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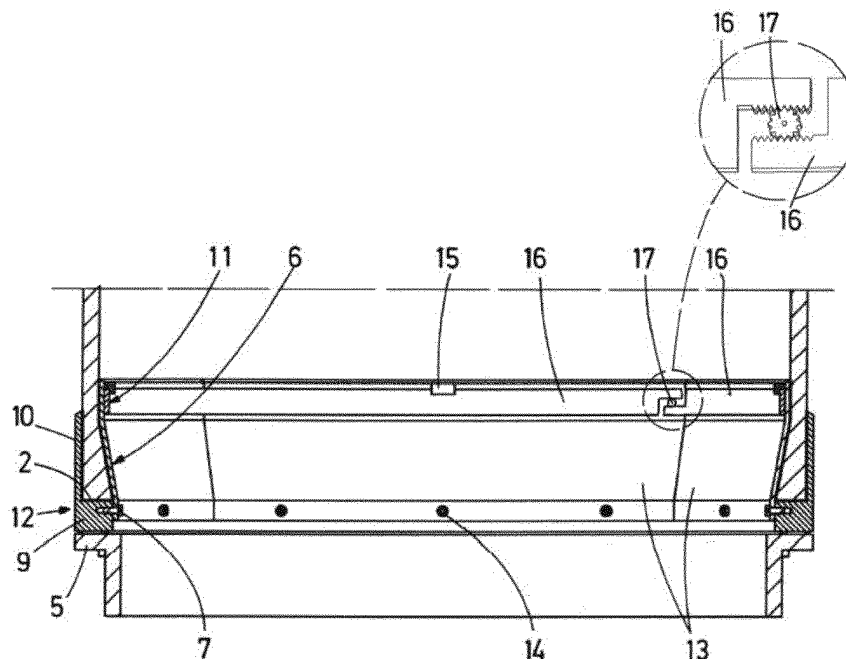
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### (54) RADOME WATERTIGHT CLOSURE MECHANISM

(57) The watertight closure mechanism clamps the radome around its edge with sufficient pressure to guarantee its watertightness and constitutes the receiving surface of the fixing means to the metal lower base plate to which the radome is attached, without the radome of composite material being machined. The mechanism is formed by an outer ring (12) and an inner ring (6) joined to the outer ring (12) that clasp the radome around its

edge (2), as well as a connecting base (9) situated against the edge (2), which can form part of the outer ring (12) or the inner ring (6) and constitutes the contact surface with the base plate (5), and by pressure and closing elements (11, 21) which ensure the snap-on closure of the inner ring (6) and the outer ring (12) against the radome (1).



**FIG.2**

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## Description

### OBJECT OF THE INVENTION

[0001] The present invention belongs to the field of radomes used as a protection surface for antennas.

[0002] It describes a watertight closure mechanism, preferably made of metal material, that clasps the radome around its lower edge with sufficient pressure to guarantee its watertightness, while constituting the receiving surface of the fixing means to the lower base plate to which the radome is attached, without the radome of composite material being machined, or subjected to any operation that could weaken it.

### BACKGROUND OF THE INVENTION

[0003] The radome is used to cover an antenna in order to protect it without affecting its electromagnetic properties, while providing good transparency to allow the passage of waves at the same time.

[0004] Radomes are made up of solid and light structures capable of withstanding the adverse weather conditions of the environment where they are located and are normally conceived in a mouldable composite material that makes it possible to create curved and/or spherical shapes.

[0005] In general, radomes are used to protect antennas installed on ground, sea or air equipment that can be fixed or mobile, such as, for example, submarines. For any application, and for the latter in particular, radomes must meet certain watertightness conditions in their connection to a lower base plate on which they are mounted, which prevent water from entering the radome.

[0006] In maritime applications, radomes must withstand pressures of 40 bar in the case of ships, or 60 bars in the case of submarines, such that the connections between the radome and the lower base plate must be conceived such that the closure that is established between the two elements is watertight at those pressures.

[0007] In addition, resistance to temperature changes and a proper shape of the connection between the radome and the base plate are crucial factors to determine the goodness of fit and therefore the durability of the watertight connection.

