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(54) **TRANSVERSE PROPULSION DEVICE OF A SHIP COMPRISING AN INCLINED GRID**

(57) A ship transverse propulsion device comprising a transverse maneuvering tunnel (25) passing through the hull (21), tunnel walls (27) and opening edges (26) delimiting a tunnel inlet opening (28) on the outer hull surface (210).

The transverse propulsion device comprises a grid (4) comprising a plurality of uprights (41) and a plurality

of crosspieces (42) incident on a grid surface (45).

The grid (4) comprises at least one crosspiece (42) extending between an inner crosspiece end (421) consecutive to the tunnel walls (27), and an outer crosspiece end (422) which is more proximal to the outer hull surface (210) with respect to the inner crosspiece end (421).

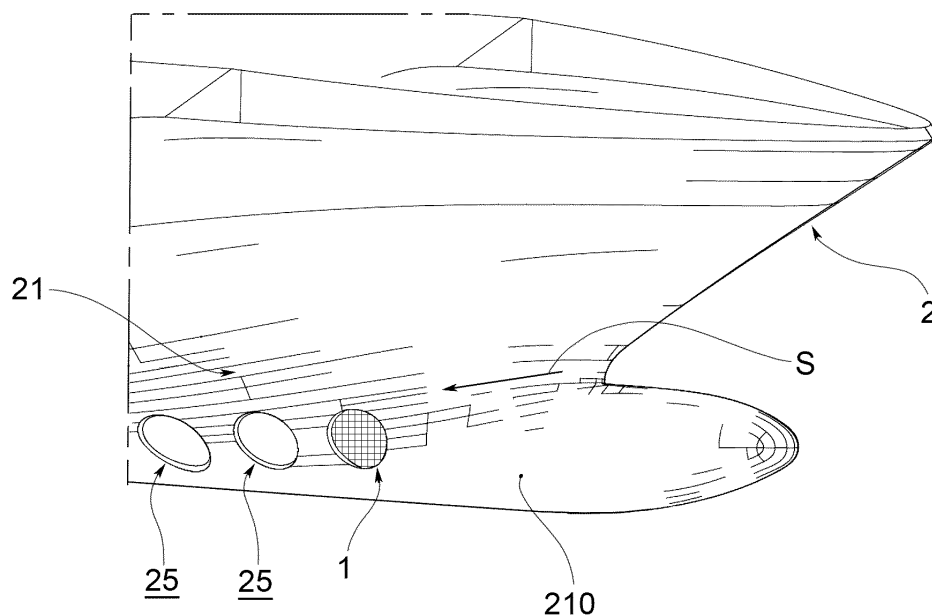


FIG.2

Description

[0001] The present invention relates to a transverse propulsion device of a ship.

[0002] Preferably, the present invention is aimed at large ships, such as container ships or cruise ships.

[0003] In the context of ship handling, it is known that, in order to carry out berthing and unberthing maneuvers in confined spaces and at low speeds, special transverse propulsion devices provided with maneuvering propellers with a rotation axis oriented transversely to the vertical longitudinal plane or diametrical plane of the vessel are indispensable.

[0004] In order to protect the transverse propulsion devices from possible shocks, it is known to affix gratings to the inlet opening of the maneuvering tunnel transverse to the hull of the ship, in which the maneuvering propellers are housed.

[0005] Additionally, in order to reduce turbulence phenomena during navigation, it is known to include special closing devices provided with movable doors, typically placed at the openings of the transverse maneuvering tunnels. The doors are movable between an open position, in which they allow a water flow inside the maneuvering tunnel, and a closed position, in which they completely close the tunnel inlet opening and substantially reconstruct the outer surface of the hull.

[0006] In particular, doors are known which are installed on a plurality of hinges connected to the mouth of the transverse maneuvering tunnel. Examples of these solutions are described in CN205819525, CN105329405, CN102381439, CN109094715, WO2019/220152 and GB782628. Further embodiment examples are described in International Applications WO2022079655A1, WO2022079651A1 and WO2022079652A1, on behalf of the Applicant. Manoeuvring transverse tunnel closing devices comprising a protective grid at the mouth of the transverse manoeuvring tunnel are known in the field. Examples of these solutions are described in EP2923942 A1, KR20140036409 A, US10988220 B2 and CN111516842 B.

[0007] Such transverse maneuvering tunnel closing devices have many critical aspects known to designers in the naval field.

[0008] The main problems include the design of the hydrodynamic shape of the doors, aimed at minimizing, during cruising, turbulence due to shape discontinuities between the doors and the outer surface of the hull, and at the same time aimed at minimizing bulk in the open position, i.e., during the operation of the transverse propulsion devices.

[0009] At the same time, the closing devices of the transverse maneuvering tunnels have high structural complexity and contribute to increasing the overall weight of the ship.

[0010] Additionally, the transverse maneuvering tunnel closing devices must be designed to minimize the potentially damaging effects of the slamming phenomena

of the ship's hull (generally the bow) abruptly plunging into water, e.g., due to the wave motion of the water. Especially at high speeds, such slamming phenomena generate high pressure gradients at the transverse maneuvering tunnels, and can cause damage to the ship's plating and connections, or impair the operation of the doors and the transverse propulsion device.

[0011] Such critical aspects and related problems push designers towards conflicting technical solutions, on the one hand towards the complete closure of the transverse maneuvering tunnel inlet opening to better reconstruct the hydrodynamic shape of the hull, and on the other hand towards the complete opening of the tunnel inlet openings to simplify and lighten the hull and eliminate any sudden pressure gradients between the inside and outside of the maneuvering tunnel.

[0012] The object of the present invention is to make a transverse propulsion device which makes it possible to overcome the drawbacks highlighted for the solutions of the prior art.

[0013] An object of the present invention is to provide a transverse propulsion device which achieves a compromise between generating low drag and turbulence during cruising, while at least partially preserving the mainly laminar water flows lapping the ship's hull externally near the transverse maneuvering tunnel inlet openings, and at the same time maximizes the overall weight reduction and reduction in structural complexity of the ship's hull.

[0014] Specifically, one of the objects of the present invention is to make a structurally simple transverse propulsion device having an extremely reduced number of components.

[0015] Yet another object of the present invention is to provide a transverse propulsion device with extremely limited weight.

[0016] An even further object is to provide a transverse propulsion device which can simplify installation and maintenance operations.

[0017] Still further, an object of the present invention is to eliminate or dampen the formation of high pressure gradients between the inside and outside of the transverse maneuvering tunnel, typically due to the slamming phenomena of the ship's hull.

[0018] These and other objects are achieved by means of a transverse propulsion device of a ship according to claim 1. The dependent claims show preferred embodiments involving a series of advantageous technical effects.

[0019] The features and advantages of the invention will be evident from the description below, from its preferred embodiment examples and the accompanying figures, in which:

- figure 1 shows a detail of a hull of a ship having a plurality of maneuvering tunnels and a closing device associated with each maneuvering tunnel, according to an embodiment of the invention;

- figure 2 illustrates a forward part of a ship, having a plurality of maneuvering tunnels made in the hull, and a closing device associated with a maneuvering tunnel, according to an embodiment of the invention;
- figure 3 depicts a cross-sectional view of the ship's hull at the transverse maneuvering tunnel, according to an embodiment of the invention;
- figure 4 depicts a frontal view of a pair of grids for two transverse maneuvering tunnels, aligned along the outer flow direction, according to an embodiment of the invention;
- figure 5 shows a grid of a transverse maneuvering tunnel, according to a first embodiment of the invention;
- figure 6 depicts a grid of a transverse maneuvering tunnel, according to a second embodiment of the invention;
- figure 7 illustrates a grid of a transverse maneuvering tunnel, according to a third embodiment of the invention;
- figure 8 depicts a perspective view of the grid of figure 5;
- figure 9 shows a sectional view of the ship's hull on a substantially vertical cross-sectional plane of the ship, near the tunnel inlet opening, according to the embodiment of figure 5;
- figure 10 depicts a sectional view of the ship's hull on a substantially horizontal cross-sectional plane, at the transverse maneuvering tunnel, according to the embodiment of figure 5;
- the figure illustrates a perspective view of the grid of figure 6;
- figure 12 depicts a perspective view of the grid of figure 7;
- figure 13 shows a grid of a transverse maneuvering tunnel, according to a fourth embodiment of the invention;
- figure 14 depicts a sectional view of the ship's hull on a substantially horizontal cross-sectional plane, at the transverse maneuvering tunnel, according to the embodiment of figure 13;
- figure 15 illustrates a perspective view of the grid of a transverse maneuvering tunnel, according to a fifth embodiment of the invention;
- figure 16 shows a grid of a transverse maneuvering tunnel, according to the embodiment of figure 15;
- figure 17 depicts a sectional view of the ship's hull on a substantially vertical cross-sectional plane of the ship, near the tunnel inlet opening, according to the embodiment of figure 15;
- figure 18 depicts a sectional view of the ship's hull on a substantially horizontal cross-sectional plane, at the transverse maneuvering tunnel, according to the embodiment of figure 15;
- figure 19 shows a grid of a transverse maneuvering tunnel, according to the sixth embodiment of the invention;
- figure 20 depicts a sectional view of the ship's hull

on a substantially horizontal cross-sectional plane, at the transverse maneuvering tunnel, according to the embodiment of figure 19;

- figure 21 depicts a sectional view of the ship's hull on a substantially horizontal cross-sectional plane, at the transverse maneuvering tunnel, according to a first embodiment the opening edges, with the opening edges joined;
- figure 22 depicts a sectional view of the ship's hull on a substantially horizontal sectional plane, at the transverse maneuvering tunnel, according to a second embodiment of the opening edges, with angled opening edges;
- figure 23 depicts a sectional view of the ship's hull on a substantially horizontal sectional plane, at the transverse maneuvering tunnel, according to a third embodiment of the opening edges, with the opening edges comprising a countersink.

[0020] With reference to the attached figures, the reference number 1 indicates a transverse propulsion device as a whole. The reference number 2 indicates a ship as a whole.

[0021] The ship 2 comprises a hull 21, which comprises an outer hull surface 210. During cruising, an external water flow 200 flows locally along the outer hull surface 210, along a flow direction S.

[0022] In an embodiment, the ship 2 comprises the transverse propulsion device.

[0023] Generally, the ship 2 comprises a bulbous bow 29 projecting in front, configured to direct the external water flow 200 along the outer hull surface 210, in particular along the flow direction S. The flow direction S is typically inclined with respect to a horizontal bottom plane extending mainly along the keel of the ship by a flow angle comprised between 5 degrees and 60 degrees.

[0024] Under conditions of the ship's forward motion and navigation at cruising speed, the external water flow 200 flows along the outer hull surface 210 at high speeds.

[0025] Cruising speed is intended as ship navigation speeds comprised between 10 knots and 25 knots, preferably equal to around 18 knots.

[0026] High external water flow speeds are defined as speeds close to or greater than 4 meters per second, preferably greater than 5 meters per second, e.g., comprised between 7 and 10 meters per second. Conversely, low external water flow speeds are intended as speeds close to or below 2.5 meters per second, e.g., about equal to 1 meter per second.

[0027] The transverse propulsion device comprises a transverse maneuvering tunnel 25 extending transversely in the hull of the ship, preferably open on both longitudinal sides of the ship.

[0028] In an embodiment, the transverse propulsion device comprises at least one maneuvering propeller housed in the transverse maneuvering tunnel 25 and configured to move water through the tunnel inlet opening 28, from the inside to the outside of the transverse

maneuvering tunnel 25, in an operating transverse propulsion device configuration.

[0029] In an inactive configuration of the transverse propulsion device, the maneuvering propeller is stationary.

[0030] In a different embodiment, the transverse propulsion device lacks a maneuvering propeller. In an embodiment, the transverse maneuvering tunnel is of the anti-suction type, e.g., with a diameter equal to approximately 1.5 meters, configured to fluidically connect the two longitudinal sides of the ship in order to dampen or eliminate opposite water flows generated by the maneuvering propellers of other transverse maneuvering tunnels.

[0031] The transverse maneuvering tunnel 25 comprises tunnel walls 27 which peripherally delimit the transverse maneuvering tunnel 25 inside the hull 21.

[0032] The transverse maneuvering tunnel 25 comprises a tunnel axis X oriented incidentally to the outer hull surface 210, e.g., along which the tunnel walls 27 mainly extend.

[0033] The transverse maneuvering tunnel 25 comprises opening edges 26 extending at least partially about the tunnel axis X and delimiting a tunnel inlet opening 28, open on the outer hull surface 210.

[0034] Specifically, the tunnel inlet opening 28 is placed on the projection of the outer hull surface 210 between the opening edges 26.

[0035] In an embodiment, the opening edges 26 are connected to the tunnel walls 27 with a connecting radius comprised between 100 and 500 millimeters, preferably comprised between 200 and 400 millimeters.

[0036] In an embodiment, the opening edges comprise a markedly flared aft section, located downstream of the transverse maneuvering tunnel, along the flow direction, having the purpose of facilitating the external water flow.

