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(54) **PROTECTION DEVICE FOR ANODES OF AN ELECTROLYTIC CELL, COMPRISING MOVABLE PANELS, AND ITS IMPLEMENTATION METHOD**

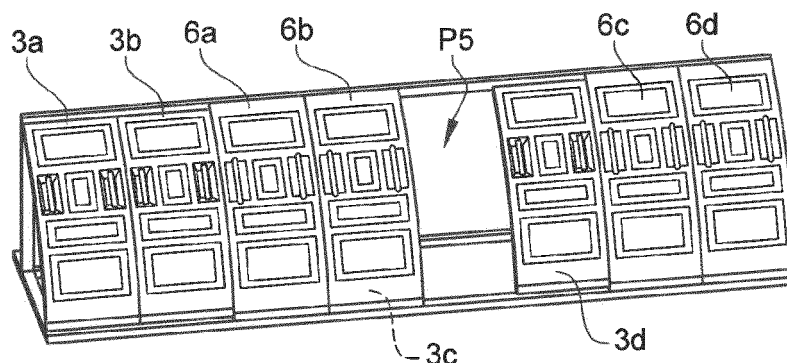
(57) This protection device, which is adapted to be placed in front of the anodes, comprises a frame (1) and a plurality of panels (3,6) which are mounted on the frame and are adapted to be displaced with respect to this frame, so as to allow access to said anodes for an operator.

According to the invention panels (3,6) comprise a first set of inner panels (3a-3d), as well as a second set of so-called outer panels (6a-6d), said panels being adapted to slide with respect to said frame (1) along a

longitudinal direction (XX) of anodes line(s) so that:

- in a so-called closing configuration, panels (3,6) form a substantially continuous shield (S) in front of the line of anodes; and
- in a so-called access configuration, at least one panel of inner set is at least partially retracted behind at least one panel of outer set, so as to define one passage (P5) for access to at least one of the anodes which are part of said line.

Fig. 33



Description**Technical field of the invention**

5 **[0001]** The invention relates to the field of fused salt electrolysis, and more precisely to an anodic assembly which is part of an electrolytic cell suitable for the Hall-Heroult process. In particular, the invention relates to a device which is adapted to protect the environment from the emission of anodes, which belong to this anode assembly.

Prior art

10 **[0002]** The Hall-Heroult process is the only continuous industrial process for producing metallic aluminium from aluminium oxide. Aluminium oxide (Al_2O_3) is dissolved in molten cryolite (Na_3AlF_6), and the resulting mixture (typically at a temperature comprised between 940 °C and 970 °C) acts as a liquid electrolyte (usually called "electrolytic bath") in an electrolytic cell. An electrolytic cell (also called "pot") used for the Hall-Heroult process typically comprises a steel shell (so-called potshell), a lining (comprising refractory bricks protecting said steel potshell against heat, and cathode blocks usually made from graphite, anthracite or a mixture of both).

15 **[0003]** This cell is also provided with so-called anodic assemblies, which are formed by an anode hanger and at least one anode (usually made from carbon) that plunges into the liquid electrolyte. Anodes and cathodes are connected to external busbars. An electrical current is passed through the cell (typically at a voltage between 3.5 V and 5 V) which electrochemically reduces the aluminium oxide, split by the electrolyte into aluminium and oxygen ions, into aluminium at the cathode and oxygen at the anode; said oxygen reacting with the carbon of the anode to form carbon dioxide. The resulting metallic aluminium is not miscible with the liquid electrolyte, has a higher density than the liquid electrolyte and will thus accumulate as a liquid metal pad on the cathode surface from where it needs to be removed from time to time, usually by suction into a crucible.

20 **[0004]** The electrical energy is a major operational cost in the Hall-Heroult process. Capital cost is an important issue, too. Ever since the invention of the process at the end of the 19th century much effort has been undertaken to improve the energy efficiency (expressed in kW/h per kg or ton of aluminium), and there has also been a trend to increase the size of the pots and the current intensity at which they are operated in order to increase the plant productivity and bring down the capital cost per unit of aluminium produced in the plant.

25 **[0005]** Industrial electrolytic cells used for the Hall-Heroult process are generally rectangular in shape and connected electrically in series, the ends of the series being connected to the positive and negative poles of an electrical rectification and control substation. The general outline of these cells is known to a person skilled in the art and will not be repeated here in detail. They have a length usually comprised between 8 and 25 meters and a width usually comprised between 3 and 5 meters. The cells (also called "pots") are always operated in series of several tens (up to more than a hundred) pots (such a series being also called a "potline"); within each series DC currents flow from one cell to the neighbouring cell. For protection the cells are arranged in a building, with the cells arranged in rows either side-by-side, that is to say that the long side of each cell is perpendicular to the axis of the series, or end-to-end, that is to say that the long side of each cell is parallel to the axis of the series. It is customary to designate the sides for side-by-side cells (or ends for end-to end cells) of the cells by the terms "upstream" and "downstream" with reference to the current orientation in the series. The current enters the upstream and exits downstream of the cell. The electrical currents in most modern electrolytic cells using the Hall-Heroult process exceed 200 kA and can reach 400 kA, 450 kA or even more; in these potlines the pots are arranged side by side. Most newly installed pots operate at a current comprised between about 350 kA and 600 kA, and more often in the order of 400 kA to 500 kA.

30 **[0006]** The superstructure of the cell comprises a fixed frame and a mobile metallic anode busbar, also called "anode beam", which extends at the outer periphery of the fixed frame. Each anode is equipped with a metallic rod, for mechanical attachment and electrical connection to said anode beam. Anodes are provided along at least one line, typically along two lines on either side of the superstructure.

35 **[0007]** More precisely, anodes (also called "anode blocks") in the Hall-Heroult process are prebaked cuboids made from a carbonaceous material. The anode blocks are fixedly connected to so-called anode hangers. They serve two different purposes, namely to keep the carbon anodes at a predetermined distance from the cathode, and to carry the electrical current from an anode busbar (also called "anode beam") down to the carbon anodes. Anode hangers are fixed to the overhanging anode beam in a detachable manner using clamps. They comprise an upper part called "anode rod" or "anode stem", which is connected to the anode beam, and a lower part, called "anode yoke". The anode yoke has a number of arms each of which terminates in a cylindrical stub that is embedded in preformed stubholes of the carbon anode blocks and fixed with cast iron acting as temperature-resistant, electrically conductive glue; this process is called "anode rodding" or "anode casting".

40 **[0008]** The entity "anode rod plus anode yoke" is sometimes called "anode hanger", and the entity "anode hanger plus anode block" is called "anode assembly".

[0009] Anodes are subject to oxidative consumption during the electrolysis process, the carbon being oxidized into carbon dioxide. More generally, the Hall-Heroult electrolytic process leads to gaseous emissions, which, in addition to CO₂, mainly comprise fluorine compounds such as hydrogen fluoride, originating from the electrolytic bath, as well as minor amounts of SO₂. These fluorine compounds are noxious to workers and to the environment. Concerning environmental damage, it has been observed over the decades, as the production of smelters has increased, that fluorine compounds can damage the neighbouring vegetation, and can also cause damage (so-called fluorosis) to the cattle raised near aluminium smelters. Therefore, since the 1970s, gaseous emissions of Hall-Heroult cells are no longer released into the environment but undergo a purification.

[0010] More precisely, gaseous emissions from electrolytic pots are collected using protection devices such as hooding systems, and treated in gas treatment stations to remove fluorine compounds and other noxious compounds before releasing the collected air into the environment. Said gas treatment usually comprises a dry absorption of said noxious compounds on fresh alumina that is subsequently introduced into the electrolytic pot.

[0011] In practice, each protection (hooding) device is intended to cover at least one line of anodes. In this respect, this device comprises first an elongated frame which extends, in use, substantially parallel to the line of anodes. This frame supports two fixed end walls, located at the opposite extremities of the anodes line. Moreover, facing the front side of the anodes, several panels (so-called "hood panels") are provided between these end walls. These panels are typically curved, in particular shaped as a quarter of a circle, so as to ensure an optimal protection. Said hood panels also act as heat shields, thereby limiting thermal losses of the electrolytic cell and protecting the workers.