[0008] The lower base plate to which the radome is coupled is usually made of metal material while the radome is made of composite material, due to which a suitable watertight solution is required for a connection that is problematic in principle due to the use of different materials.

[0009] A known solution consists in introducing inserts into the lower edge of the radome and defining spaces following the inserts intended to house nuts to which fixing elements are screwed that pass through the lower base plate, ensuring the connection between the base plate and the radome. In order to establish a metal-metal contact in the connection, an L-shaped metal ring is in-

corporated between the radome and the base, with its horizontal side situated on the edge of the radome and its vertical side situated against the inner face of the radome.

[0010] Defining holes to house the inserts in the radome, and the openings intended to house the nuts, weaken the lower surface of the radome, which means that when the radome is subjected to pressure stresses or loads, it leads to deformations resulting in leaks in the watertightness between the ring and the radome, especially between the vertical surface of the ring and the radome.

[0011] Another known solution is to laminate the radome so that it incorporates a metal ring to which the lower base plate is affixed in its connection to the radome, a ring that has a pointed tooth that projects upwardly and is clasped by the laminate of the radome. In this case, the problem arises from the different levels of dilation that occur as a result of the use of different materials, which causes a deformation and delamination of this area of the radome leading to a deformation that ultimately allows water to enter.

### DESCRIPTION OF THE INVENTION

[0012] The radome watertight closure mechanism described in the present invention solves the problem described above by means of an anchoring solution around the radome, which is preferably made of metal, that allows the watertight connection to the lower base plate to which the radome is attached, without the need to machine the composite of the radome. It is, unlike other solutions that weaken the composite of the radome, a closure that simply clasps the radome around its edge with sufficient pressure to guarantee it remains watertight.

[0013] The radome watertight closure mechanism essentially comprises:

- an outer ring intended to remain at least against the outer face of the radome in the vicinity of the lower edge of the radome;
- an inner ring formed by one or more adjoining segments, intended to remain against the inner face of the radome in the vicinity of its lower edge, and joined to the outer ring, such that both the inner ring and the outer ring clasp the radome around its lower edge;
- optionally and preferably, connecting elements, such as screws, pins or hooks, that establish the connection between the inner ring and the outer ring;
- a connecting base intended to be placed against the edge of the radome, which may form part of the outer ring or the inner ring, constituting the contact surface with the base plate, preferably through O-rings, and which, if connecting elements are incorporated between the outer ring and the inner ring, constitutes the receiving surface to which said connecting ele-

ments are affixed;

- optionally, at least one watertight seal intended to be situated between the outer ring, the inner ring and the radome, and
- a pressure and closing element, such as a compressive hoop, for example, mounted on the inner ring, which ensures the snap-on closure of the inner ring and the outer ring against the radome.

**[0014]** Furthermore, in order to join the lower base plate to the connecting base of the closure mechanism, the desired fixing elements will be used, such as, for example, screws that pass through the base plate and thread to the connecting base, without passing through the latter so as not to penetrate the composite of the radome.

**[0015]** The composite of the radome thus remains intact, without drill holes that can result in unwanted deformations. The closure mechanism object of this invention simply clasps the radome by wrapping around its edge, and by means of the pressure exerted by the pressure and closing elements against the radome, optionally through the watertight seal, it guarantees a watertight closure.

**[0016]** The pressure and closing element selected will allow pressure to be exerted on the seal of the radome, which is higher than the external pressure exerted by the environment of the location of the radome, either under the sea, above the sea, in a static or dynamic situation, and/or at high altitudes.

**[0017]** The configuration of the outer ring and the inner ring may vary, as represented in the following drawings, and similarly the radome can show different shapes in the vicinity of its lower edge, which can be vertical on its inner face or, for example, have a sloping heel, contemplating different solutions for mounting the rings around the radome.

## DESCRIPTION OF THE DRAWINGS

**[0018]** To supplement the description that is being made and in order to aid a better understanding of the features of the invention according to a preferred practical exemplary embodiment thereof, a set of drawings has been attached as an integral part of said description, which represent the following by way of illustration and not limitation:

FIG. 1 shows a cross-sectional elevational view of the radome mounted on the base plate by means of the closure mechanism for a first embodiment thereof.