[0037] Preferably, the transverse maneuvering tunnel 25 further comprises second opening edges delimiting a tunnel exit opening opposite the tunnel inlet opening 28, for example opposite along the tunnel axis X.

[0038] Along the flow direction S, the opening edges 26 are divided into a first edge portion 261 and a second edge portion 262 complementary to the first edge portion 261, both having extension around the tunnel axis X, e.g., a substantially circular or oval or elliptical extension.

[0039] Along the flow direction S, the first edge portion 261 is destined to be lapped by the external water flow 200 first.

[0040] In other words, along the flow direction S, the external water flow 200 initially encounters the first edge portion 261 and subsequently the second edge portion 262.

[0041] In still other words, the first edge portion 261 substantially, at least partially, towards the bow of the ship, extending around the tunnel axis X according to the flow direction S.

[0042] In still other words, the opening edges 26 consist of the first edge portion 261 and the second edge

portion 262.

[0043] Similarly, the tunnel inlet opening 28 is divided into a first half area 281 partially delimited by the first edge portion 261, and a second half area 282 complementary to the first half area 281 and partially delimited by the second edge portion 262.

[0044] In other words, along the flow direction S, the external water flow 200 encounters the first half area 281 and then the second half area 282.

[0045] In still other words, the tunnel inlet opening 28 consists of the first half area 281 and the second half area 282.

[0046] The opening edges 26 extend along the tunnel axis X between an inner edge section 265 connected to the tunnel walls 27 and an outer edge section 267 connected to the outer hull surface 210.

[0047] In an embodiment, the opening edges 26 comprise a central edge portion 266 comprised along the tunnel axis X between the inner edge section 265 and the outer edge section 267.

[0048] In an embodiment, the opening edges 26 substantially have the shape of a corner, e.g., substantially a right angle (figure 22).

[0049] In an embodiment, the opening edges 26 are flared, preferably they comprise a flared section (figure 23).

[0050] In an embodiment, the opening edges 26 extend between a first edge section 273 flush with the outer hull surface 210, and a second edge section 270 inside the transverse maneuvering tunnel 25 and spaced along the tunnel axis X by a height comprised between 400 and 600 millimeters from the first edge section 273.

[0051] The transverse propulsion device comprises a grid 4 associated with the transverse maneuvering tunnel 25.

[0052] In an embodiment, the grid 4 is fixed to the opening edges 26.

[0053] In an embodiment, the grid 4 is fixed to the opening edges 26 in a removable manner, e.g., by means of bolted screws.

[0054] In an embodiment, the grid 4 extends with respect to the entire tunnel inlet opening 28.

[0055] In an embodiment, the grid 4 engages the first edge portion 261 and the second edge portion 262.

[0056] The grid 4 comprises a plurality of uprights 41 and a plurality of crosspieces 42 oriented incidentally to the uprights 41.

[0057] The intersection of the crosspieces 42 and the uprights 31 makes the grid 4 as a whole.

[0058] In an embodiment, at least some or all of the uprights 41 are oriented substantially orthogonal to the flow direction S.

[0059] In an embodiment, the grid 4 has a thickness, i.e., dimension of the uprights 41 and the crosspieces 42 along the tunnel axis X, greater than 70 millimeters. Preferably, the thickness of the grid 4 is comprised between 80 and 130 millimeters.

[0060] In an embodiment, the grid 4 cooperates with

the outer hull surface 210 to create as a whole a hydrodynamically-shaped surface along which the external water flow 200 flows.

[0061] In particular, the grid 4 cooperates with the outer hull surface 210 in the second half area 282 of the inlet opening 28.

[0062] In an embodiment, the grid 4 is positioned so that the grid surface 45 is substantially tangent to the outer hull surface 210 near or at the outer crosspiece end 422.

[0063] In an embodiment, the grid 4 is positioned so that the grid surface 45 is substantially tangent to the outer hull surface 210 at or near the second edge portion 262.

[0064] In an embodiment, the grid 4 extends on a curved grid surface 45.

[0065] In an embodiment, the grid 4 extends on a curved grid surface 45 which is convex with respect to the transverse maneuvering tunnel 25.

[0066] In an embodiment, all or only some uprights 41 and all or only some crosspieces 42 intersect and delimit a plurality of functional through windows 40 therebetween.

[0067] In an embodiment, for all or only some functional through windows 40, the upright distance D along the flow direction S between two consecutive uprights 41 delimiting a functional through window 40 is comprised between 150 and 250 millimeters.

[0068] In an embodiment, the upright distance D is comprised between 180 and 220 millimeters.

[0069] In an embodiment, for all or only some functional through windows 40, the distance between two crosspieces 42 delimiting a functional through window 40 is comprised between 300 and 500 millimeters, e.g., equal to 400 millimeters.

[0070] In an embodiment, all or only some of the functional through windows 40 have a main dimension along a direction incident upon or substantially transverse to the flow direction S.

[0071] In an embodiment, all or only some of the functional through windows 40 have a substantially rectangular shape, with the longer side oriented in a direction substantially transverse to the flow direction S.

[0072] In an embodiment, all or only some of the functional through windows 40 are essentially rectangular in shape, with the longer side of the rectangle being equal to approximately twice the shorter side of the rectangle.

[0073] In an embodiment, with the transverse maneuvering tunnel 25 at least partially filled with water and external water flow 200 flowing along the flow direction S at high speeds, preferably speeds greater than 4 meters per second, the transverse propulsion device is configured so as to keep the water inside the transverse maneuvering tunnel 25 at low speeds along the tunnel axis X, preferably speeds less than 2.5 meters per second.

[0074] In an embodiment, with external water flow 200 flowing along the flow direction S at high speeds, prefer-

ably speeds greater than 4 meters per second, the functional through windows 40 are configured to cooperate with each other and create a low-friction hydrodynamic surface which favours the external water flow 200 along the flow direction S.

[0075] In an embodiment, with external water flow 200 flowing along the flow direction S at high speeds, preferably speeds greater than 4 meters per second, the functional through windows 40 are configured to cooperate with each other and limit or prevent the external water flow 200 crossing the functional through windows 40, towards the inside of the transverse maneuvering tunnel 25.

[0076] In an embodiment, with external water flow 200 flowing along the flow direction S at high speeds, preferably speeds greater than 4 meters per second, the functional through windows 40 are configured to retain water at low speeds, preferably speeds less than 2.5 meters per second, at said functional through windows 40 and/or inside the transverse maneuvering tunnel 25 near said functional through windows 40.

[0077] In an embodiment, the tunnel inlet opening 28 can be approximated to an imaginary inlet circumference extending around the tunnel axis X on the inlet plane P, which delimits the inlet area A.

[0078] In an embodiment, each functional through window 40 has a functional area A_f on the grid surface 45.

[0079] In an embodiment, the functional ratio A_f/A between the functional area A_f and the inlet area A is comprised between 0.05% and 3%.

[0080] Preferably, the functional ratio A_f/A is comprised between 1% and 2.5%, e.g., it is equal to about 1.7%.

[0081] In an embodiment, the uprights 41 have a reduced size along the flow direction S. In other words, with respect to the flow direction S, the uprights are thin.

[0082] In an embodiment, the grid 4 comprises a grid surface 45, along which the uprights 41 and the crosspieces 42 are arranged.

[0083] The grid surface 45 is incident to the tunnel axis X.

[0084] The grid surface 45 is incident to the outer hull surface 210.

[0085] The grid surface 45 is an imaginary surface which is at least partially curved in space, identified by the position of the transverse maneuvering tunnel along the hull and along the flow direction S.

[0086] In an embodiment, the grid surface 45 is substantially a grid plane 45.

[0087] In an embodiment, the grid surface 45 is inclined with respect to the outer hull surface 210, forming a grid angle α comprised between 5 and 20 degrees, preferably comprised between 7 and 12 degrees.

[0088] In an embodiment, the grid angle α is convex with respect to the flow direction S, i.e., it faces the flow direction S.

[0089] In an embodiment, the grid surface 45 is inclined with respect to the tunnel axis X by an internal angle δ

comprised between 70 and 85 degrees, preferably between 78 and 83.

[0090] Preferably, the internal angle δ is complementary to the grid angle α .

[0091] Preferably, the tunnel walls 27 comprise a plurality of fixing ledges 275 protruding into the transverse maneuvering tunnel 25, for example protruding from the tunnel walls or opening edges, configured to mechanically engage at least one upright 41 and/or crosspiece 42, for example by bolted screws or by means of a shape coupling or force coupling.

[0092] In an embodiment, on the grid plane 45 and along the flow direction S, the grid 4 comprises at least one upright 41 mechanically connected to the inner edge section 265, at least one upright 41 mechanically connected to the central edge portion 266 and at least one upright 41 mechanically connected to the outer edge section 267.

[0093] In an embodiment, the uprights 41 extend with respect to the tunnel inlet opening 28 between a first upright end 411 and a second upright end 412.

[0094] The grid 4 comprises a crosspiece 42 extending on the grid surface 45, for example a grid plane 45, between an inner crosspiece end 421 and an opposite outer crosspiece end 422.

[0095] Preferably, the inner crosspiece end 421 is consecutive to the tunnel walls 27.

[0096] The inner crosspiece end 421 is mechanically connected to the inner edge section 265 or to the tunnel walls 27 near the inner edge section 265.

[0097] The outer crosspiece end 422 is mechanically connected to the outer edge section 267 or to a portion of the opening edges 26 between the inner edge section 265 and the outer edge section 267.

[0098] In an embodiment, the inner crosspiece end 421 is mechanically connected to the inner edge section 265.

[0099] In an embodiment, the outer crosspiece end 422 is mechanically connected to the outer edge section 267.

[0100] In an embodiment, the inner crosspiece end 421 is mechanically connected to the first edge portion 261 of the opening edges.

[0101] In an embodiment, the outer crosspiece end 422 is mechanically connected to the second edge portion 262 of the opening edges.

[0102] In an embodiment, e.g., the embodiment of figure 8, all the uprights 41 are positioned substantially orthogonal to the flow direction S.

[0103] The grid 4 comprises at least one crosspiece 42 extending on the grid surface 45, for example a grid plane 45, between an inner crosspiece end 421 mechanically connected to the inner edge section 265, and an outer crosspiece end 422 mechanically connected to the outer edge section 267.

[0104] In an embodiment, the grid 4 is positioned so that the outer crosspiece end 422 is in a position proximal to the outer hull surface 210 and the inner crosspiece end 421 is in a position distal to the outer hull surface 210.

[0105] In an embodiment, the grid 4 is positioned so that the outer crosspiece end 422 is in a more proximal position to the outer hull surface 210 with respect to the position of the inner crosspiece end 421.

[0106] In an embodiment, in the first half area 281 and along the tunnel axis X, the grid 4 is lowered with respect to the outer hull surface 210.

[0107] In an embodiment, at least one upright 41 is substantially in the shape of a polyline or broken straight line.

[0108] Preferably said at least one upright 41 comprises at least two upright segments 417, 419 mainly extending over two mutually distinct, incident imaginary straight lines R1, R2 mainly extending over the grid surface 45.

[0109] In an embodiment, said at least one upright 41 comprises at least one upright segment 417, 419 inclined by an upright angle β_1 , β_2 which is convex with respect to the flow direction S.

[0110] In an embodiment, said upright angle β_1 , β_2 is less than 90° .

[0111] In an embodiment, said upright angle β_1 , β_2 is comprised between 15 and 60 degrees, e.g., it is equal to about 45 degrees.

[0112] In an embodiment, said at least one upright 41 comprises at least one upright segment 418 substantially orthogonally with respect to the flow direction S on the grid surface 45.

[0113] In an embodiment, all of the uprights 41 are substantially in the shape of a polyline or broken straight lines, in which each upright 41 comprises a central upright segment 418 substantially orthogonal to the flow direction S on the grid surface 45, and two inclined upright segments 417, 419, which are consecutive and arranged at the ends of the central upright segment 418.

[0114] In an embodiment, at least one upright 41 has a substantially curved shape.

[0115] In an embodiment, at least one upright 41 has a substantially circumferential arc shape.

[0116] In an embodiment, said circumferential arc is convex with respect to the flow direction S.

[0117] In an embodiment, as for example shown by way of example in figure 14, the grid 4 is housed in the transverse maneuvering tunnel 25 and comprises at least one crosspiece, preferably all the crosspieces, having inner crosspiece ends 421 and outer crosspiece ends 422 mechanically connected to the tunnel walls 27, near the inner edge section 265 of the opening edges 26.

[0118] In an embodiment, as for example shown in figures 16, 17 and 18, the grid 4 comprises at least one upright, preferably all the uprights, having the first upright end 411 mechanically connected to the tunnel walls 27, preferably near the inner edge section 265 of the opening edges 26.

[0119] In particular, the first upright end 411 is the lower end of said at least one upright 41.

[0120] In addition, at least one upright, preferably all the uprights, have second upright end 412 mechanically connected to the tunnel walls 27 in a distal position of

the inner edge section 265.