[0012] During the use of the cell, operators need to have access to the anode assemblies, in particular in view of their maintenance or the replacement of spent anode assemblies by new anode assemblies, or in emergency situations such as so-called anode effects. In this respect, the panels need to be movable between two main configurations. In a first so-called protection configuration, these panels are located side by side to define a shield, with a close lateral contact for sealing matters. Moreover in a second so-called access configuration, these panels must be mutually separated so as to define a passage towards the anodes for the operators.

[0013] More precisely, a typical industrial electrolytic pot (known as DX+™ or DX+ Ultra™ technology, commercialized by Emirates Global Aluminium) has 18 anodes on each side, arranged along a longitudinal axis (called here also "anode line") of the cell, and there are 19 hood panels on each side. In these pots anodes are changed by pairs, and for changing a pair of anodes three adjacent hoods need to be removed to gain access to the pair of anodes to be changed; eventually these three hood panels need to be put back in place.

[0014] In known solutions, hood panels can be removed from the frame by lifting. Such a lifting operation may first be carried out manually. In this case, there are risks of premature mechanical damage of the panels, due to potential mishandling of the operators. In practice, these hoods need to be replaced when they exhibit a deformation such that they do no longer guarantee sufficient tightness. Repair and replacement of hood panels represent a rather significant cost in a smelting plant. Moreover, due to the substantial weight of the panels (typically around 17 kg per panel for DX+™ or DX+ Ultra™ technology), their manual handling by an operator may cause injuries. As these panels are also very hot, their manual handling may lead to accidental burns, too.

[0015] Under these circumstances, it has been considered to develop specific devices which are adapted to mechanically lift to the panels. Specific pot tending machines for handling hood panels have been patented (see for instance WO 2015/132479 assigned to E.C.L.) and are commercially available. However, this implies extra costs. In addition, such a mechanical lifting is not a very convenient operation, so that it does not avoid accidental deformation of the hood panels.

[0016] In view of the above, one goal of the invention is first to provide a device adapted to reliably protect environment from the emissions of the anodes of an electrolytic cell, which can be implemented by operators without any excessive physical strength.

[0017] One other goal of the invention is to provide such a device which can bring about an improved sealing, in particular with respect to gaseous emissions of the anodes, compared to prior art solutions.

[0018] One other goal of the invention is to provide such a device, which has a relatively simple structure and a satisfactory compactness.

Objects of the invention

[0019] According to the invention, at least one of the aforementioned goals is achieved by a protection device (100) for an anodic assembly of an electrolytic cell, suitable for the Hall-Heroult electrolysis process, said assembly comprising a superstructure (102) as well as a plurality of anodes (A1-A8) arranged along at least one line (L1, L2), said superstructure (102) comprising a fixed frame (104) of substantially rectangular shape and an anode beam (106) adapted to support anode rods (108),

said protection device, which is adapted to be placed in front of said anodes, comprising a frame (1) and a plurality

of panels (3,6) which are mounted on the frame and are adapted to be displaced with respect to this frame, so as to allow access to said anodes for an operator, characterized in that

said panels (3,6) comprise a first set of so-called inner panels (3a-3d), adjacent to anodes in use, as well as a second set of so-called outer panels (6a-6d), away from anodes in use, at least part of said panels and, preferably, all of these said panels being adapted to slide with respect to said frame (1) along a longitudinal direction (XX) of anodes line(s) so that

- in a so-called closing configuration, panels (3,6) form a substantially continuous shield (S) in front of the line of anodes; and
- in a so-called access configuration, at least one panel of inner set is at least partially retracted behind at least one panel of outer set, so as to define one passage (P2, P'2, P3, P'3) for access to at least one of the anodes which are part of said line.

[0020] According to some embodiments of this protection device:

- said first set of inner panels (3a-3d) and said second set of outer panels (6a-6d) comprise the same number of panels.
- said frame defines at least a first track (24, 28) and at least a second track (25, 29), which are mutually parallel, each inner panel (3) comprising at least a first slider (36, 50) adapted to cooperate with said first track and each outer panel comprising at least a second slider (66, 80) adapted to cooperate with said second track.
- said frame comprises three longitudinal beams, namely a first so-called central beam (10), a second so-called outer beam (11) and a third so-called upper beam (12), as well as cross pieces (13-15) extending between central beam and outer beam, and posts 16-18) extending between central beam and upper beam.
- a pair of first (24) and second (25) tracks are provided on outer beam, whereas another pair of first (28) and second (29) tracks are provided on the upper beam.
- each panel (3, 6) comprises an inner skin (31, 61) and an outer skin (32, 62), said skins being at least partly distant so as to define a hollow body.
- said outer skin is provided with at least one recess, said recess being in particular provided with one handle (41, 43, 71, 73), said handle being either integrated into the global volume of the hollow body, or protruding out of said volume.
- in closing configuration, at least one inner panel and at least one outer panel define an overlap zone (OV) in front view.
- said device comprises locking means (46), movable between a locking position wherein they are adapted to lock said panel (3, 6) with respect to said frame in a predefined position, and a release position, said locking means comprising in particular a locking rod (46) mounted on said panel, as well as a hole (110) provided in said frame.
- said protection device comprises a compression spring (46) adapted to move said rod into said hole, as well as a release ring (49) adapted to remove said rod out of said hole.
- said device comprises insulation means, which are provided over part of said panel, in particular over opposite end walls of said panel.

[0021] Another object of the invention is an electrolytic cell suitable for the Hall-Heroult electrolysis process, comprising a protection device (100) as above.

[0022] Another object of the invention is a method for changing a spent anode assembly in an electrolytic cell as above, comprising the steps of:

- opening said protection device (100) by sliding at least one panel from a closed position into an open position, such as to open an access to an anode assembly,
- replacing said spent anode assembly by a new anode assembly,
- closing said protection device (100) by sliding back said at least one panel from said open position into said closed position.

[0023] Another object of the invention is an aluminium electrolysis plant comprising at least one line of electrolytic cells of substantially rectangular shape, said cells being arranged side by side, and said plant further comprising means for electrically connecting said cells in series and for connecting the cathodic busbar of a cell to the anode beam of a downstream cell, characterized in that more than 80% of the electrolytic cells in at least one of said line, and preferably each electrolytic cell of said line, is an electrolytic cell as above.

[0024] Another object of the invention is a method for making aluminium by the Hall-Heroult electrolysis process using electrolytic cells of substantially rectangular shape, characterized in that said method is carried out in an aluminium electrolysis plant as above.

Figures

[0025]

5	Figures 1 to 36 illustrate various aspects and embodiments of the invention. They are given here for illustration only and are not intended to limit the scope of the invention.	
	Figure 1 is a perspective view, showing an anodic assembly of an electrolytic Hall-Heroult electrolytic cell, which is equipped with protection devices according to the invention.	
10	Figures 2 and 3 are perspective views, illustrating under different angles one of the protection devices shown on figure 1.	
	Figures 4 and 5 are respectively front and side views of the protection device shown on figure 1, in its closing configuration.	
	Figures 6 and 7 are views of details VI and VII on figure 5, showing at a much larger scale different tracks that are provided on the frame, which is part of said protection device.	
15	Figures 8 to 10 are respectively perspective, front and side views of an inner panel, provided on said protection device.	
	Figures 11 to 16 are cross-section views, along lines XI-XI to XVI-XVI on figure 9.	
	Figure 17 is a front view, showing under another angle locking means which are also illustrated on figure 14.	
	Figures 18 to 20 are respectively perspective, front and side views of an outer panel, provided on said protection device.	
20	Figures 21 to 26 are cross-section views, along lines XXI-XXI to XXVI-XXVI on figure 19.	
	Figure 27 is a view of detail XVII on figure 4, showing the cooperation between locking means of figures 14 and 17 and the frame of the device according to the invention.	
	Figures 28 to 31 are schematic front views, illustrating several possibilities with regard to the implementation of the protection device according to the invention.	
25	Figure 32 is a front view, analogous to figure 4, showing in greater detail the access configuration illustrated on figure 29, of the protection device according to the invention.	
	Figures 33 to 36 are perspective views, illustrating other possible access configurations of the protection device according to the invention	
30	1	Frame
	10,11,12	Longitudinal beams
	13,14,15	Cross pieces
	16,15,16	Posts
	19	Oblique bar
35	20,21	Plain walls
	22,23	Brackets
	24,25	Inner and outer tracks
	26,27	Brackets
	28,29	Lower and upper tracks
40	3	Inner panel
	31,32	Inner and outer skin of 3
	320,321,322	Inner, intermediate and outer recess of panel 3
	323,324,325,326,327	Long (323,324), end (325,326) and median (327) recess of 3
	33,34	Longitudinal walls
45	330,331	Rivets
	332,333,334,335	Lines of rivets
	35	Housing
	351	Reinforcement member
	352	Structural support frame
50	36	Outside rollers
	37	Groove
	38	Fixing piece
	40	Physical axis
	41,43	Handles
55	42	U-shaped element
	44	Housing
	440,442	Walls
	444	Notch