FIG. 2 shows an enlarged view of FIG. 1.

FIG. 3 shows a detailed view representing a radome with a straight inner wall, without a heel, and an embodiment of the closure mechanism similar to the first with a shape adapted to the heel of the radome.

FIG. 4 shows a detailed view similar to FIG. 1, where-

in the outer ring of the closure mechanism has an extension to which the fixing elements that join the lower base plate to the radome are affixed.

FIG. 5 shows a detailed view of a closure mechanism with a single inner ring, wherein the connection is a snap-on connection between the inner ring and the outer ring, and the radome.

FIG. 6 shows a detailed view of a solution similar to that of FIG. 5 wherein the inner ring is formed by several segments.

FIG. 7 shows a detailed view of the solution of the closure mechanism in FIGS. 1 and 2, wherein the inner ring is formed by a larger number of segments and the radome exhibits a sloping heel.

FIG. 8 shows a detailed view of the solution of the closure mechanism similar to that shown in FIG. 7, wherein the closure mechanism includes a pressure and closing element other than the compressive hoop consisting of a tension mechanism that makes the segments of the inner ring move.

FIG. 9 shows a detailed view of the solution of the closure mechanism similar to FIG. 6, but with a sloping heel.

FIG. 10 shows a detailed view of a solution of the closure mechanism, wherein the inner ring has two compressive hoops for a radome with a sloping heel.

FIG. 11 shows a detailed view of a solution wherein, unlike the previous solutions, the connecting base is part of the inner ring instead of the outer ring, and the lower base plate is joined to that connecting base by means of screws.

## PREFERRED EMBODIMENT OF THE INVENTION

**[0019]** In light of the figures, a preferred embodiment of the radome watertight closure device constituting the object of this invention is described below.

**[0020]** As shown in FIG. 1, the composite radome (1) has a lower edge (2), an inner face (3) and an outer face (4) that project upwardly from the edge (2), which is affixed to a lower base plate (5), normally made of metal material, by means of the closure mechanism object of this invention. This closure mechanism guarantees the watertightness of the radome and constitutes the contact and connection surface with the base plate (5), to which it will be attached through any fixing means.

**[0021]** As shown in detail in FIG. 2, which constitutes an enlarged view of FIG. 1, the closure mechanism essentially comprises an outer ring (12) which partially covers the radome on its outer face (4), as well as an inner ring (6) formed by several segments (13), which have a contact face with a shape similar to that of the inner face (3) of the radome (1) against which they rest, and are joined to the outer ring (12) by corresponding connecting elements (7), such as screws, so that the outer ring (12) and the inner ring (6) clasp the radome (1) between them.

**[0022]** The closure mechanism also incorporates a connecting base (9) which is intended to remain against

the edge (2) of the radome (1), and which in the case of FIGS. 1 to 10, forms part of the outer ring (12), while in the case of FIG. 11, it forms part of the inner ring (6). In the first case, an upper wing (10) extends from the connecting base (9) of the outer ring (12), which is intended to remain against the outer face (4) of the radome (1).

**[0023]** As shown in FIG. 2, the inner ring (6) is formed by several adjoining segments (13) that are joined to the connecting base (9) of the outer ring (12), using the connecting elements (7) that previously pass through openings (14) defined in said segments (13). The segments (13) press against the radome (1) by means of a pressure and closing element (11,21), in this case a compressive hoop (11), represented in FIG. 2 mounted on the inner ring (6), which ensures the snap-on closure of the segments (13) of the inner ring (6) against the inner face (3) of the radome (1) and integrally of the outer ring (12) against the outer face (4) of the radome (1).

**[0024]** As shown in FIG. 2, the inner ring (6) has tabs (15) in its segments (13) that limit the movement of the compressive hoop (11), except in the circumferential direction, and said compressive hoop (11) consists of metal plates (16) and a tensioning mechanism (17) of said metallic plates (16).

**[0025]** FIG. 3 shows another solution wherein the radome (1) does not have a sloping heel in its inner face (3), but rather the inner face (3) is straight, and that there is a watertight seal (18) between the inner ring (6) and the outer ring (12).