[0121] In particular, the second upright end 412 is the upper end of said at least one upright 41.

[0122] In an embodiment, as for example shown in figures 16, 17 and 18, the grid 4 surface 45 is incident to the tunnel walls 27 and transverse to the tunnel axis X.

[0123] In an embodiment, the transverse maneuvering tunnel 25 comprises an inlet plane P incident to the tunnel axis X, and the tunnel inlet opening 28 has an inlet area A on the inlet plane P.

[0124] In an embodiment, the inlet plane P is transverse to the tunnel axis X.

[0125] In an embodiment, the inlet plane P is essentially passing through the opening edges 26.

[0126] In an embodiment, the first edge portion 261 corresponds to a circumferential arc of the imaginary inlet circle subtended by an angle less than 180 degrees, preferably less than 150 degrees, even more preferably less than 140 degrees.

[0127] In an embodiment, the first edge portion 261 corresponds to a circumferential arc of the imaginary inlet circle subtended by an angle comprised between 100 and 140 degrees, preferably comprised between 120 and 130 degrees.

[0128] In an embodiment, the flow direction S is essentially secant to the angle subtending the circumferential arc corresponding to the first edge portion 261.

[0129] In an embodiment, the ship 2 has an overall length greater than 200 meters, e.g., equal to 250 meters.

[0130] In an embodiment, the transverse maneuvering tunnel 25 has an internal diameter between the tunnel walls 27 comprised between 2.0 meters and 2.8 meters, preferably comprised between 2.1 and 2.5 meters, e.g., 2.2 meters.

[0131] Innovatively, the transverse propulsion device which is the subject of the present invention fulfils its intended purpose and overcomes the typical problems of the prior art by simplifying the hull structure, reducing the weight and facilitating the design, installation and maintenance operations.

[0132] Advantageously, the transverse propulsion device minimizes the potentially damaging effects of hull slamming, protecting the transverse maneuvering tunnel.

[0133] Advantageously, the propulsion device achieves a high compromise between structural simplicity and minimization of unwanted turbulence phenomena along the outer hull surface. Advantageously, the transverse propulsion device generates low turbulence at high cruising speeds, preferably at cruising speeds equal to or greater than 9 or 10 knots, at which turbulence resistance significantly impacts the efficiency of the ship.

[0134] Advantageously, the external water flow flows along the tunnel inlet opening in an essentially constant manner along the flow direction.

[0135] Advantageously, the grid is denser, i.e., it has substantially doubled or tripled the number of uprights, with respect to the grids typically used in the transverse

propulsion devices of the prior art, reducing the generation of turbulence.

[0136] Advantageously, the grid has a dimension along the tunnel axis which is thicker with respect to the grids typically used in the transverse propulsion devices of the prior art. This contributes to preventing or limiting the crossing of the functional through windows.

[0137] Advantageously, the grid allows the passage of water through the tunnel inlet opening, with an operating transverse propulsion device.

[0138] Advantageously, the grid achieves a compromise between minimizing the throttling effect of the tunnel inlet opening and maximizing the effect of conveying the external water flow at high speeds along the flow direction.

[0139] Advantageously, the grid allows for sudden pressure gradients between the inside and outside of the transverse maneuvering tunnel due to the hull slamming with water.

[0140] Advantageously, the uprights generate a reduced friction against the external water flow along the flow direction.

[0141] Advantageously, at the grid, the external water flow mainly encounters the functional through windows, as the uprights have a reduced surface area facing the external water flow, thus the external water flow slides with a low friction coefficient over the water present in the functional through windows.

[0142] Advantageously, with external water flow at high speeds, the functional through windows achieve the closing function of the tunnel inlet opening.

[0143] Advantageously, the grid exploits the kinematic inertia of the external water flow to conduct the water outside the transverse maneuvering tunnel, along the flow direction, minimizing or eliminating the crossings in the functional through windows.

[0144] Advantageously, the structural complexity of the transverse propulsion devices is reduced.

[0145] Advantageously, the grid is connected in a removable manner, obviating the need to dry-dock the ship.

[0146] Advantageously, the grid can be removed to access the inside of the maneuvering tunnel for inspection and maintenance operations.

[0147] Advantageously, the grid is adaptable to different embodiments of the opening edges.

[0148] Advantageously, the grid with uprights having straight broken shape, the inclined upright segment favours the external water flow from the center of the tunnel inlet opening towards the opening edges, i.e., in a centrifugal direction with respect to the tunnel axis X. Advantageously, the inclined upright segment contributes to preventing or limiting the inlet of water inside the transverse maneuvering tunnel, i.e., favouring the flow thereof along the flow direction.

[0149] Advantageously, in the grid embodiment with convex uprights in the shape of a circumferential arc, the radius of curvature favours the external water flow from the center of the tunnel inlet opening towards the opening

edges, i.e., in a centrifugal direction with respect to the tunnel axis X. Advantageously, the uprights in the shape of a circumferential arc contribute to preventing or limiting the inlet of water inside the transverse maneuvering tunnel.

[0150] It is clear that a person skilled in the art may make modifications to the invention described above so as to satisfy contingent requirements, all contained within the scope of protection as defined by the following claims.

[0151] For example, a person skilled in the art could make a transverse propulsion device comprising a grid substantially as described above but comprising only uprights or only crosspieces. Such an equivalent solution is, however, a pejorative solution, as the grid would be subject to highly undesirable vibrational and resonance phenomena.

LIST OF REFERENCE NUMBERS

[0152]

1 Transverse propulsion device
 2 Ship
 21 hull
 200 external water flow
 210 outer hull surface
 25 transverse maneuvering tunnel
 26 opening edges
 261 first edge portion
 262 second edge portion
 265 inner edge section
 266 central edge section
 267 outer edge section
 27 tunnel walls
 270 second edge section
 273 first edge section
 275 fixing ledges
 28 tunnel inlet opening
 281 first half area
 282 second half area
 3 -
 4 grid
 40 functional through window
 41 uprights
 411 first upright end
 412 second upright end
 417 upright segment (inclined)
 418 upright segment (central)
 419 upright segment (inclined)
 42 crosspieces
 421 inner crosspiece end
 422 outer crosspiece end
 A inlet area
 D upright distance
 P inlet plane
 S flow direction
 X tunnel axis
 α grid angle

δ internal angle
 β upright angle

5 Claims

1. A ship transverse propulsion device (1), wherein the ship (2) comprises a hull (21) which comprises an outer hull surface (210), along which an external water flow (200) is intended to flow locally along a flow direction (S); wherein the transverse propulsion device comprises:

- a transverse maneuvering tunnel (25) comprising tunnel walls (27) extending along a tunnel axis (X) oriented incidentally to the outer hull surface (210), and opening edges (26) extending at least partially about the tunnel axis (X) and delimiting a tunnel inlet opening (28) open on the outer hull surface (210), wherein the opening edges (26) extend along the tunnel axis (X) between an inner edge section (265) incident to the tunnel axis (X) and connected to the tunnel walls (27), and an outer edge section (267) incident to the tunnel axis (X) and connected to the outer hull surface (210);

- a grid (4) associated with the transverse maneuvering tunnel (25), comprising a plurality of crosspieces (42) and/or a plurality of uprights (41) incident to one another, mainly extending over a grid surface (45) incident to the tunnel axis (X) and the outer hull surface (210);

wherein the transverse propulsion device is **characterized in that** the grid (4) comprises at least one crosspiece (42) extending over the grid surface (45) between:

- an inner crosspiece end (421) mechanically connected to the inner edge section (265) or to a portion of the tunnel walls (27) proximal to said inner edge section (265), and
- an outer crosspiece end (422) mechanically connected to the outer edge section (267) or to a portion of the opening edges (26) axially enclosed between the inner edge section (265) and the outer edge section (267) .

2. A ship transverse propulsion device according to claim 1, wherein the grid surface (45) is substantially a grid plane (45).

3. A ship transverse propulsion device according to claim 1 or claim 2, wherein the grid (4) comprises at least one crosspiece (42) extending over the grid surface (45) between an inner crosspiece end (421) mechanically connected to the inner edge section (265) and an outer crosspiece end (422) mechani-

cally connected to the outer edge section (267).

4. A ship transverse propulsion device according to any one of the preceding claims, wherein all the uprights (41) are positioned substantially orthogonally to the flow direction (S). 5
5. A ship transverse propulsion device according to any one of claims 1 to 3, wherein at least one upright (41) is substantially in the shape of a polyline or broken straight line and comprises at least two upright segments (417, 419) mainly extending over two mutually distinct, incident imaginary straight lines (R1, R2) mainly extending over the grid surface (45). 10
6. A ship transverse propulsion device according to claim 5, wherein said at least one upright (41) comprises at least one upright segment (418) substantially orthogonally to the flow direction (S) over the grid surface (45). 15
7. A ship transverse propulsion device according to any one of claims 1 to 3, wherein at least one upright (41) is substantially curvilinear in shape. 20
8. A ship transverse propulsion device according to any one of the preceding claims, wherein, along the flow direction (S), the opening edges (26) are divided into a first edge portion (261) intended to be lapped first by the external water flow (200), and a second edge portion (262), complementary to the first edge portion (261), wherein the inner crosspiece end (421) is mechanically connected to the first edge portion (261), and wherein the outer crosspiece end (422) is mechanically connected to the second edge portion (262). 25
9. A ship transverse propulsion device according to claim 8, wherein, in the second half area (282), the grid (4) cooperates with the outer hull surface (210) to form, as a whole, a surface with a hydrodynamic shape along which the external water flow (200) flows. 30
10. A ship transverse propulsion device according to any one of the preceding claims, wherein the grid (4) extends over a curvilinear grid surface (45) and comprises at least one crosspiece (42) having an outer crosspiece end (422) substantially tangent to the outer hull surface (210). 35
11. A ship transverse propulsion device (1), wherein the ship (2) comprises a hull (21) which comprises an outer hull surface (210), along which an external water flow (200) is intended to flow locally along a flow direction (S); wherein the transverse propulsion device comprises: 40

- a transverse maneuvering tunnel (25) comprising tunnel walls (27) extending along a tunnel axis (X) oriented incidentally to the outer hull surface (210), and opening edges (26) extending at least partially about the tunnel axis (X) and delimiting a tunnel inlet opening (28) open on the outer hull surface (210), wherein, along the flow direction (S), the opening edges (26) are divided into a first edge portion (261) intended to be lapped first by the external water flow (200), and a second edge portion (262) complementary to the first edge portion (261);
 - a grid (4) associated with the transverse maneuvering tunnel (25), comprising a plurality of uprights (41) and a plurality of crosspieces (42) incident to one another, mainly extending over a grid surface (45) incident to the tunnel axis (X) and the outer hull surface (210); wherein the tunnel inlet opening (28) is divided into a first half area (281) partially delimited by the first edge portion (261), and a second half area (282) complementary to the first half area (281) and partially delimited by the second edge portion (262);

wherein the transverse propulsion device is **characterized in that**, in the first half area (281), the grid (4) is lowered with respect to the outer hull surface (210), along the tunnel axis (X) and towards the interior of the volume of the ship (2) defined by the outer hull surface (210) .

12. A ship transverse propulsion device according to any one of the preceding claims, wherein the grid (4) is mechanically connected to the tunnel walls (27) in a removable manner, for example, by means of bolted screws connected to fixing ledges (275) protruding from the tunnel walls (27) and/or the opening edges (26), with the hull (21) being immersed in water. 45
13. A ship transverse propulsion device according to any one of the preceding claims, wherein all or only some uprights (41) and all or only some crosspieces (42) delimit a plurality of functional through windows (40) therebetween, wherein, with the external water flow (200) flowing along the flow direction (S) at high speeds, preferably speeds exceeding 4 meters per second, the grid (4) is configured to prevent or limit the passage of the external water flow (200) through said functional through windows (40). 50
14. A ship transverse propulsion device according to claim 13, wherein the functional through windows (40) have a main dimension in a direction incident or substantially orthogonal to the flow direction (S). 55
15. A ship transverse propulsion device according to claim 14, wherein an upright distance (D) along the

flow direction (S) between two consecutive uprights (41), which delimit a functional through window (40) therebetween, is between 150 and 250 millimeters, preferably between 180 and 220 millimeters.