EP 4 174 216 A1

	46	Locking rod
	47	Pin
	48	Compression spring
	49	Ring
5	50	Slider
	51	Tip of 50
	6	Outer panel
	61,62	Inner and outer skin of 6
	620 to 652	Same elements as those 320 to 327, 330 to 335, 351 and 352 for panel 6
10	64	Rim of 6
	66	Rollers
	71,73	Handles
	74	Housing
	76	Rod
15	80	Slider
	81	Tip of 80
	100	Protection device according to the invention
	102	Superstructure
	104	Fixed frame
20	A1-A8	Anodes
	106	Anode beam (mobile)
	108	Anode rod
	110	Hook
	112	Hole
25	OV	overlap zones
	F3x, F6x	Motions of panels 3x and 6x
	P2, P'2, P3, P'3, P5, P'5, P6, P7	Passages towards anodes

Detailed description

[0026] An aluminium smelter comprises a plurality of electrolytic cells arranged the one behind the other (and side by side), typically along two parallel lines. These cells are electrically connected in series by means of conductors, so that electrolysis current passes from one cell to the next. The number of cells in a series is typically comprised between several tens up to more than four hundred, but this figure is not substantial for the present invention. The cells are arranged transversally in reference of main direction of the line they constitute. In other words the main dimension, or length, of each cell is substantially orthogonal to the main direction of a respective line, i.e. the circulation direction of current.

[0027] The Hall-Heroult process as such, the way to operate the latter, as well as the cell arrangement are known to a person skilled in the art and will not be described here in more detail. In the present description, the terms "upper" and "lower" refer to mechanical elements in use, with respect to a horizontal ground surface. Moreover, unless otherwise specifically mentioned, "conductive" means "electrically conductive".

[0028] As aforementioned an electrolytic cell used for the Hall-Heroult process typically comprises first a potshell and a lining, which are not illustrated on the figures. This cell also comprises a plurality of anode assemblies, each of which is formed by a metallic rod (so-called "anode rod") and at least one anode fixed to it by means of an anode yoke. This anodic assembly, known as such, is not part of the invention, so that it will not be described in detail. As shown on figure 1, superstructure **102** comprises a fixed frame **104** and a mobile metallic anode frame **106**, hereafter called "anode beam", which extends at the outer periphery of the fixed frame.

[0029] In an usual way each anode is provided with a metallic anode rod **108** for mechanical attachment and electrical connection to the anode beam. These anodes are not shown on figure 1, but their positioning is illustrated in particular on figure 4. On this figure 1, anode beam **106** is provided with pairs of hooks **110**, adapted to facilitate the attachment of the anode rods **108** to the anode beam **106** in the usual way. Two lines L1 and L2 are provided, on either side of superstructure **102**.

[0030] The general structure of a Hall-Heroult electrolysis pot is known *per se* and will not be explained here. It is sufficient to explain that the current is fed into the anode beam, flows from the anode beam to the plurality of anode rods and to the anodes in contact with the liquid electrolyte where the electrolytic reaction takes place. Then the current crosses the liquid metal pad resulting from the process and eventually will be collected at the cathode block.

[0031] The present invention is more particularly directed to a protection device **100**, which is adapted to cooperate with one anode line. On figure 1, two such devices, referenced I and II as a whole, cooperate with respective anodes

lines L1 and L2. Each of said devices forms a hood which separates the content of the electrolytic cell, as well as any off-gases generated by the electrolysis process, from the environmental atmosphere. Said off-gases are sucked through the superstructure into a gas treatment station, as mentioned above; this is known as such and will not be explained here in more detail. Device I will now be described, bearing in mind that the structure of device II is similar.

[0032] On figure 2, let us note XX the longitudinal axis of this device I, which is parallel in use to one anodes line, YY the transversal axis and ZZ the horizontal axis. "Inner" and "outer" refer to positions respectively close and away from the anodes in use, along YY axis. Said device of the invention comprises an elongated frame 1, which includes longitudinal beams 10, 11 and 12. Respective inner and outer beams 10 and 11 are positioned at the bottom of the frame, whereas upper beam 12 is positioned substantially above central beam 10.

[0033] Longitudinal beams 10 and 11 are mutually linked by horizontal cross pieces, namely a middle cross piece 13 as well as two opposite cross pieces 14 and 15. In addition longitudinal beams 10 and 12 are mutually linked by vertical posts, namely a middle post 16 as well as two opposite end posts 17 and 18. Several oblique bars 19 are also provided, so as to stiffen this frame. In addition two plain walls 20 and 21, each having substantially the shape of a quarter of a disc, are fixed at the opposite ends of said longitudinal beams 10, 11 and 12.

[0034] As shown on figure 6, longitudinal beam 10 supports two mutually parallel brackets 22 and 23, each being V shaped and positioned side-by-side. The upper surface of these brackets defines respective inner and outer tracks 24 and 25. In a similar way, upper beam 12 is equipped with two further parallel brackets 26 and 27, schematically illustrated on figure 7, which are positioned the one under the other. The outer surface of these brackets defines further respective lower and upper tracks 28 and 29, also schematically illustrated. As will be described in further details, these different tracks are adapted to cooperate with sliders, provided on panels which are part of the device I.

[0035] According to an essential feature of the invention, the device I comprises two sets of panels, namely a first set of inner panels 3, as well as a second set of outer panels 7. Advantageously the two sets comprise the same number, namely four inner panels 3a to 3d and four outer panels 6a to 6d in the illustrated example (see in particular figure 3). However a different number of panel can be considered.

[0036] Let us now describe one inner panel 3, with reference in particular to figures 8 to 17, bearing in mind that the structures of all inner panels are substantially identical. Viewed from the side, as shown on figure 10, this panel is bent so as to have substantially the shape of a quarter of the circle, with a diameter which is slightly inferior to that of each aforementioned wall 20 and 21.

[0037] Panel 3 comprises an inner skin 31 and an outer skin 32, which are mutually distant over part of the panel, so that the latter partly forms a hollow body. By way of an advantageous example, inner skin may be a stainless steel sheet, whereas outer skin may be a sheet of aluminium. This stainless steel sheet is adapted to be exposed to flames and high temperatures, while also reinforcing the aluminium sheet. In particular, said skins are separated on longitudinal ends of the panel, so as to define longitudinal walls 33 and 34. However outer skin 32 is designed to form some recesses, namely regions where this skin 32 extends close to inner skin 31.

[0038] More in detail, as shown on figures 8 to 10, outer skin 32 is first equipped with so-called long recesses, namely which extend over substantially its whole length : an inner recess 320, an opposite outer recess 321 and an intermediate recess 322. In addition three further so-called recesses are provided side-by-side, between long recesses 323 and 324: end recesses 325 and 326, as well as a median recess 327. As illustrated more in detail on figure 11, U shaped elements 41 and 43 are fixed on the inner and outer edges of each recess 325 and 326. These U shaped elements form handles, which enable operators to move the panel, as will be described hereafter. Since these handles are positioned in recesses, they do not protrude outside the global surface of outer skin, as shown on figure 10.

[0039] In addition, over some other regions of the panel, the two skins 31 and 32 contact each other and are mutually fixed by any appropriate means, such as rivets. First, on the outer longitudinal edge of the panel, skins are mutually fixed by a longitudinal line 330 of rivets. In this region, as shown on figure 12, a rim 34 is interposed between these skins, so as to protrude outside with respect to these skins. This rim extends substantially over the whole length of the panel, namely along XX axis.

[0040] As represented on figure 13, the panel 3 is equipped with some outside rollers 36, which form sliders. The shape of each roller is designed so as to cooperate with the above described inner track 24. Indeed said roller is provided with a V-shaped groove 37. In the present embodiment, two rollers are provided close to opposite longitudinal ends of the panel, bearing in mind that a superior number of rollers may be provided. In theory, one single roller may be considered: however this is not a preferred variant, due to its lack of stability.

