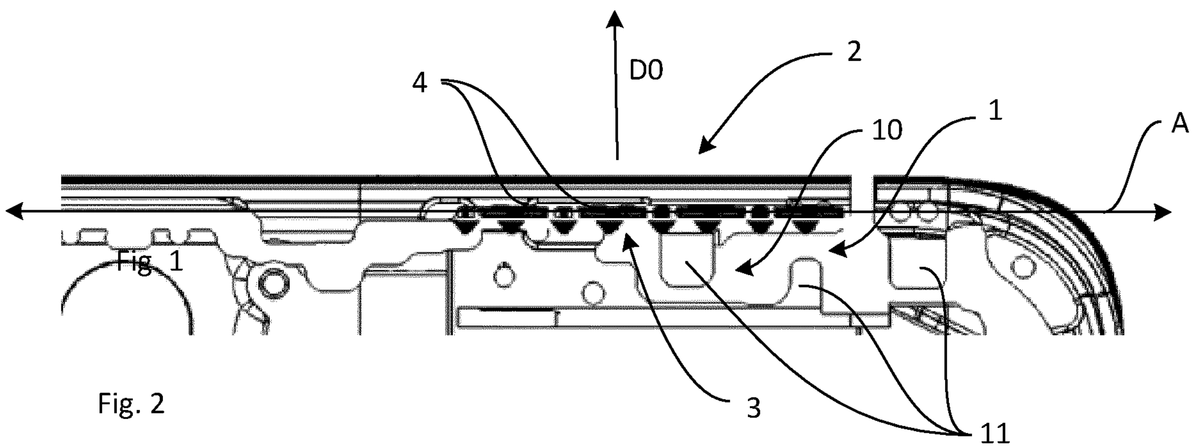

Fig. 2

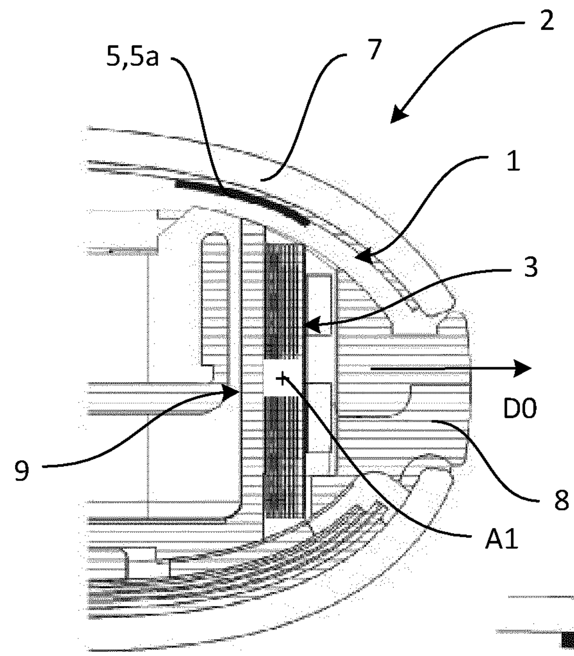

Fig. 3

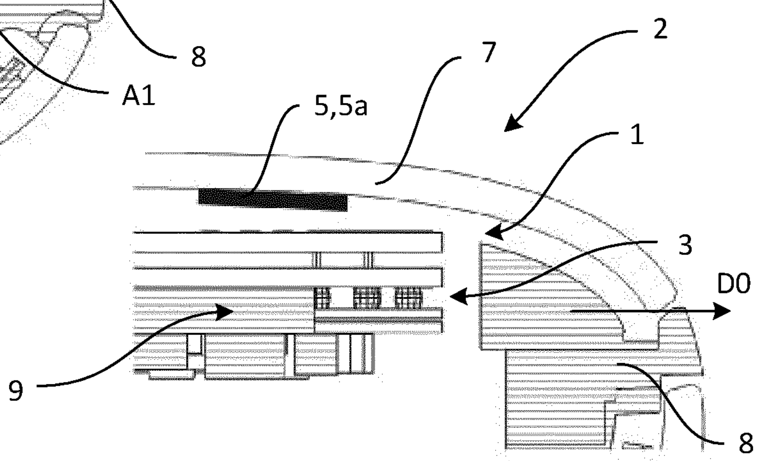

Fig. 4

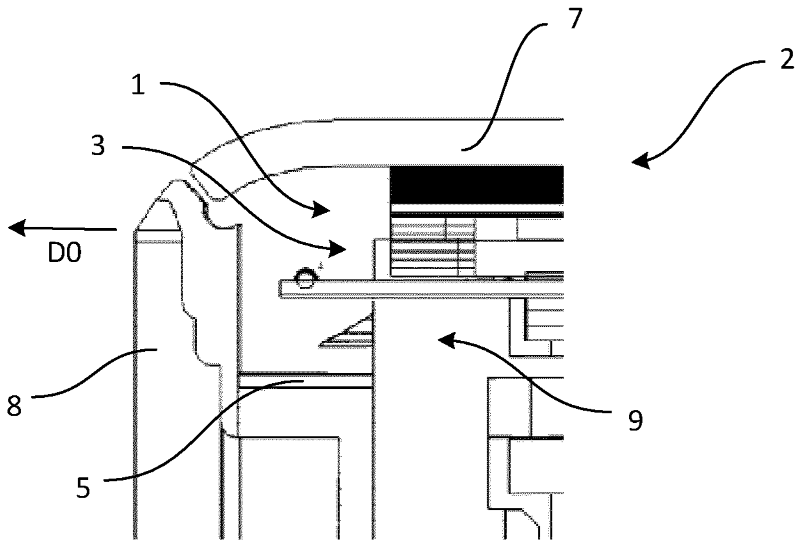

Fig. 5

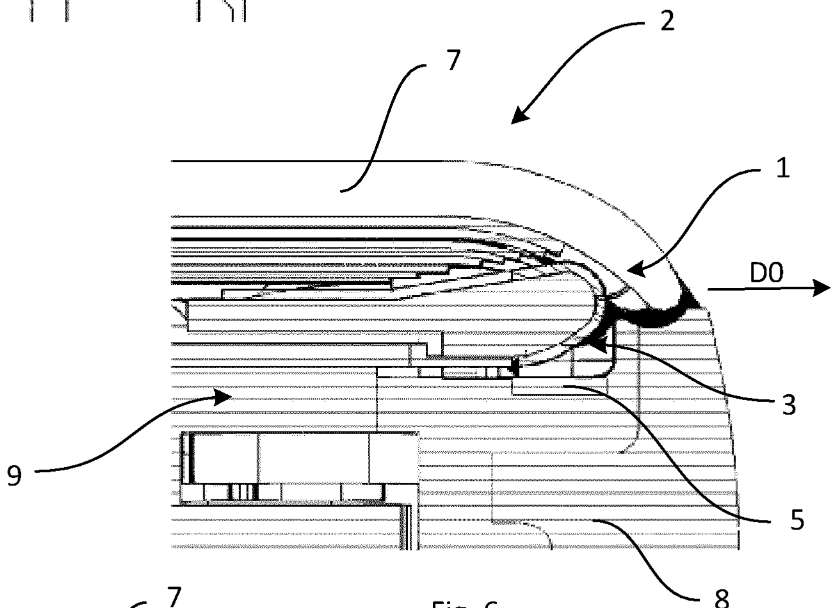

Fig. 6

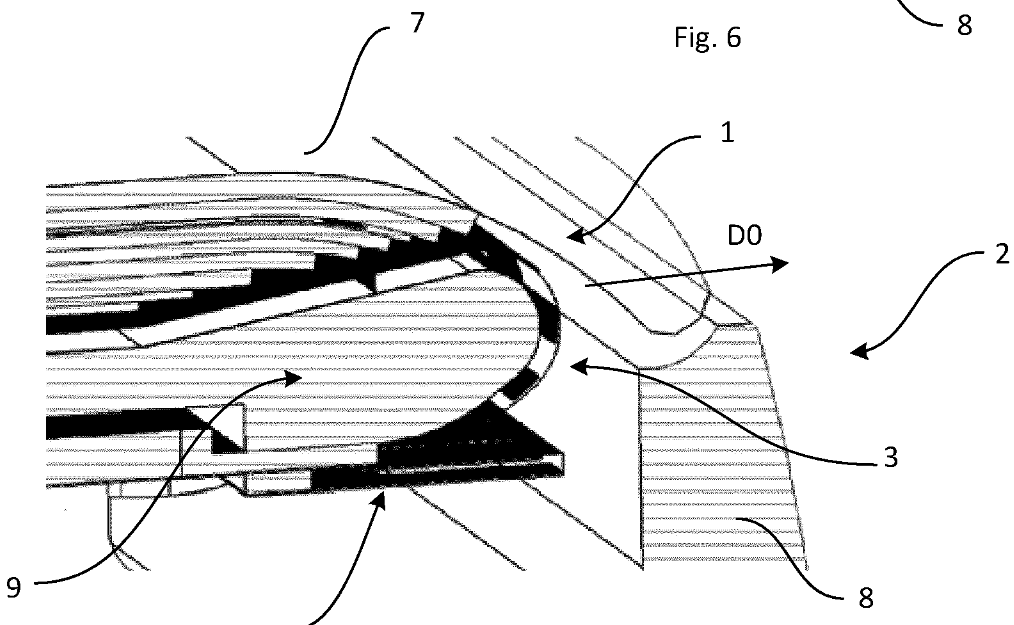

Fig. 7

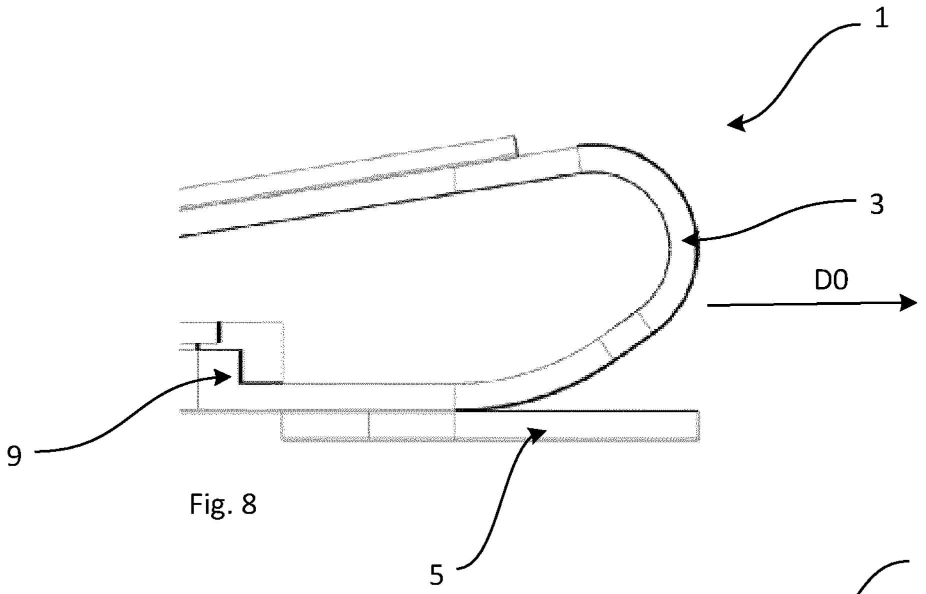