16. A ship transverse propulsion device according to any one of claims 13 to 15, wherein the functional through windows (40) are configured to retain water at low speeds, preferably speeds below 2.5 meters per second, at said functional through windows (40) and/or inside the transverse maneuvering tunnel (25) close to said functional through windows (40).
17. A ship transverse propulsion device according to any one of the preceding claims, wherein, in an inactive configuration, with the transverse maneuvering tunnel (25) at least partially filled with water and the external water flow (200) flowing along the flow direction (S) at high speeds, preferably speeds exceeding 4 meters per second, the functional through windows (40) are configured to cooperate with one another and keep the water inside the transverse maneuvering tunnel (25) at low speeds along the tunnel axis (X), preferably speeds below 2.5 meters per second.
18. A ship transverse propulsion device (1), wherein the ship (2) comprises a hull (21) which comprises an outer hull surface (210), along which an external water flow (200) is intended to flow locally along a flow direction (S); wherein the transverse propulsion device comprises:
- a transverse maneuvering tunnel (25) comprising tunnel walls (27) extending along a tunnel axis (X) oriented incidentally to the outer hull surface (210), and opening edges (26) extending at least partially about the tunnel axis (X) and delimiting a tunnel inlet opening (28) open on the outer hull surface (210), wherein the opening edges (26) substantially form a straight corner or comprise a flaring between the outer hull surface (210) and the tunnel walls (27); wherein the opening edges (26) extend between a first edge section (273) flush with the outer hull surface (210), and a second edge section (270) inside the transverse maneuvering tunnel (25) and spaced apart, along the tunnel axis (X), by an amount between 400 and 600 mm from the first edge section (273);
 - a grid (4) associated with the transverse maneuvering tunnel (25), comprising a plurality of crosspieces (42) and/or a plurality of uprights (41) incident to one another, mainly extending over a grid surface (45) incident to the tunnel axis (X) and the outer hull surface (210);

terized in that the grid (4) comprises at least one crosspiece (42) extending over the grid surface (45) between:

- an inner crosspiece end (421) mechanically connected to the second edge section (270) or to a portion of the tunnel walls (27) proximal to said second edge section (270), and
- an outer crosspiece end (422) mechanically connected to the first edge section (273) or to a portion of the opening edges (26) axially enclosed between the first edge section (273) and the second edge section (270) .

wherein the transverse propulsion device is **charac-**

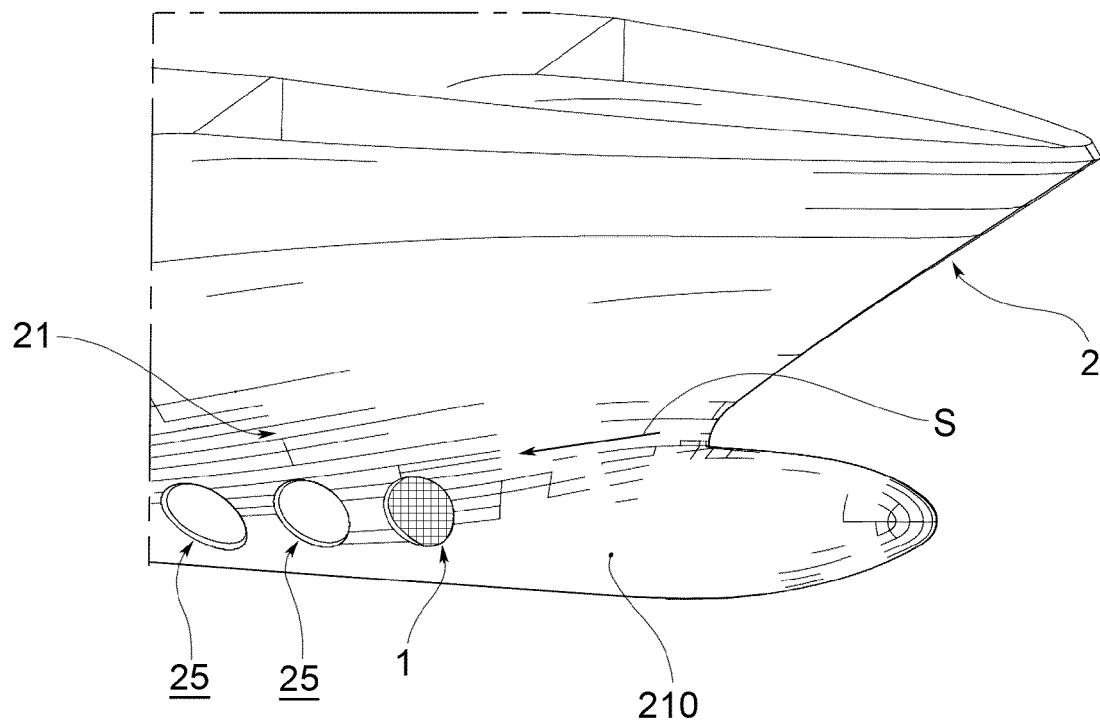
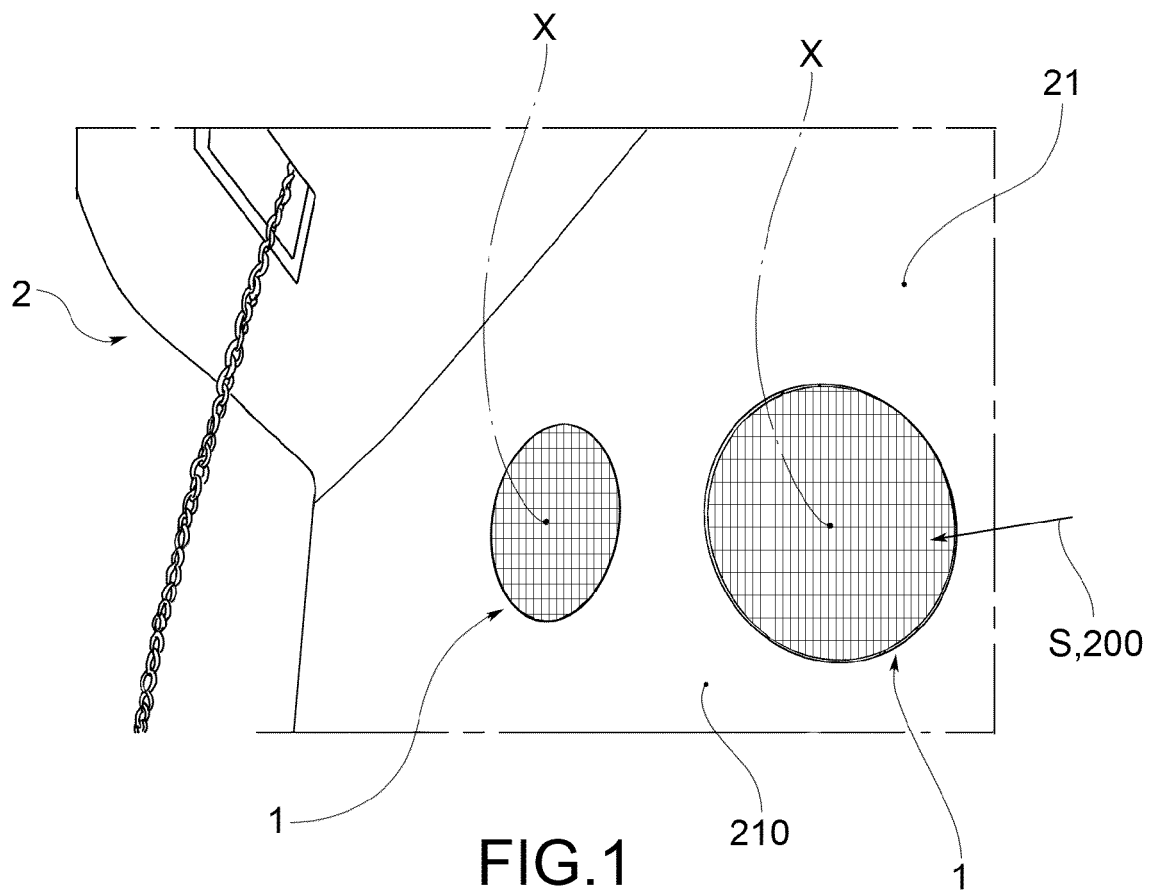