[0041] The attachment of the roller on the skins is achieved by a fixing piece 38, which is substantially S shaped. This latter is attached on the inner skin by one of the above described rivet 330, as well as a further rivet 331. A physical axis 40 is mounted on facing walls of rim 34 and piece 38, with interposition of a U shaped element 42. This makes it possible to rotate roller 36 around a geometric axis A36, which extends along transverse axis YY.

[0042] Referring now to figures 14 and 17, a housing 44 is attached on the inner wall of rim 34, in particular by welding. A locking rod 46 is slidably mounted in this housing, through opposite top 440 and bottom 442 walls thereof. Moreover a horizontal pin 47, protruding from said rod, is adapted to slide along a vertical notch 444 in the housing. A compression

spring **48** is wrapped around rod **46**, so as to push said rod downwards, until pin **47** abuts against bottom wall of notch **444**. Finally a ring **49** allows activation by an operator, so that the latter may pull rod **46** upwards, against compression action of the spring **48**. As will be further described, locking rod **46** is adapted to engage a so-called locking hole **112**, provided in the upper face of longitudinal beam **11** as shown by figure 27.

[0043] Turning now to figure 15 transversal edges of recess **321**, namely parallel to YY axis, are mutually attached by opposite lines **332** and **333** of rivets. Finally a further line **334** of rivets, extending parallel to XX axis as shown on figure 8, is provided between adjacent recesses **321** and **322**. The presence of rivets is suitable, in particular due to thermal vibrations issues: indeed rivets have pressed heads on both ends, whereas fasteners are likely to loosen due to thermal expansion.

[0044] With reference again to figure 8, the inner longitudinal side of skins **31** and **32** are mutually fixed by a supplementary line **335** of rivets. As shown more in detail on figure 16, some of these rivets **335** ensure the attachment of a further slider **50**, which is adapted to cooperate with the lower track **28**. To this end, slider **50** is accommodated in a housing **35**, which is mounted on the ends of skins **31** and **32**. Moreover member **351** is intended to reinforcement purpose, whereas **352** denotes a structural frame module, for holding the slider tip **51**.

Let us now describe one outer panel **6**, with reference in particular to figures 18 to 26, bearing in mind that the structures of all outer panels are substantially identical. The structure of each outer panel **6** is to be compared with that of each inner panel **3**, as above described. In particular, said outer panel is formed by an inner skin **61** and an outer skin **62**. On figures 18 to 26 the mechanical elements of said outer panel **6**, which are analogous to those of inner panel **3** as shown on figures 8 to 17, are given the same references added by numbers respectively 30 and 300.

[0045] As can be seen on side view of figure 5, outer panel **6** has substantially the same curved shape as inner panel **3**. Due to its position outside panel **3**, said outer panel **6** has a slightly superior radius of curvature. In use, the two panels **3** and **6** are positioned in close proximity, so as to strengthen the sealing effect. On figure 5 let us note D36 the closest distance between outer skin **32** of inner panel **3** and inner skin **61** of outer panel **6**. Advantageously this distance D36 is very little, in particular inferior to the thickness of hollow bodies.

[0046] Figures 18 to 20, as well as 22 to 26 show structural elements of panel **6**, that are substantially identical to those of panel **3**, which are illustrated on figures 8 to 10, as well as 12 to 16. As shown on figures 18 to 20, panel **6** is provided with several recesses, similar to those of panel **3**. Panel **6** is also equipped with a rim **64**, identical to that **34** (see figure 22). As illustrated on figure 23, panel **6** comprises rollers **66**, analogous to those **36**. The inner wall of said rim **64** is provided with a housing **74**, adapted to cooperate with a locking rod **76** (see figure 24). Further, as shown on figure 26, panel **6** is equipped with a slider **80**. It shall also be noted that several lines of rivets **630** to **635** are also provided in several locations of panel **6**, in a similar way as rivets **330** to **335** of panel **3**.

[0047] The most significant difference between panels **3** and **6** is represented on figure 11. Recesses **625** and **626** of panel **6** are also provided with handles **71** and **73**: however, contrary to handles **41** and **43**, these handles **71** and **73** protrude outside with respect to outer skin **62**. Indeed, due to the outer position of panel **6**, handles **71** and **73** do not need to be integrated in the volume of the hollow body forming this panel. Moreover an outside protruding configuration is more convenient, in view of implementation by the operators.

[0048] Several examples of implementation, regarding the protection device according to the invention, will now be given.

[0049] Let us suppose first that anodes are in a normal use situation. Under these circumstances, the protection device is in its closing configuration illustrated in particular on figure 4. As shown on this figure, the different panels define a sort of shield in front of the side-by-side anodes. More in detail, inner panels **3a** and **3b** are in mutual contact, while panel **3a** abuts against wall **21**. In addition outer panels **6a** and **6b** are in mutual contact, while panel **6a** advantageously overlaps panel **3b**. Moreover outer panels **6c** and **6d** are in mutual contact, while panel **6d** abuts against opposite wall **20**, and inner panels **3c** and **3d** are in mutual contact. Advantageously, on the one hand outer panel **6c** overlaps inner panel **3d** whereas, on the other hand, outer panel **6b** overlaps inner panel **3c**. These different overlap zones, which are referenced OV on figure 4, advantageously have a length ensuring a thermal insulation effect. In this closing configuration, locking rod **46** extends into facing hole **112**: this cooperation between rod and hole applies at least for some of the above panels.

[0050] Let us suppose now that operators need to access to one of the anodes, for example the one A3 located behind outer panel **6a**. This situation may in particular occur this anode needs maintenance, or even needs to be replaced. Several possibilities can be considered.

[0051] In any case, the operator will move at least panel **6a** which is initially located in front of target anode A3. To this end, he first pulls upwards ring **49**, so as to disengage rod **46** out of initial hole **112** (see arrow F49 on figure 27). Under these circumstances, panel **6a** can then be pushed manually by the operator using handles **71** and **73**. More in detail this panel will slide with respect to the frame due to the cooperation, first between rollers **36** **66** and tracks **25** **24**, in addition between sliders **50** **80** and tracks **28** **29**. During this sliding motion.

[0052] In the example illustrated on figure 28, panel **6a** is pushed towards the left according to arrow F6a, bearing in mind that it may be pushed towards the right according to arrow f6a. At the end of this motion, this outer panel is

maintained in position, since spring 48 pushes locking rod 46 into another hole, located at the left with respect to the above mentioned initial hole (see arrow F48 on figure 27). Said panel 6a extends now in front of inner panel 3b namely, in other words, the latter is retracted behind this outer panel.

[0053] This sliding motion makes it possible to create a passage referenced P3, which allows access to the operator towards target anode A3. Once the operator has carried out its intended work on this anode, he disengages the locking rod and pushes panel 6a towards the right according to arrow G6a, so as to place this panel back in its initial position. At the end of these operations, panels are back in their initial shield configuration illustrated on figure 4.

[0054] In some cases, the width of the above passage P3 may not be sufficient. In this respect the operator pushes, not only panel 6a as described above, but also adjacent panel 6b. As shown on figure 29, it is in general more convenient to slide this adjacent panel 6b towards the right along arrow F6b, namely away from panel 6a. At the end of these two motions, panels 6a and 6b are located in front of respectively inner panels 3b and 3c.

[0055] Under these circumstances, this makes it possible to create a larger passage P'3 towards anode A3. It is to be noted that this large passage also enables access to adjacent anode A4. This passage P'3, which is schematically shown on figure 29, is also illustrated more in detail on figure 32. The latter is placed on the same sheet as figure 4 so as to show, the one above the other, the respective closing and access configurations of the protecting device according to the invention.

[0056] As a variant, both panels 6a and 6b may be displaced towards the left, so as to cover inner panels 3a and 3b in view of the creation of passage P'3. In case of an intervention on adjacent anode A4, only single panel 6b may be displaced so as to create a narrow passage, analogous to P3. Moreover steps analogous to those of the last two paragraphs may be carried out, in case of interventions on either anodes A7 or A8.

[0057] Let us suppose now that operators need to access to one of the anodes located behind an inner panel, for example the one A2 located behind inner panel 3b. In such an event different possibilities can also be considered, bearing in mind that they are slightly different from the one described above with respect to anode located behind outer panels.