**[0026]** FIG. 4 shows that the connecting base (9) has an extension (19) that will constitute the surface to which fixing elements (20), such as those represented in FIG. 11, are affixed, which join the lower base plate (5) to the radome (1).

**[0027]** The connection solution shown in FIG. 5 dispenses with the connecting elements (7) and in this case the inner ring (6) is a single part that is manufactured such that its outer diameter at 0 °C is greater than the inner diameter of the radome (1). For placement, the inner ring (6) is taken to cryogenic temperatures, and after reaching the desired size, the inner ring (6) is introduced into the radome (1), where the outer ring (12) has previously been placed, and the whole system is allowed to reach room temperature. This achieves the required pressure between the rings (6, 12) and the radome (1). The outer ring (12) can be co-laminated in the manufacturing process of the radome (1) itself, or glued or even machined with its inner diameter, which is smaller than the outer diameter of the radome (1), and then introduced by heating the outer ring (12).

**[0028]** FIGS. 6 and 9 reproduce the same closure mechanism as FIG. 5, showing, unlike FIG. 5, that in FIG. 6 the inner ring (6) is formed by several segments (13), and that in FIG. 9, the radome incorporates a heel. Both FIGS. 6 and 9 show the connecting elements (7) as well.

**[0029]** FIG. 7 shows a solution similar to FIG. 2, representing a larger number of segments (13) and tabs (15).

**[0030]** FIG. 8 shows an alternative to the use of tension

hoops (11), wherein the pressure and closing element (11,21) now consists of a spacer mechanism (21) that joins and expands the segments (13) in the circumferential direction, exerting snap-on pressure on the radome (1). This second tensioning mechanism (21) may consist of mechanical wedges or cams, or hydraulic systems, for example.

**[0031]** FIG. 10 shows that the closure mechanism incorporates two pressure and closing elements (11, 21) consisting of corresponding compressive hoops (11) situated at different heights.

**[0032]** FIG. 11 shows an alternative embodiment, wherein, unlike what is represented in FIGS. 1 to 10, the connecting base (9) that is intended to remain against the edge (2) of the radome (1) forms part of the inner ring (6) rather than part of the outer ring (12).

## Claims

1. A radome watertight closure mechanism, wherein the radome (1) is made of composite material and has a lower edge (2), an inner face (3) and an outer face (4) that project upwardly from the edge (2), and is intended to be affixed to a lower base plate (5), normally made of metal material, by means of corresponding fixing elements (20), **characterised in that** the closure mechanism comprises:

- an outer ring (12) intended to remain at least against the outer face (4) of the radome in the vicinity of the lower edge (2) of the radome;
- an inner ring (6) formed by one or more adjoining segments (13), intended to remain against the inner face (3) of the radome in the vicinity of its lower edge (2), and joined to the outer ring (12), such that the inner ring (6) and the outer ring (12) clasp the radome around its lower edge (2) between them;
- a connecting base (9) intended to be placed against the edge (2) of the radome, which may form part of the outer ring (12) or the inner ring (6) and constitutes the contact surface with the base plate (5); and
- at least one pressure and closing element (11, 21) mounted on the inner ring (6), which ensures the snap-on closure of the inner ring (6) and the outer ring (12) against the radome (1).

2. The radome watertight closure mechanism of claim 1 further comprises connecting elements (7), which establish the connection between the inner ring (6) and the outer ring (12), such that the connecting base (9) constitutes the receiving surface to which said connecting elements (7) are affixed.

3. The radome watertight closure mechanism of claim 1 further comprises a watertight seal (18) that is sit-

uated between the outer ring (12), the inner ring (6) and the radome (1).