FIG.2

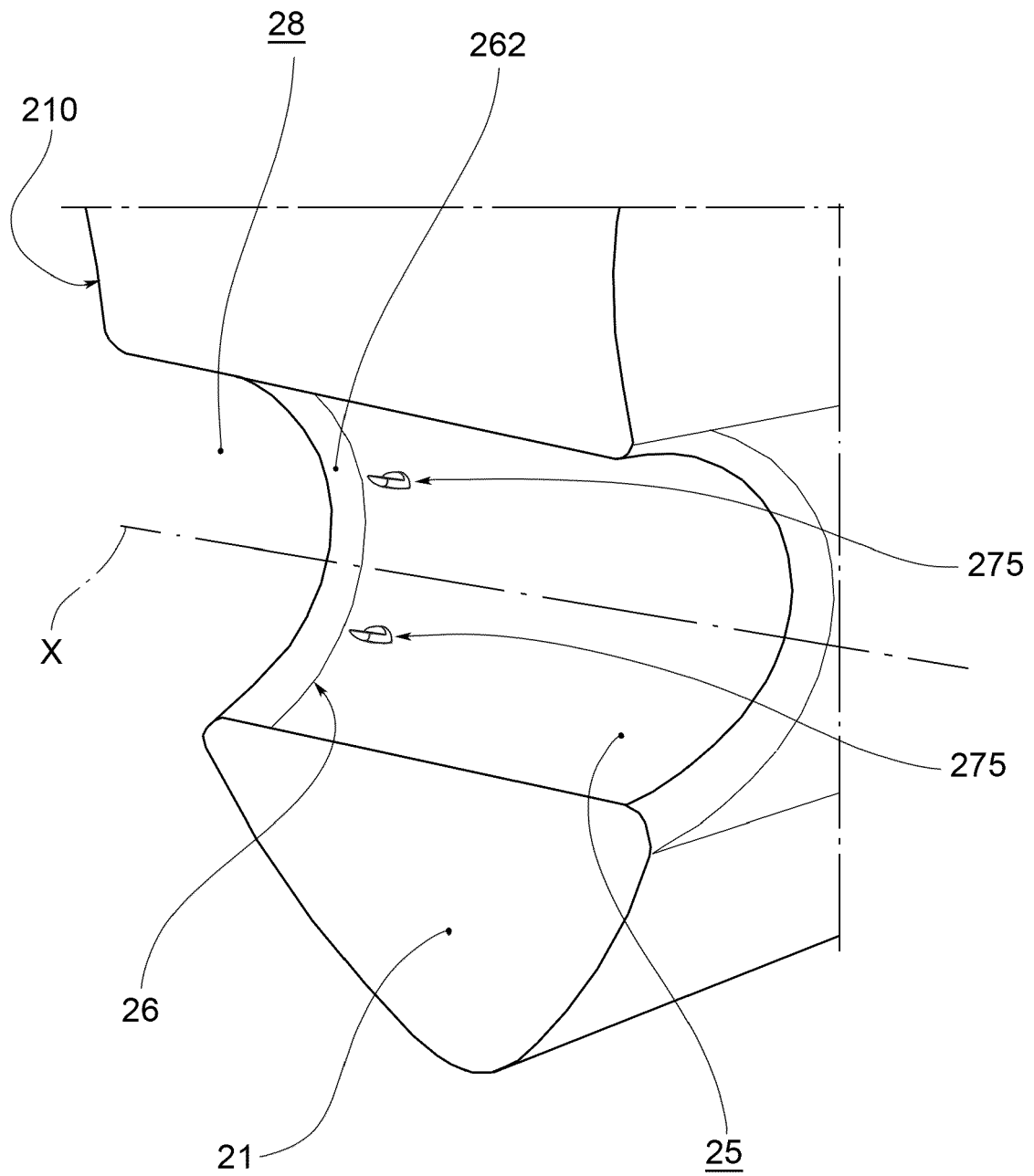


FIG.3

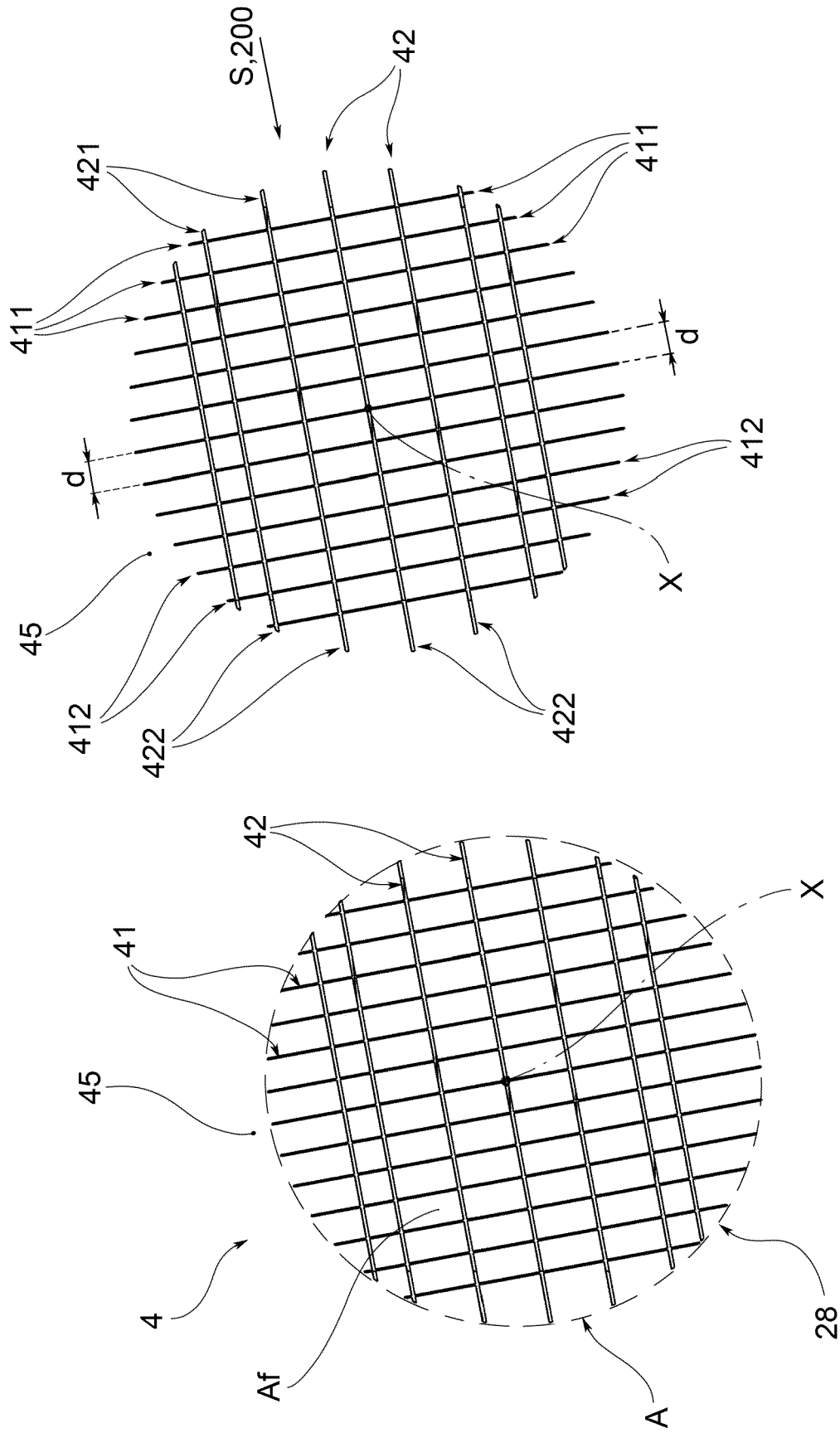
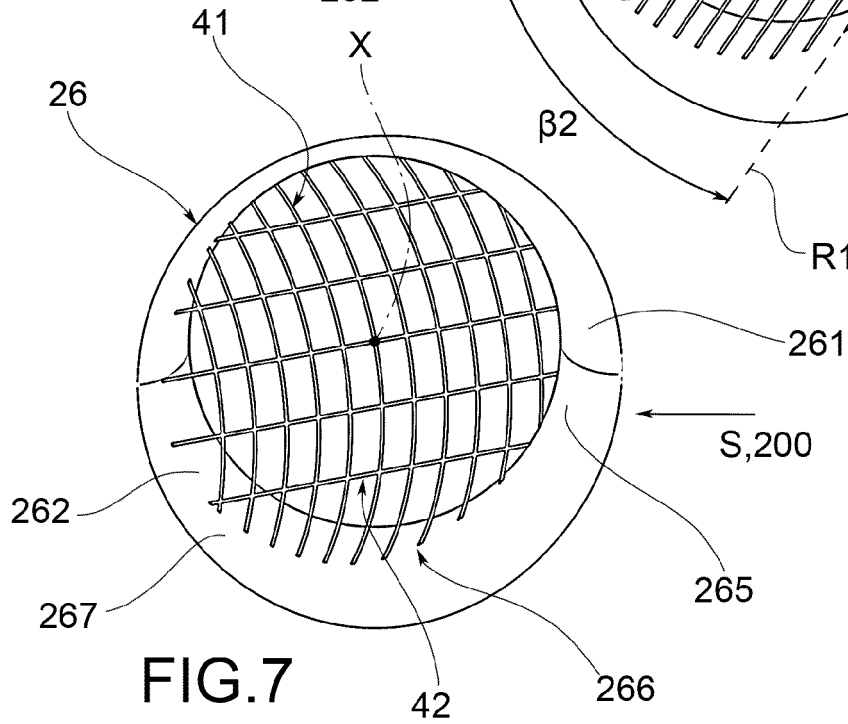
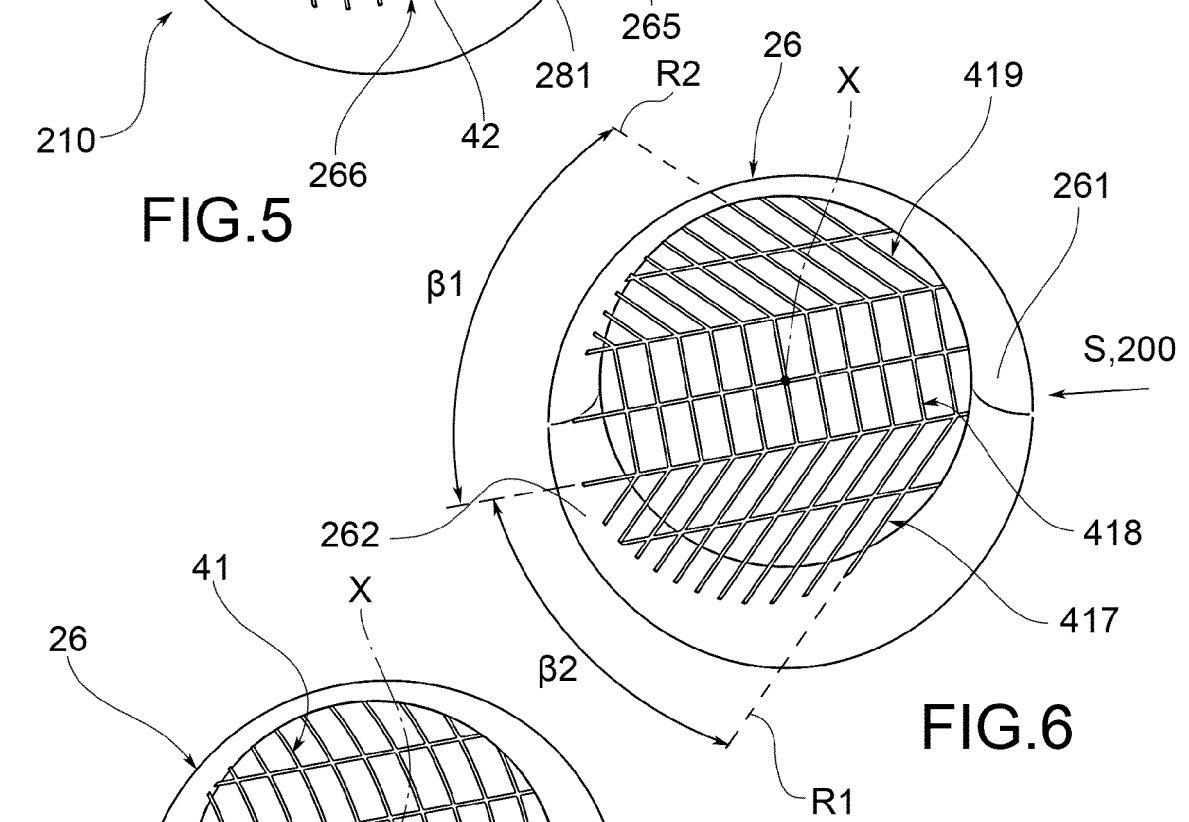
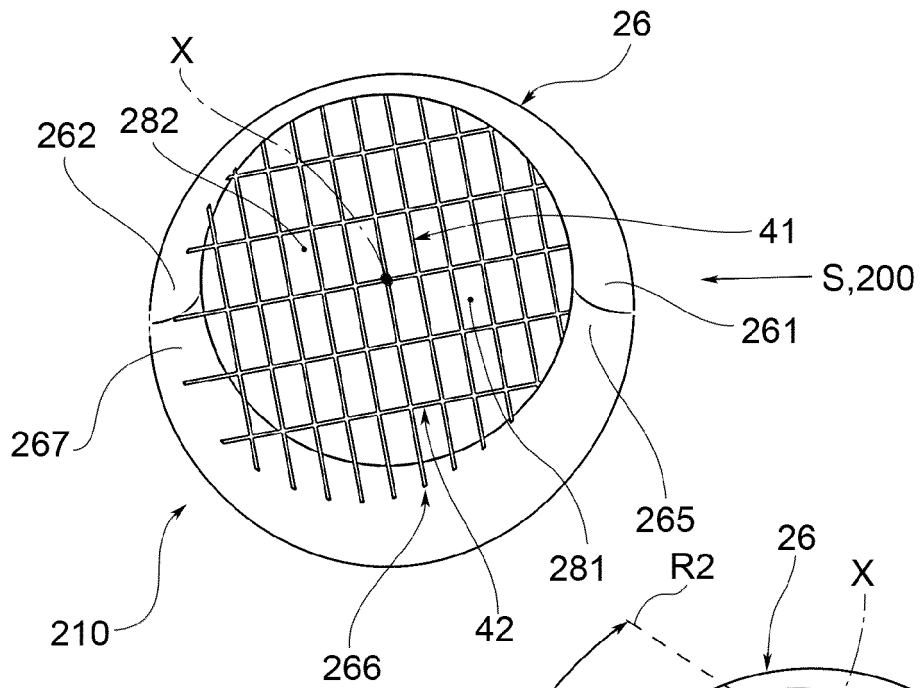