[0058] In any case, the operator will move at least inner panel 3b towards the right according to arrow F3b on figure 30. After release of locking rod 46, the operator pushes manually this panel using handles 41 and 43. It is to be noted that, due to the inner position of this panel, at least the right handle 43 cannot be easily used at the end of the motion. Therefore it may be convenient to also displace outer panels 6a and 6b towards the right according to arrows F6a and F6b. Figure 30 illustrates the final position, as well as the arrows mentioned in the present paragraph. In this access configuration of figure 30, panel 6b is in front of inner panel 3c, whereas inner panels 3a and 3b are mutually away so as to create the passage P2.

[0059] In some cases, the width of the above passage P2 may not be sufficient. In this respect, as shown on figure 31, the operator needs to push towards the right, not only panel 3a as described above, but also adjacent panel 3b. Under these circumstances, both outer panels 6a and 6b need to be moved in a preliminary step, so that the operators might easily displace above mentioned inner panels. These different motions, illustrated on figure 31 by arrows F6a, F6b for outer panels, and by arrows F3a and F3b for inner panels, have a greater amplitude than motions of figure 30.

[0060] At the end of these motions, still with reference to figure 31, panels 3a and 3b are away from extremity wall 21, so as to create a larger passage P'2 towards anode A2. It is to be noted that this large passage also enables access to adjacent anode A1. In case of an intervention on this anode A1, it is also possible to move towards the right panel 3a, from the configuration illustrated in figure 30. Moreover steps analogous to those described in the last two paragraphs may be carried out, in case of interventions on either anodes A5 or A6. In this last situation, it is preferred to move towards the left, first the outer panels 6a and 6b, and then the inner panels 3c and 3d.

[0061] Figures 33 to 36 illustrate other possibilities, for what concerns access configurations of the device according to the invention. These figures represent the basic elements of the frame, as well as the different panels.

[0062] On figure 33 panel 3c is retracted behind panel 6b, so as to create a narrow passage P5, similar to P2 and P3, towards not shown anode A5. On figure 34 panels 3c and 3d are retracted behind respective panels 6b and 6c, so as to create a wider passage P'5, similar to P'2 and P'3. On figure 35 panels 3a to 3c are retracted behind respective panels 6a to 6c, so as to create a still wider passage P7. Finally, figure 36, all the inner panels 3a to 3d are retracted behind outer panels 6a to 6d, so as to create a maximal width passage P8.

[0063] The device according to the invention can be made in various other embodiments. In the present embodiment, eight hood panels are provided on each side. More generally, the hooding device according to the present invention advantageously comprises approximately ten hood panels on each side. It is to be compared to the conventional hooding devices of a DX+™ or DX+ Ultra™ electrolytic pot, which comprise 19 hood panels on each side.

[0064] The device according to the invention has many advantages over prior art devices. Operator work is easier and safer, with less effort being required to slide the hood panels instead of removing them, reducing the risk of back injuries. Moreover, sliding hood panels are less subject to mishandling and damage than prior art panels. Sliding one or two hood panels for an anode change or other purpose requiring access to the anodes reduces emission of noxious gases into the potroom, as there is no need to slide the hood panel totally if convenient access is possible with a partially

slid panel.

[0065] As adjacent hood panels partially overlap, gas sealing is better than with conventional hood panels. Their function as a heat shield is at least as efficient as for conventional hood panels. The electrical insulation concept remains the same as for conventional hoods.

[0066] Good cleaning of the sliding parts, in particular of rollers **36** and tracks **24,25**, is desirable after each anode change, in order to avoid accumulation of dust and crushed bath.

The device according to the invention can be used in a process for changing a spent anode assembly, comprising the steps of

- opening said protection device **100** by sliding at least one panel **3** from a closed position into an open position, such as to open an access to an anode assembly,
- replacing said spent anode assembly by a new anode assembly,
- closing said protection device **100** by sliding back said at least one panel **3** from said open position into said closed position.

[0067] This process can be carried out manually, or it can be carried using a pot tending machine; the sliding facility of the hood panel simplifies the operation of said pot tending machine for opening and closing the access to the anode assembly.

Claims

1. A protection device (100) for an anodic assembly of an electrolytic cell, suitable for the Hall-Heroult electrolysis process, said assembly comprising a superstructure (102) as well as a plurality of anodes (A1-A8) arranged along at least one line (L1, L2), said superstructure (102) comprising a fixed frame (104) of substantially rectangular shape and an anode beam (106) adapted to support anode rods (108),

said protection device, which is adapted to be placed in front of said anodes, comprising a frame (1) and a plurality of panels (3,6) which are mounted on the frame and are adapted to be displaced with respect to this frame, so as to allow access to said anodes for an operator,

characterized in that

said panels (3,6) comprise a first set of so-called inner panels (3a-3d), adjacent to anodes in use, as well as a second set of so-called outer panels (6a-6d), away from anodes in use, at least part of said panels and, preferably, all of these said panels being adapted to slide with respect to said frame (1) along a longitudinal direction (XX) of anodes line(s) so that

- in a so-called closing configuration, panels (3,6) form a substantially continuous shield (S) in front of the line of anodes; and
- in a so-called access configuration, at least one panel of inner set is at least partially retracted behind at least one panel of outer set, so as to define one passage (P2, P'2, P3, P'3) for access to at least one of the anodes which are part of said line.

2. A protection device (100) according to claim 1, **characterized in that** said first set of inner panels (3a-3d) and said second set of outer panels (6a-6d) comprise the same number of panels.

3. A protection device (100) according to claim 1 or 2, **characterized in that** said frame defines at least a first track (24 28) and at least a second track (25, 29), which are mutually parallel, each inner panel (3) comprising at least a first slider (36, 50) adapted to cooperate with said first track and each outer panel comprising at least a second slider (66, 80) adapted to cooperate with said second track.

4. A protection device (100) according to any of claims 1 to 3, **characterized in that** said frame comprises three longitudinal beams, namely a first so-called central beam (10), a second so-called outer beam (11) and a third so-called upper beam (12), as well as cross pieces (13-15) extending between central beam and outer beam, and posts 16-18) extending between central beam and upper beam.

5. A protection device (100) according to claim 4, **characterized in that** a pair of first (24) and second (25) tracks are provided on outer beam, whereas another pair of first (28) and second (29) tracks are provided on the upper beam.

6. A protection device (100) according to any of claims 1 to 5, **characterized in that** each panel (3, 6) comprises an inner skin (31, 61) and an outer skin (32, 62), said skins being at least partly distant so as to define a hollow body.
7. A protection device (100) according to claim 6, **characterized in that** said outer skin is provided with at least one recess, said recess being in particular provided with one handle (41, 43, 71, 73), said handle being either integrated into the global volume of the hollow body, or protruding out of said volume.
8. A protection device (100) according to any preceding claim wherein, in closing configuration, at least one inner panel and at least one outer panel define an overlap zone (OV) in front view.
9. A protection device (100) according to any preceding claim, wherein said device comprises locking means (46), movable between a locking position wherein they are adapted to lock said panel (3, 6) with respect to said frame in a predefined position, and a release position, said locking means comprising in particular a locking rod (46) mounted on said panel, as well as a hole (110) provided in said frame.
10. A protection device (100) according to preceding claim, comprising a compression spring (46) adapted to move said rod into said hole, as well as a release ring (49) adapted to remove said rod out of said hole.
11. A protection device (100) according to any preceding claim, wherein said device comprises insulation means, which are provided over part of said panel, in particular over opposite end walls of said panel.
12. An electrolytic cell suitable for the Hall-Heroult electrolysis process, comprising a protection device (100) according to any of the previous claims.
13. A method for changing a spent anode assembly in an electrolytic cell according to preceding claim, comprising the steps of:
 - opening said protection device (100) by sliding at least one panel from a closed position into an open position, such as to open an access to an anode assembly,
 - replacing said spent anode assembly by a new anode assembly,
 - closing said protection device (100) by sliding back said at least one panel from said open position into said closed position.
14. An aluminium electrolysis plant comprising at least one line of electrolytic cells of substantially rectangular shape, said cells being arranged side by side, and said plant further comprising means for electrically connecting said cells in series and for connecting the cathodic busbar of a cell to the anode beam of a downstream cell, **characterized in that** more than 80% of the electrolytic cells in at least one of said line, and preferably each electrolytic cell of said line, is an electrolytic cell according to claim 12.
15. A method for making aluminium by the Hall-Heroult electrolysis process using electrolytic cells of substantially rectangular shape, **characterized in that** said method is carried out in an aluminium electrolysis plant according to claim 14.