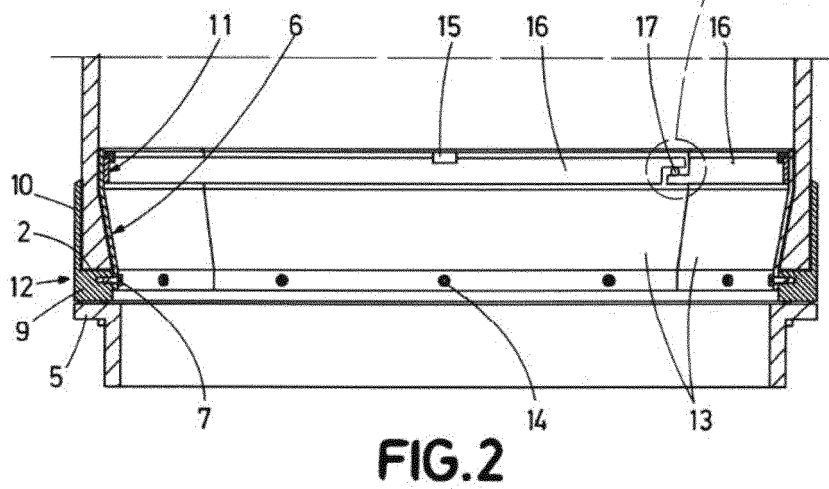
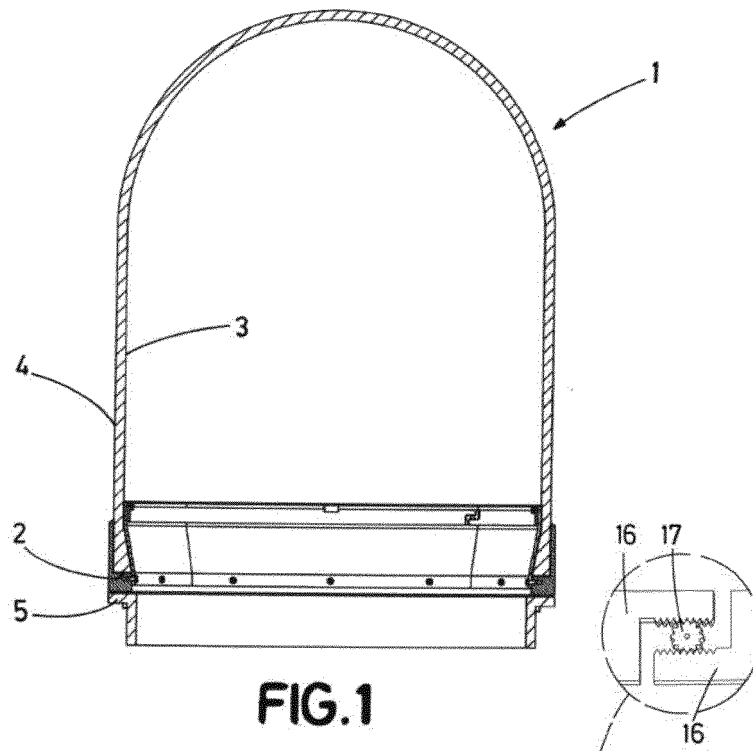
4. The radome watertight closure mechanism of claim 1, wherein the pressure and closing element (11, 21) comprises a compressive hoop (11). 5
5. The radome watertight closure mechanism of claim 4, wherein the compressive hoop (11) comprises metal plates (16) and a first tensioning mechanism (17) of said metal plates (16). 10
6. The radome watertight closure mechanism of claim 5, wherein the inner ring (6) comprises tabs (15) in its segments (13) that limit the movement of the compressive hoop (11), except in the circumferential direction. 15
7. The radome watertight closure mechanism of claim 1, wherein the pressure and closing element (11, 21) comprises a spacer mechanism (21) that joins and expands the segments (13) in the circumferential direction. 20
8. The radome watertight closure mechanism of claim 1, wherein the connecting base (9) has an extension (19) that will constitute the surface to which the fixing elements (20) joining the lower base plate (5) to the radome (1) are affixed. 25  
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9. The radome watertight closure mechanism of claim 1, wherein the outer ring (12) and/or the inner ring (6) and/or the connecting base (9) are made of metal material. 35