FIG.4



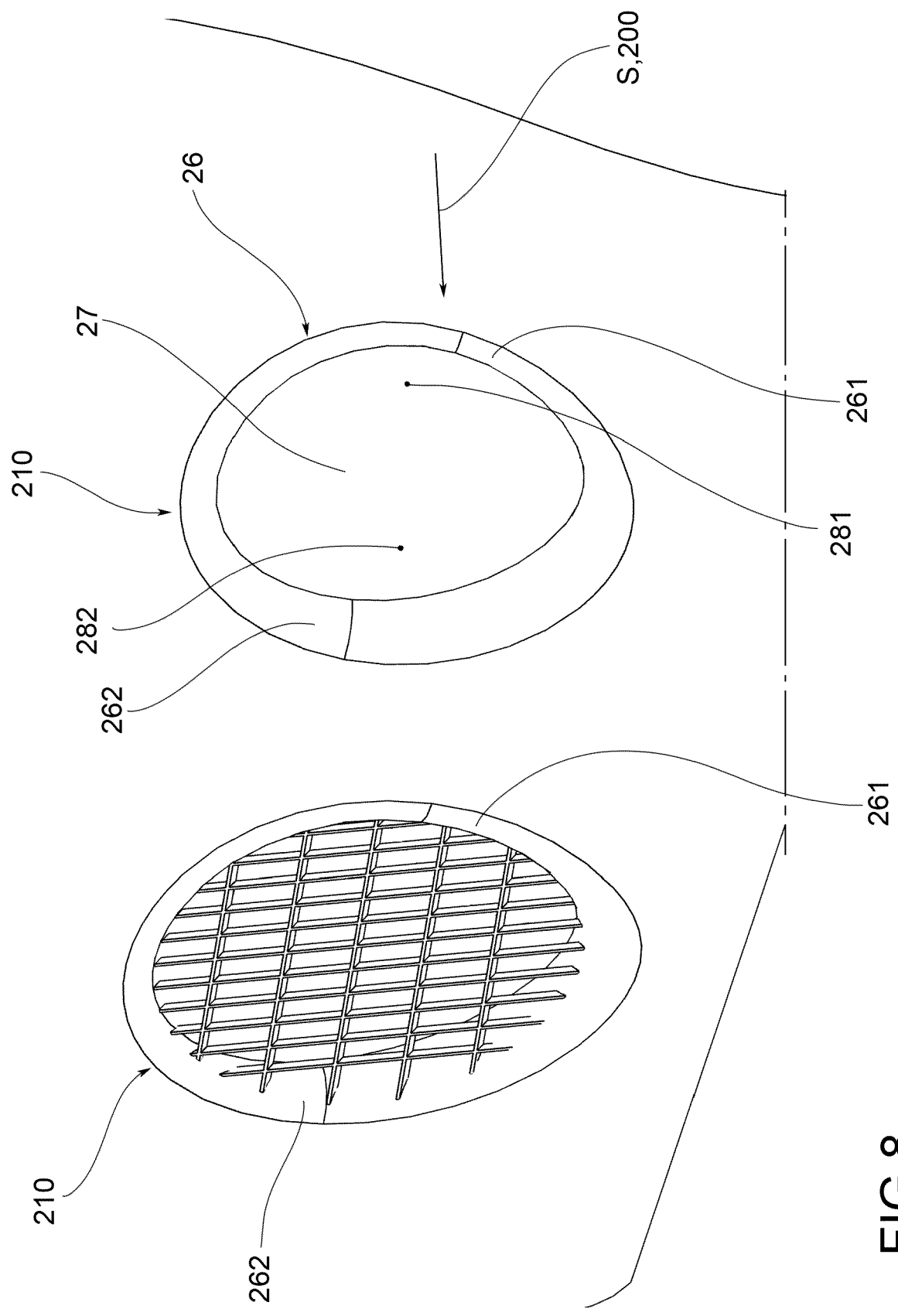


FIG. 8

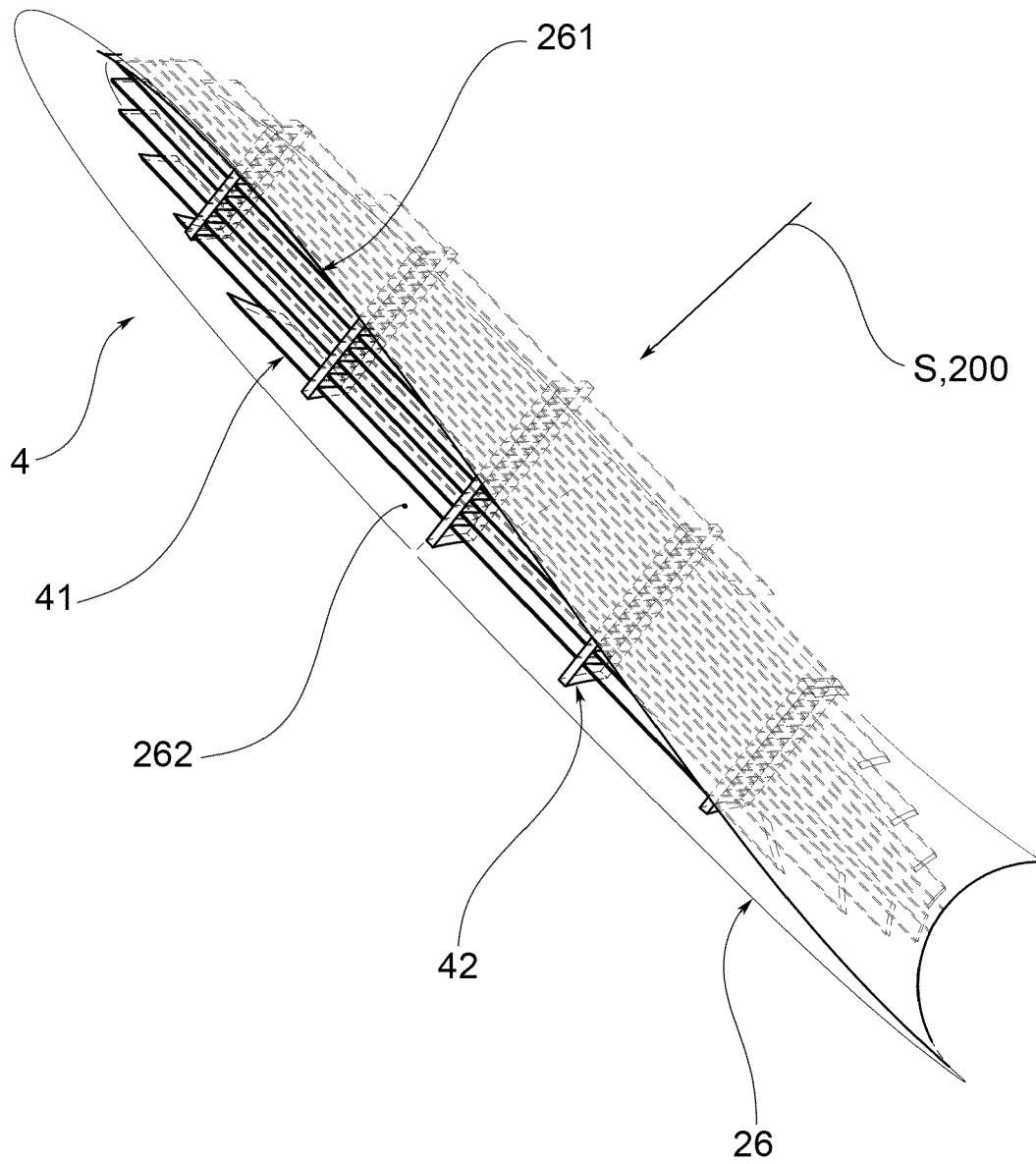


FIG.9

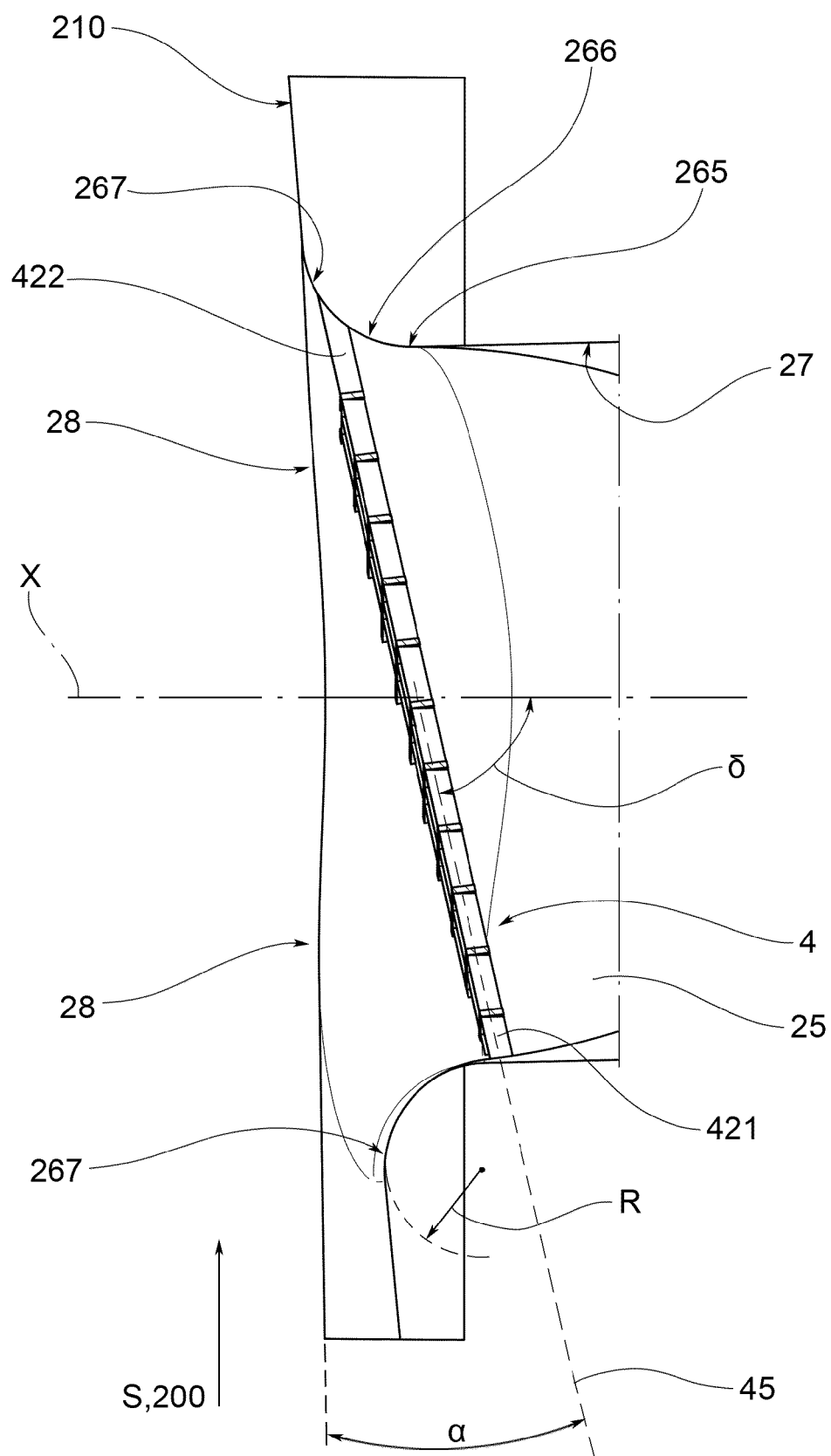


FIG.10

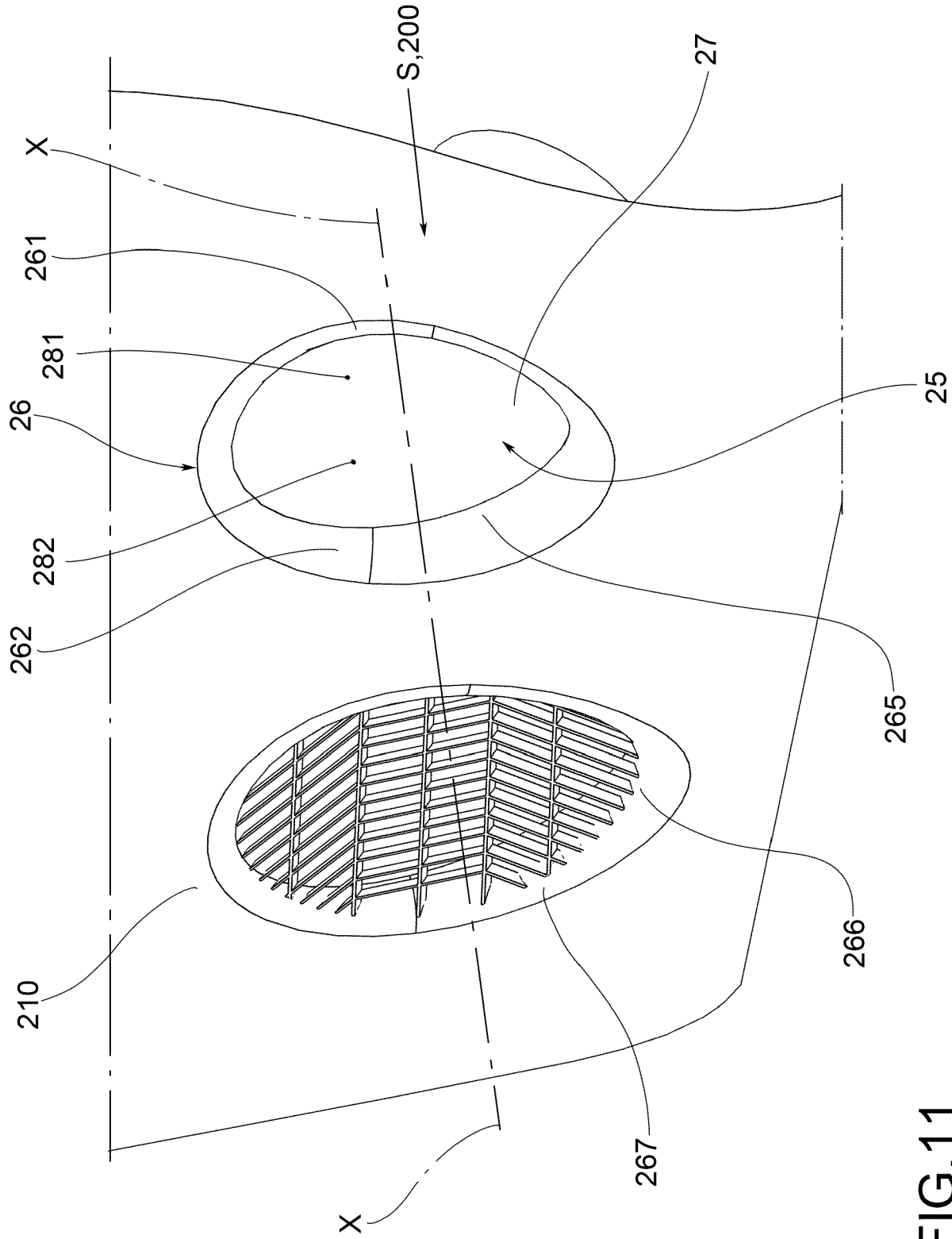


FIG.11

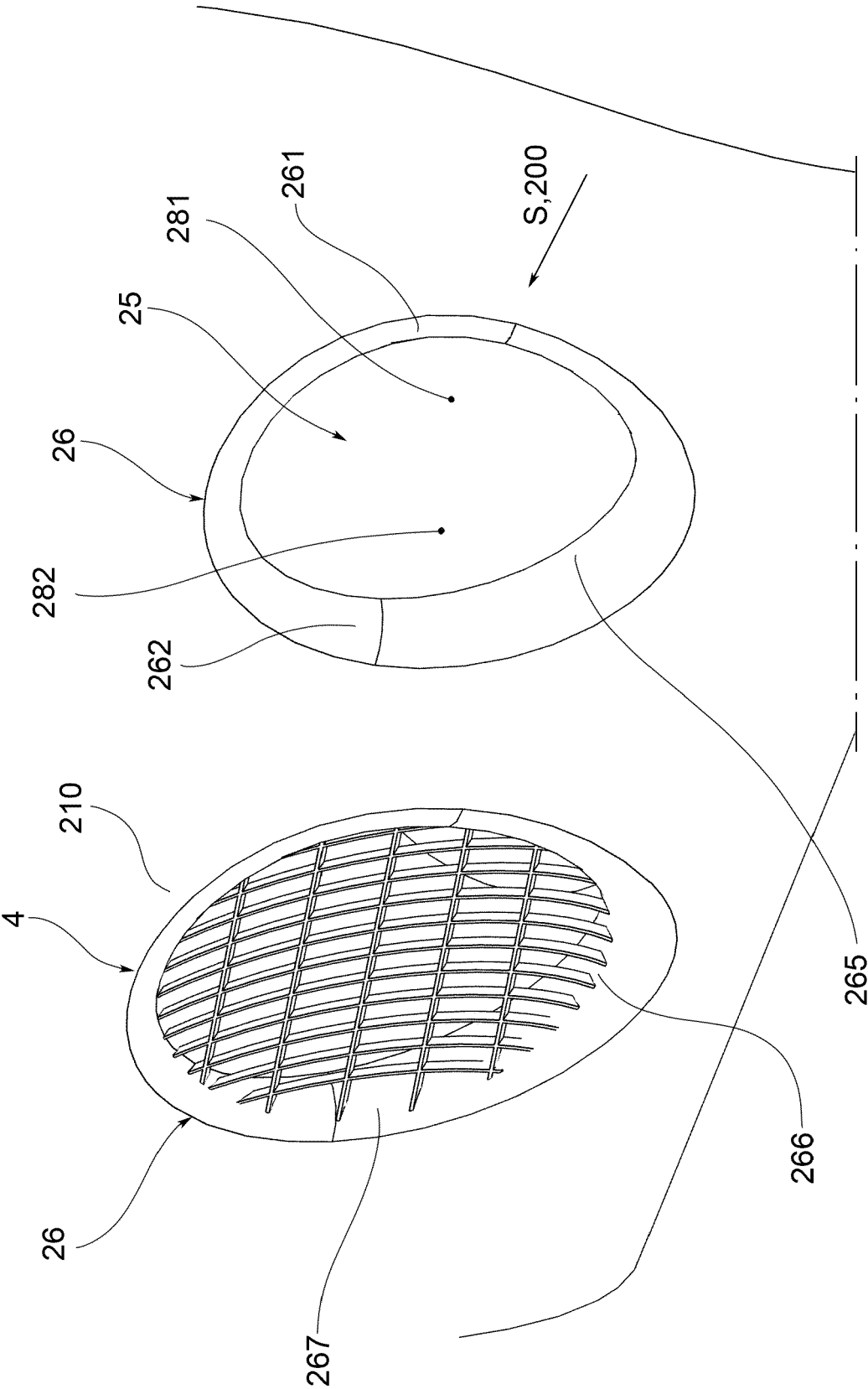


FIG.12