Fig. 1

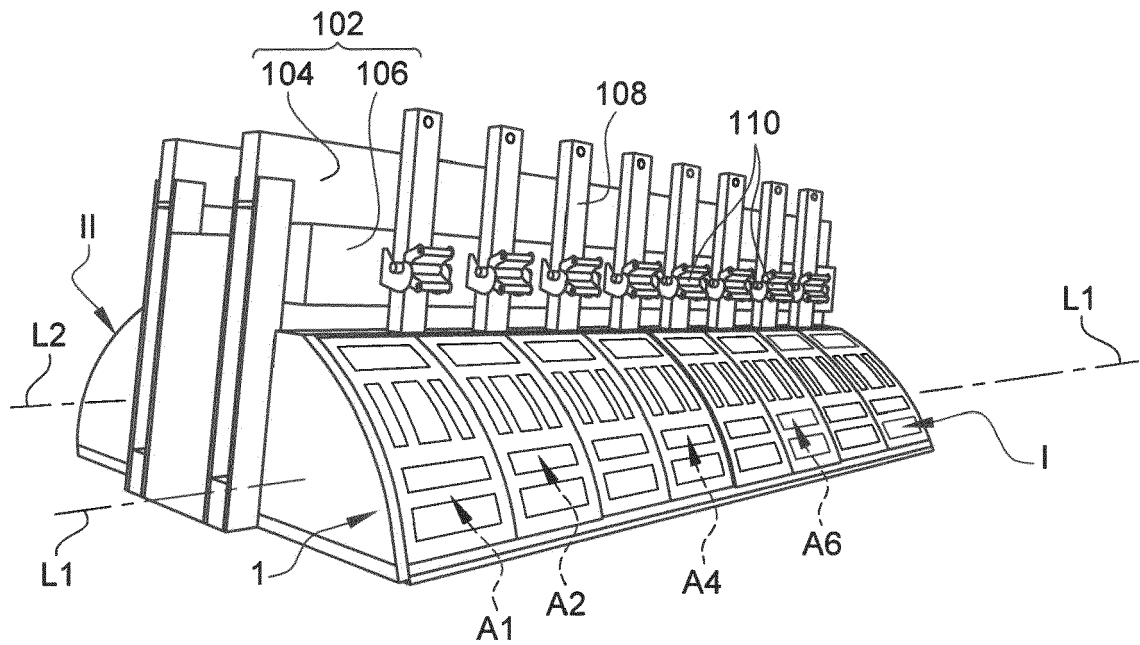


Fig. 5

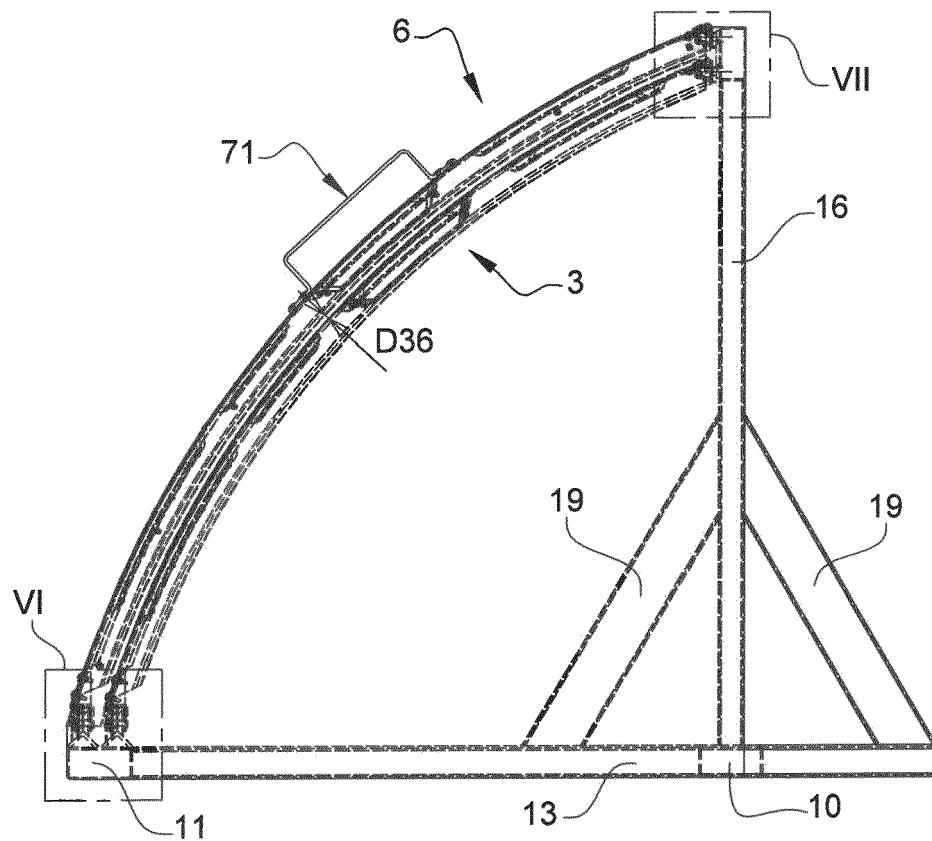


Fig. 2

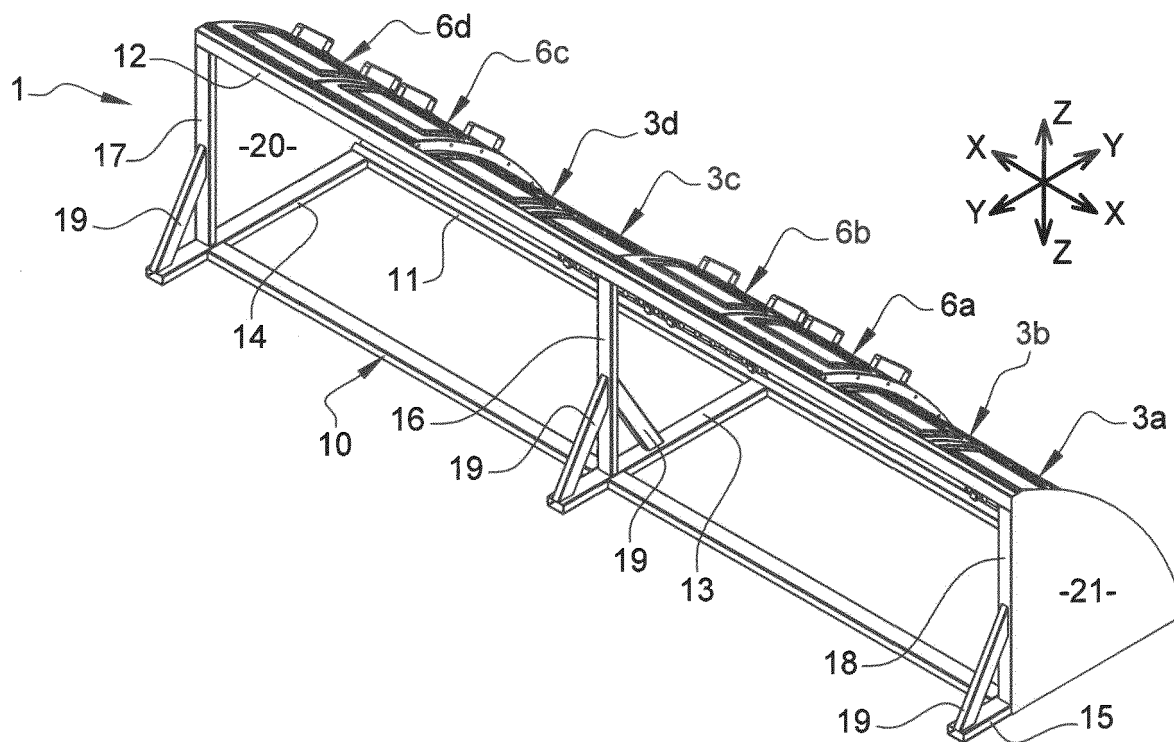


Fig. 3

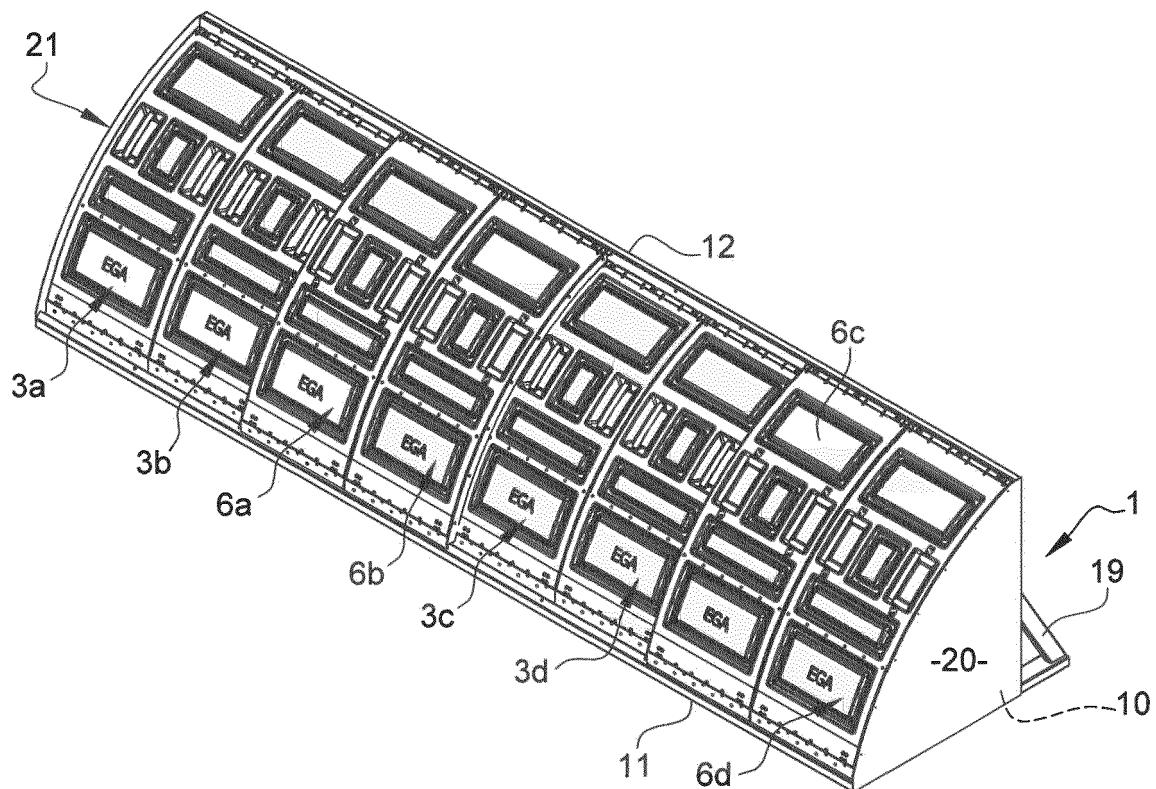