Fig. 8

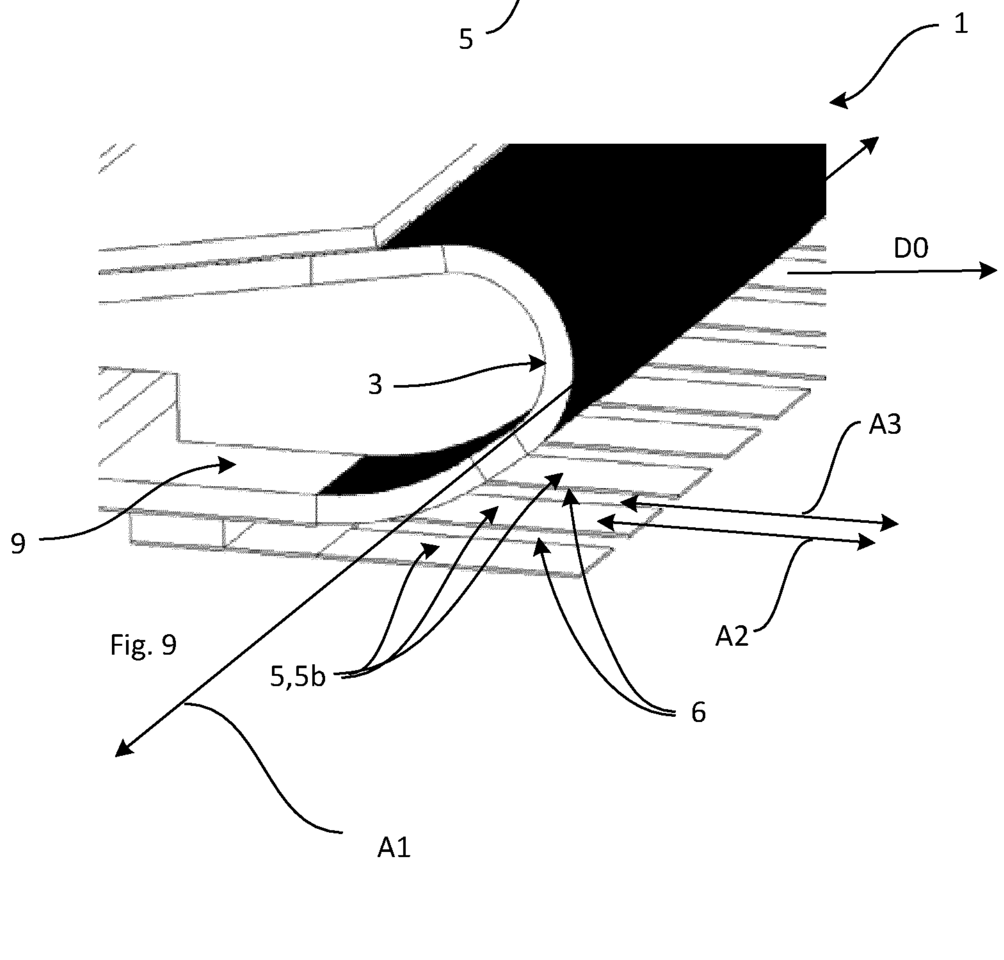

Fig. 9

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2021/064286

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01Q1/24 H01Q15/22 H01Q15/00
ADD.

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)
H01Q

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2021/089137 A1 (HUAWEI TECH CO LTD [CN]; KHRIPKOV ALEXANDER [SE]) 14 May 2021 (2021-05-14)	1,10-12
A	figure 5 page 12, line 16 - line 25 page 9, line 15 - line 21 -----	2,4,5, 13-17
X	US 2021/151868 A1 (CHI YU-JEN [TW] ET AL) 20 May 2021 (2021-05-20)	1,3,6,7
A	figures 1, 3 paragraphs [0007], [0042], [0044], [0068] -----	4,5,8,9

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 February 2022	14/02/2022

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Yvonnet, Yannick

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2021/064286

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2021089137 A1	14-05-2021	NONE	
US 2021151868 A1	20-05-2021	TW 202121734 A	01-06-2021
		US 2021151868 A1	20-05-2021