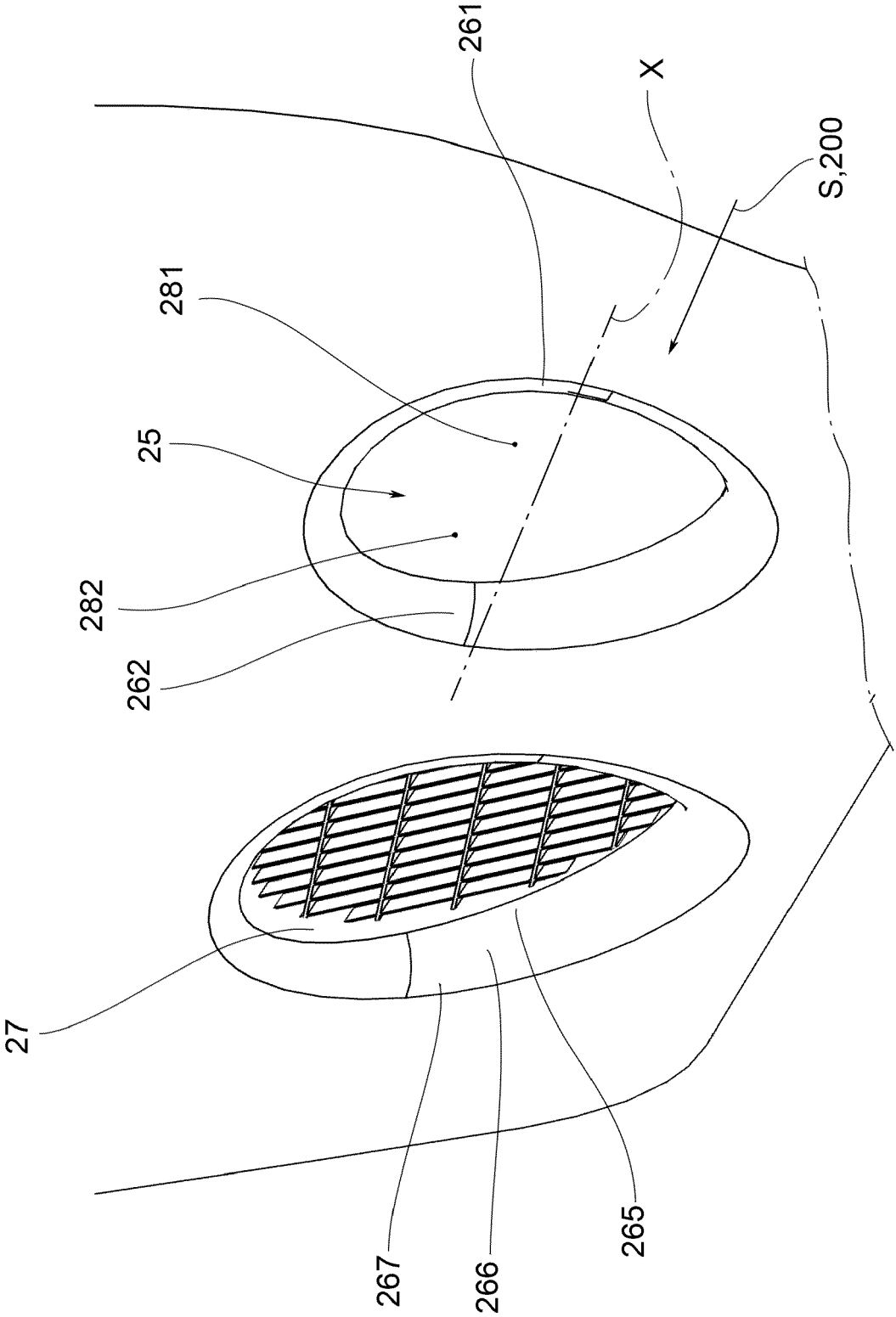


FIG.13

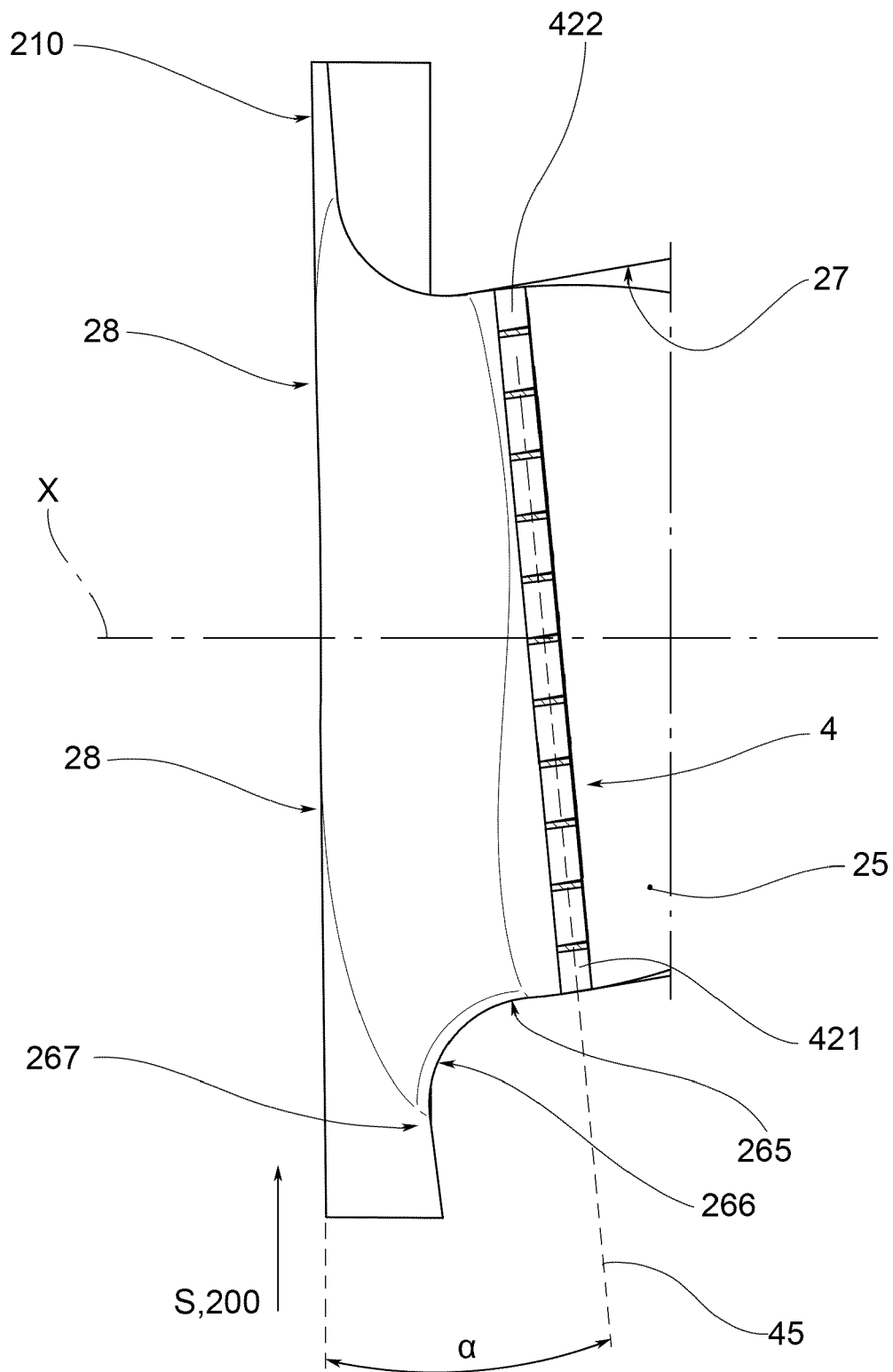


FIG.14

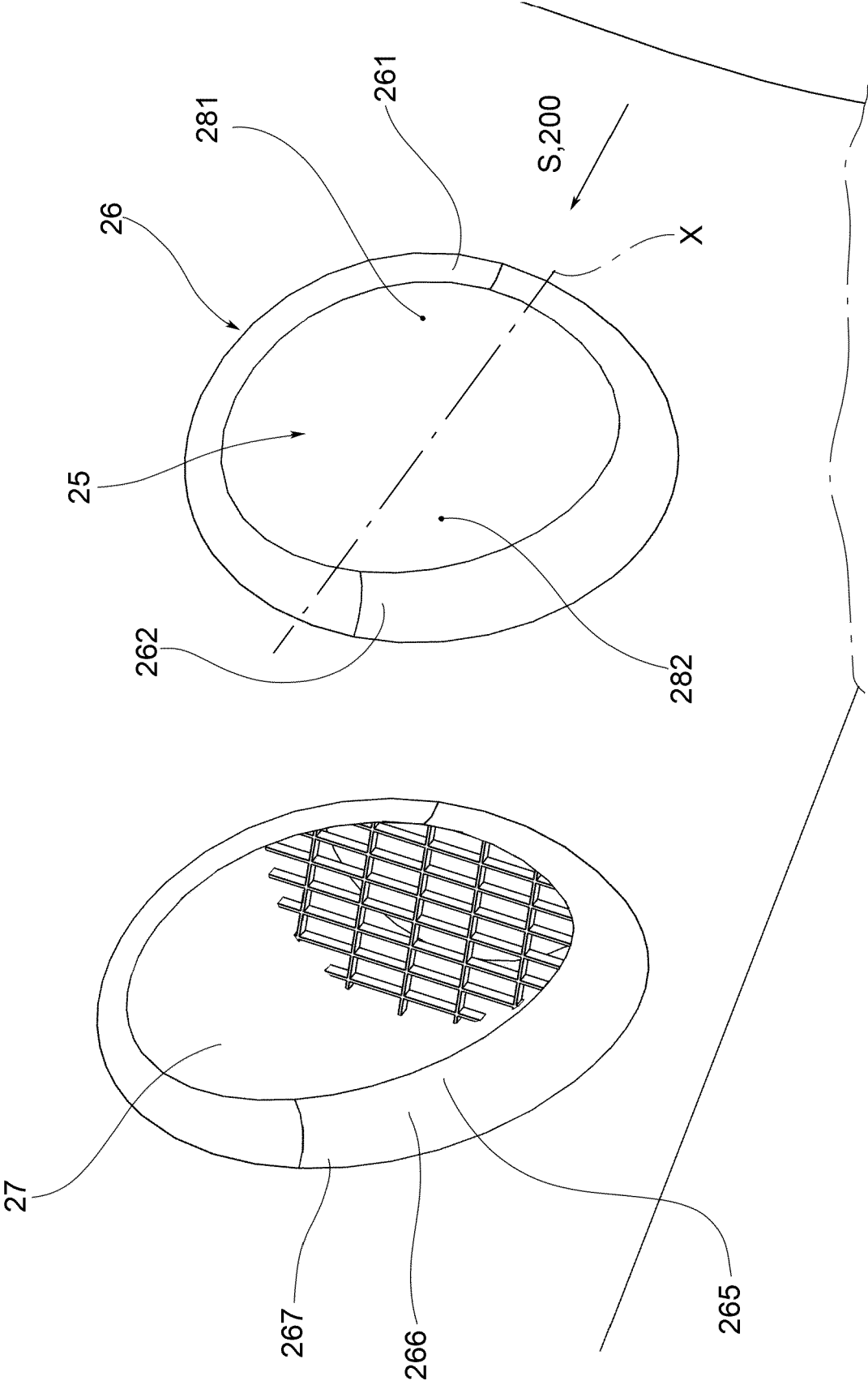
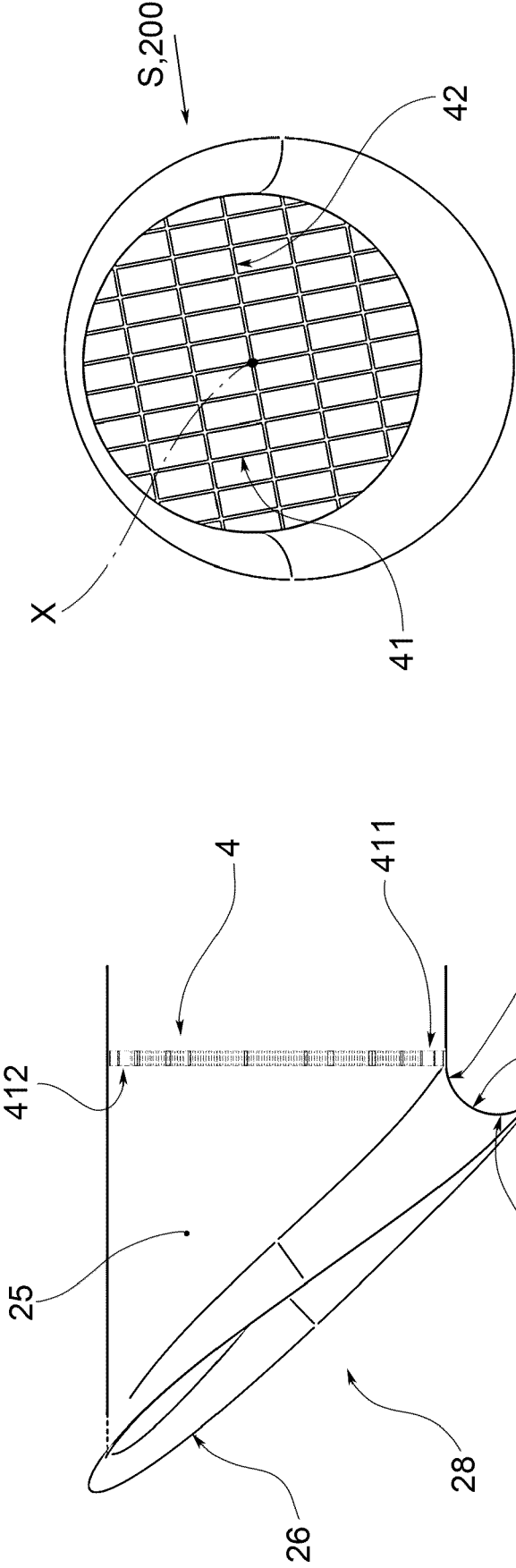


FIG.15



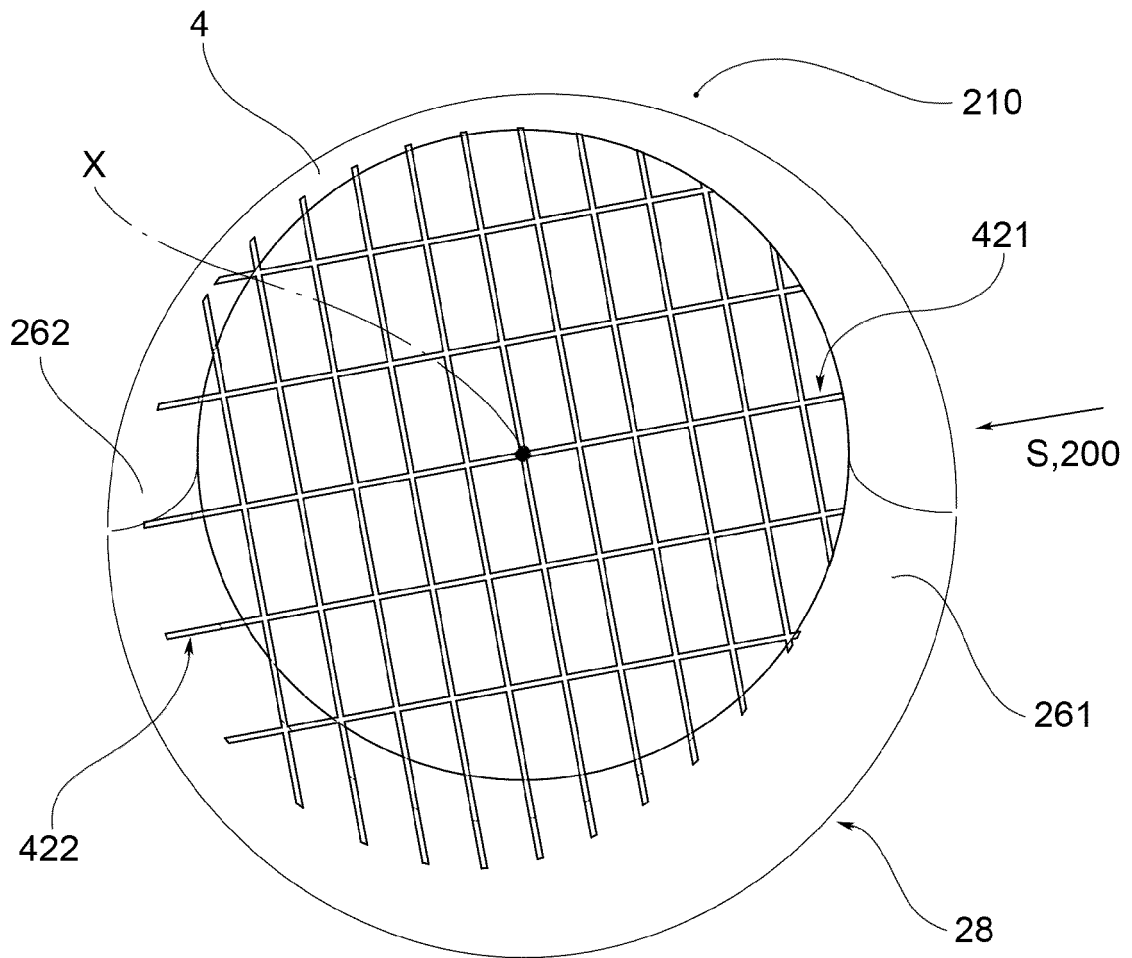


FIG.19

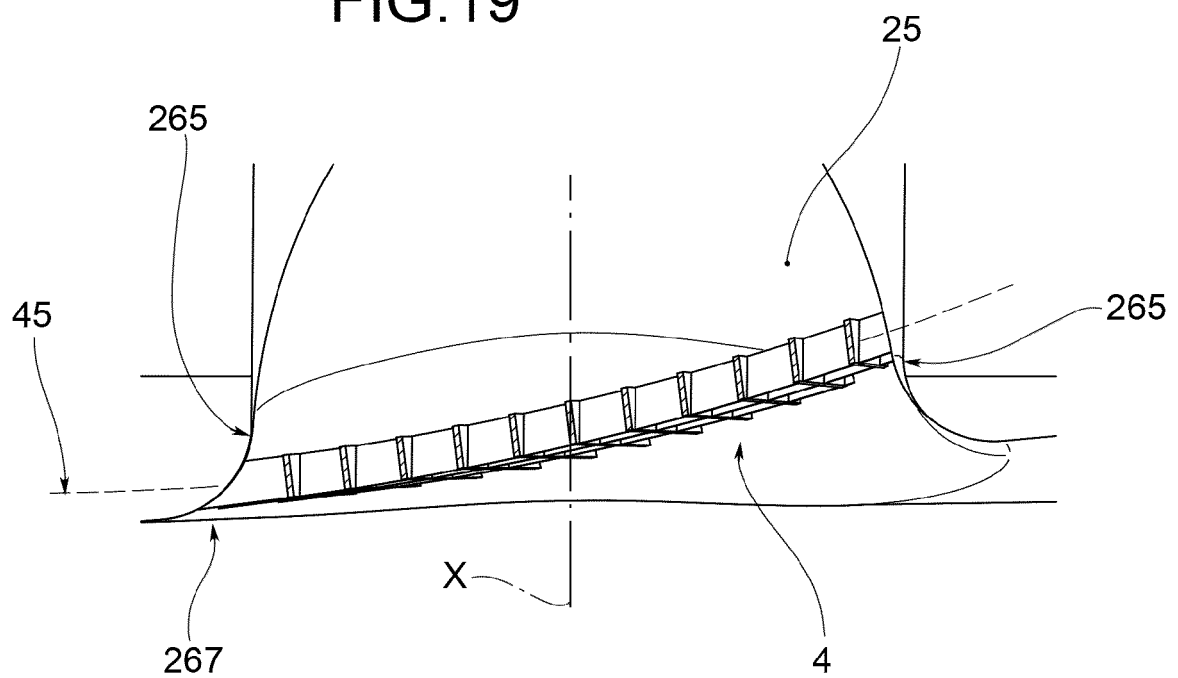