Fig. 4

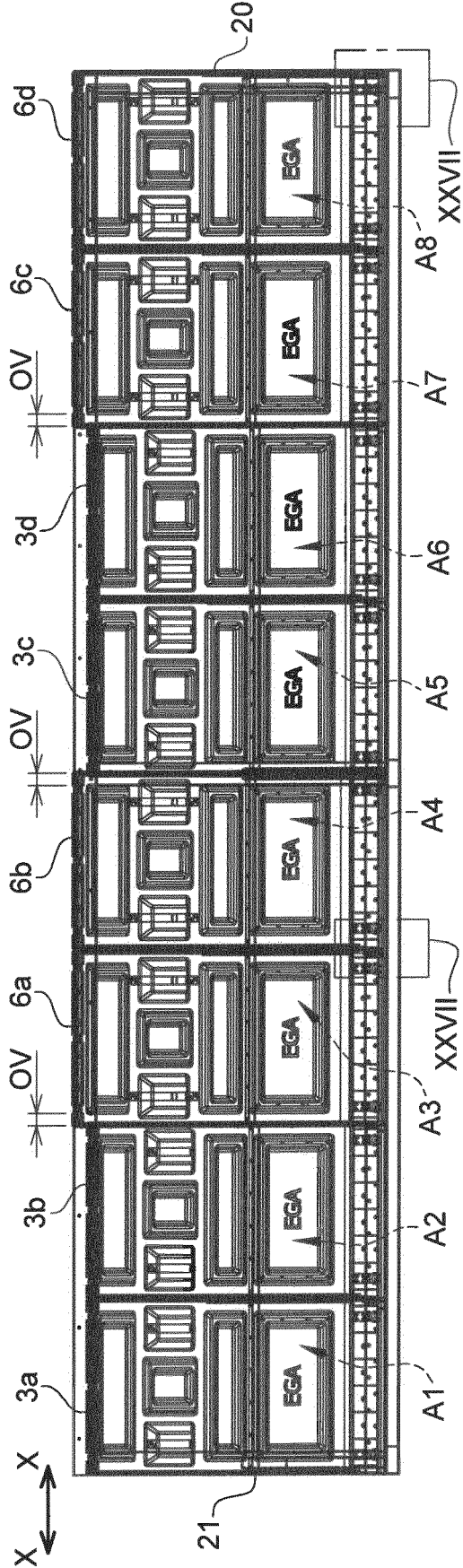


Fig. 32

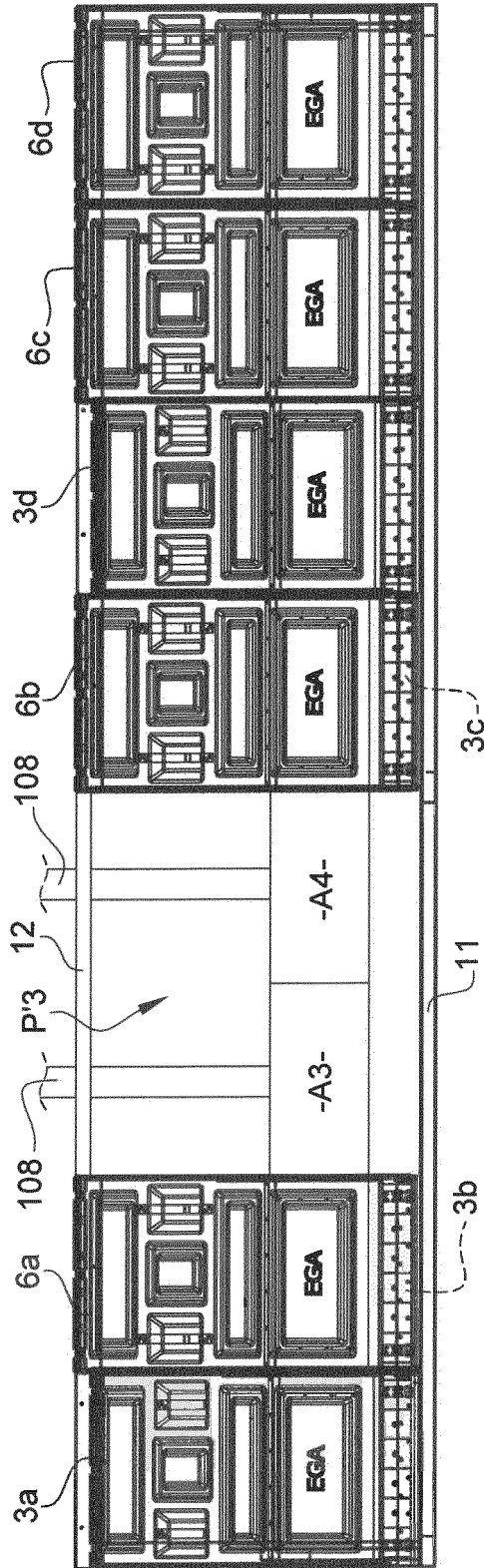


Fig. 6

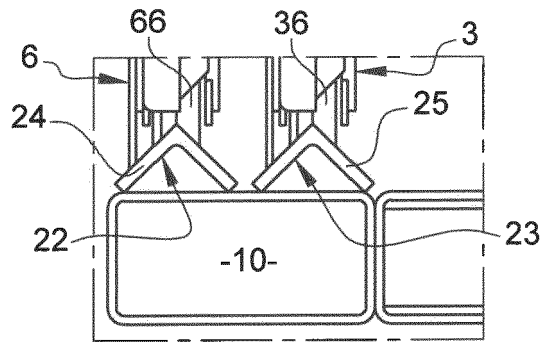


Fig. 7