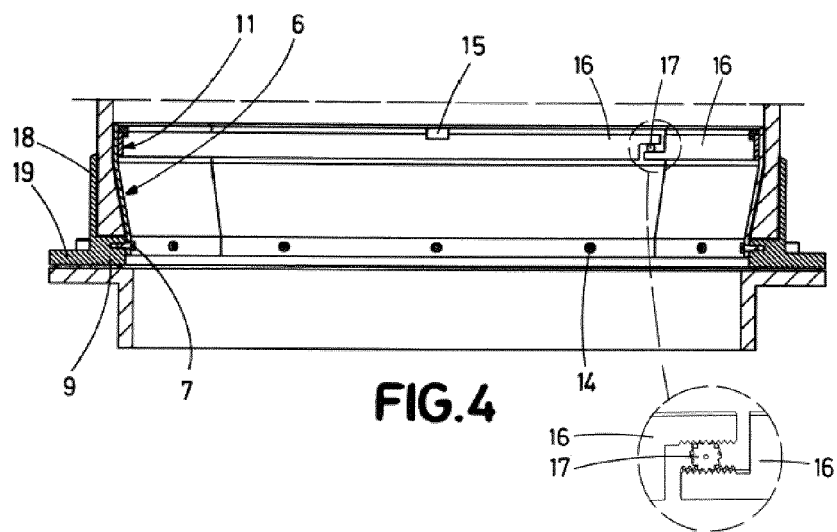
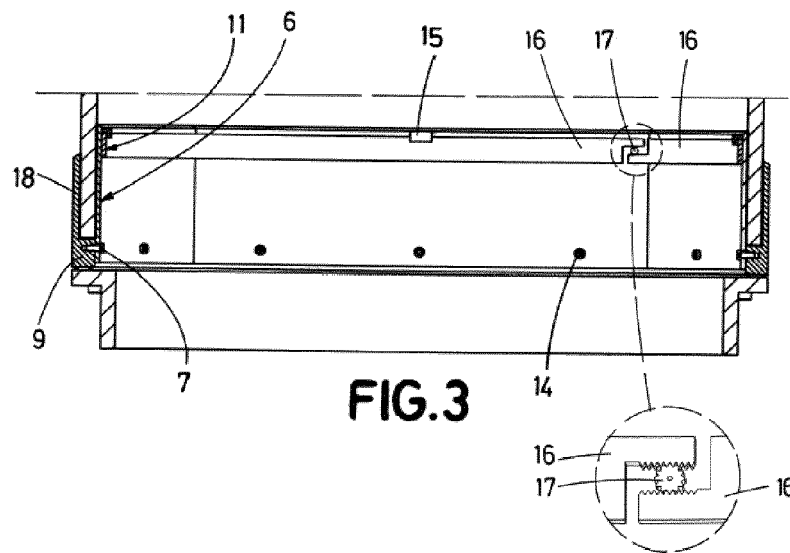
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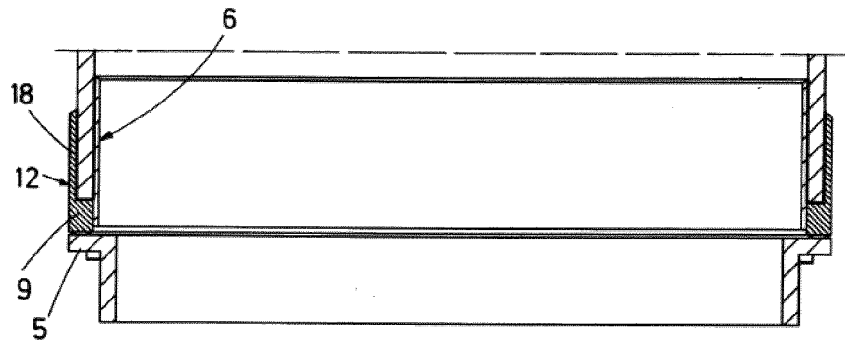
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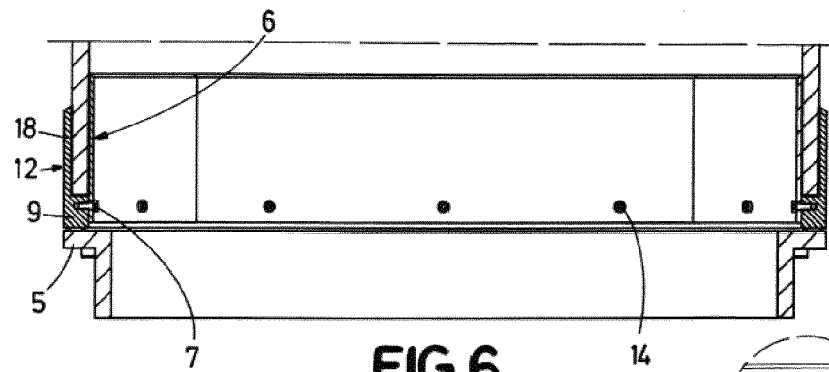
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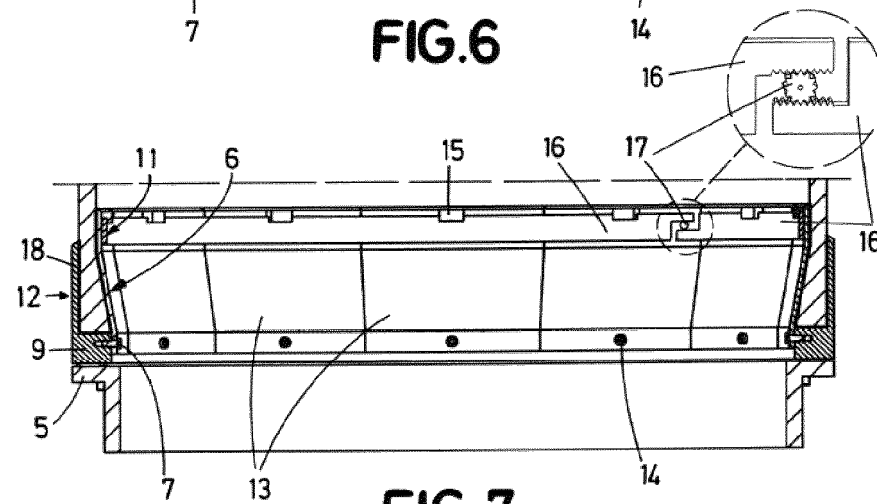