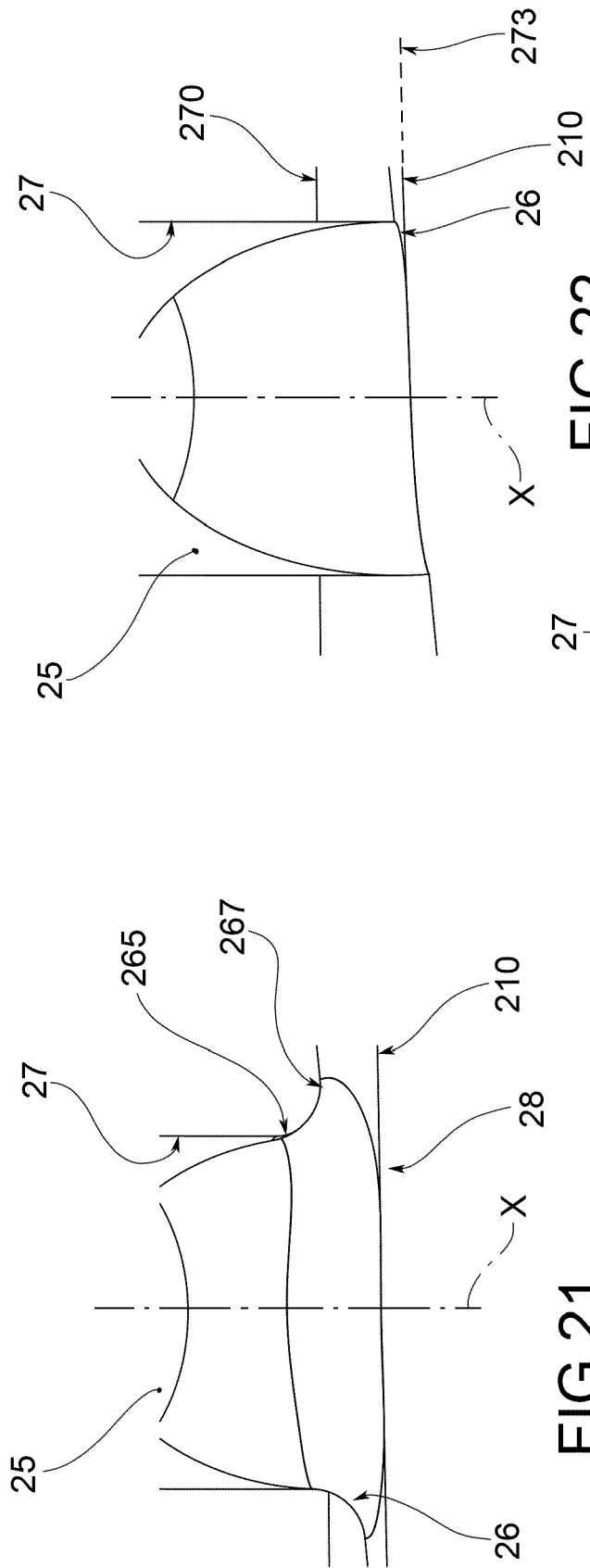


FIG.20





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			B63H B63B
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 2 August 2024	Examiner Freire Gomez, Jon
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