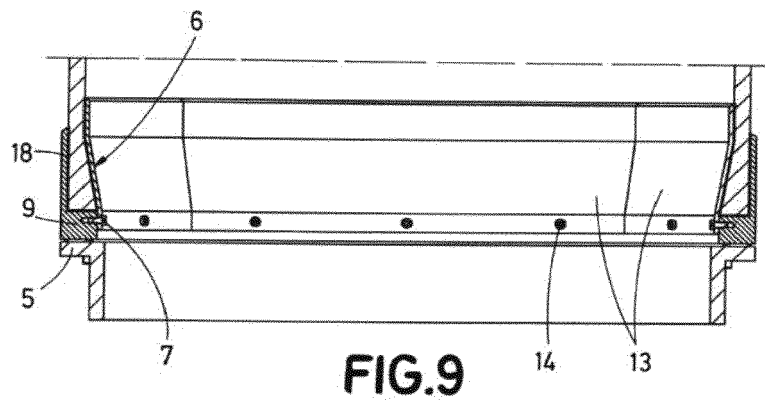
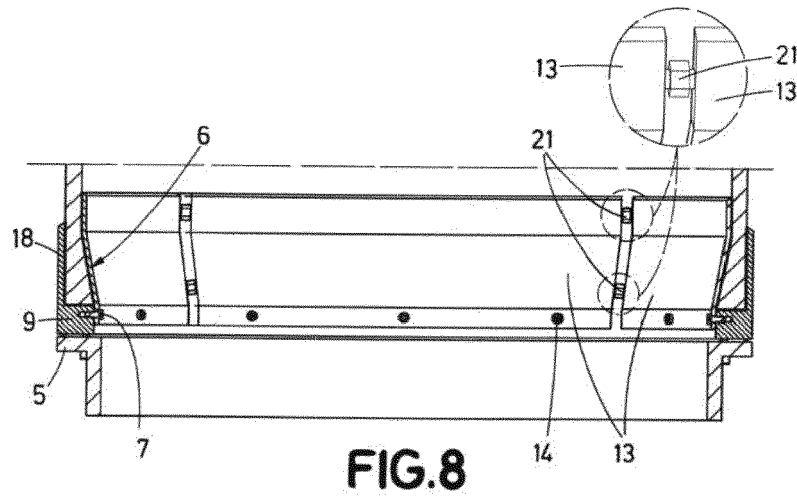
**FIG. 5**



**FIG. 6**



**FIG. 7**



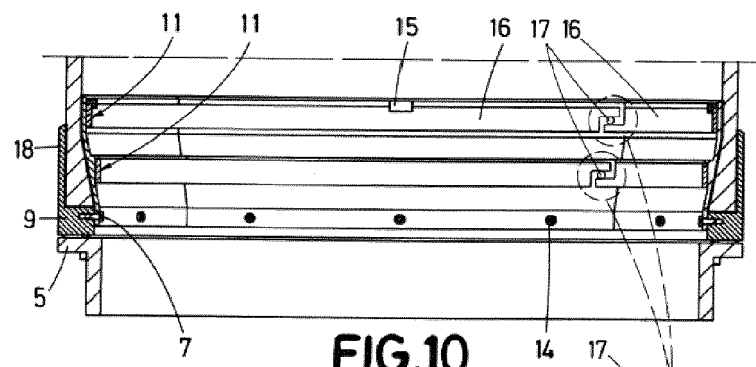


FIG.10

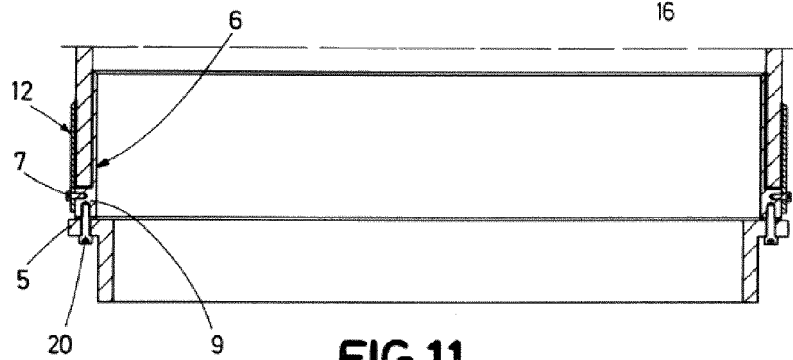
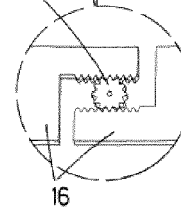


FIG.11



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| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                 |                                                 |                                         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|-----------------------------------------|
| Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Citation of document with indication, where appropriate, of relevant passages                                                                                                                   | Relevant to claim                               | CLASSIFICATION OF THE APPLICATION (IPC) |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | GB 1 588 872 A (SECR DEFENCE)<br>29 April 1981 (1981-04-29)<br>* figure 1 *                                                                                                                     | 1-4,9                                           | INV.<br>H01Q1/42                        |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | * page 1, line 13 - line 37 *<br>* page 1, line 67 - line 70 *<br>* page 2, line 90 - line 105 *<br>* page 3, line 98 - page 4, line 43 *                                                       | 5-8                                             |                                         |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | WO 94/01899 A1 (GORE & ASS [US])<br>20 January 1994 (1994-01-20)<br>* figure 2 *                                                                                                                | 1,2,4,8,9                                       |                                         |
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | * page 1, line 10 - line 15 *<br>* page 1, line 27 - page 2, line 5 *<br>* page 3, line 19 - line 29 *<br>* page 4, line 1 - line 5 *                                                           | 3,5-7                                           |                                         |
| X                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | US 2016/315376 A1 (MOTOMURA YUSUKE [JP] ET AL)<br>27 October 2016 (2016-10-27)<br>* figures 2, 4-7 *<br>* paragraphs [0010], [0020], [0022], [0025], [0027], [0029] - [0031], [0036] - [0046] * | 1                                               |                                         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                 |                                                 | TECHNICAL FIELDS SEARCHED (IPC)         |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                 |                                                 | H01Q                                    |
| The present search report has been drawn up for all claims                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                 |                                                 |                                         |
| Place of search<br>The Hague                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                 | Date of completion of the search<br>9 July 2020 | Examiner<br>Gehrmann, Elke              |
| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document<br>T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>& : member of the same patent family, corresponding document |                                                                                                                                                                                                 |                                                 |                                         |

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