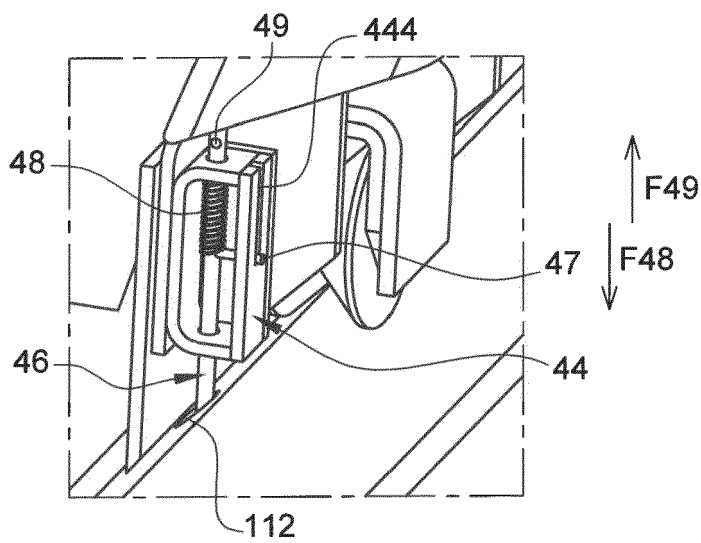
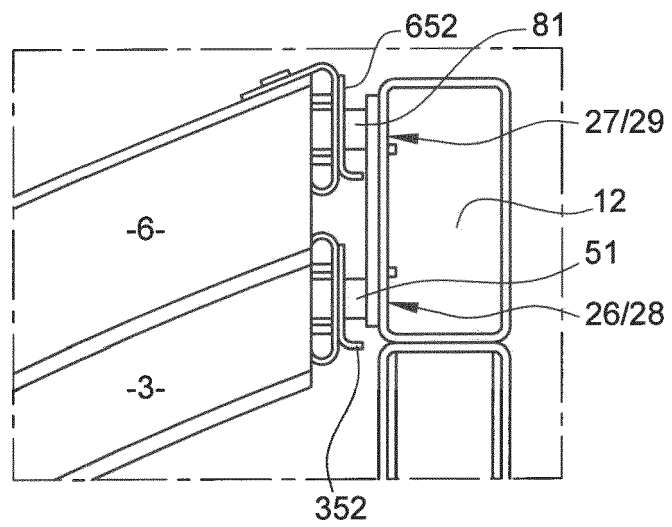


Fig. 27

Fig. 8

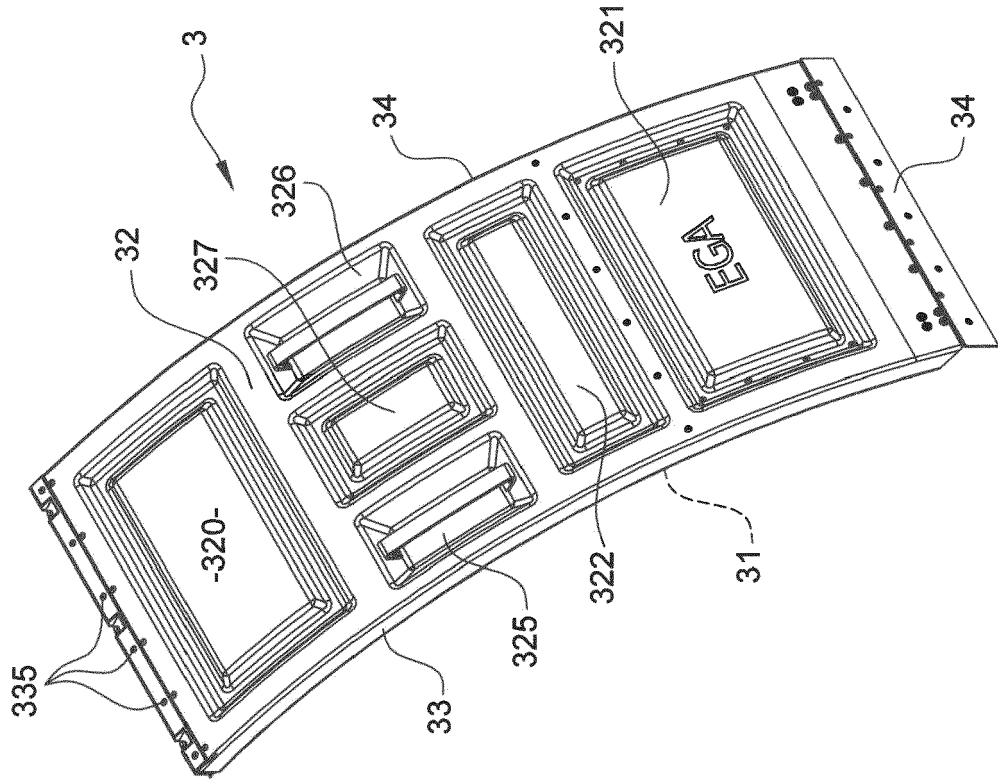


Fig. 9

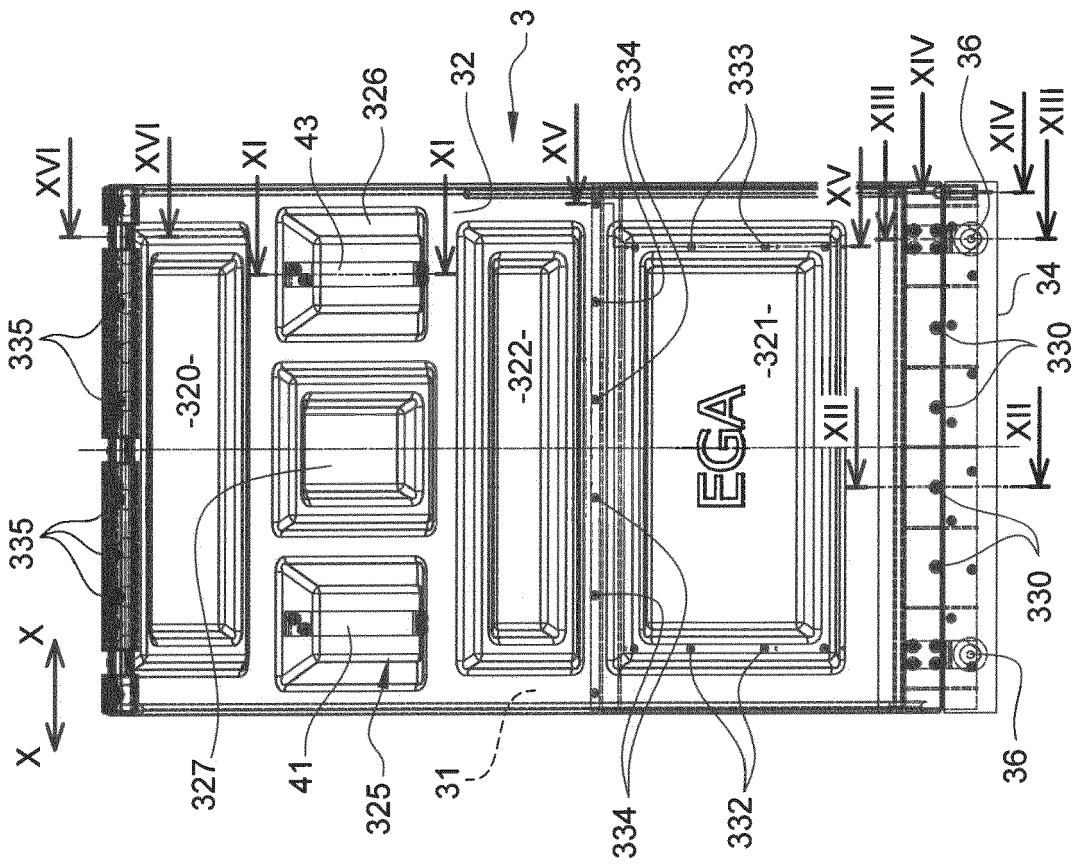


Fig. 10

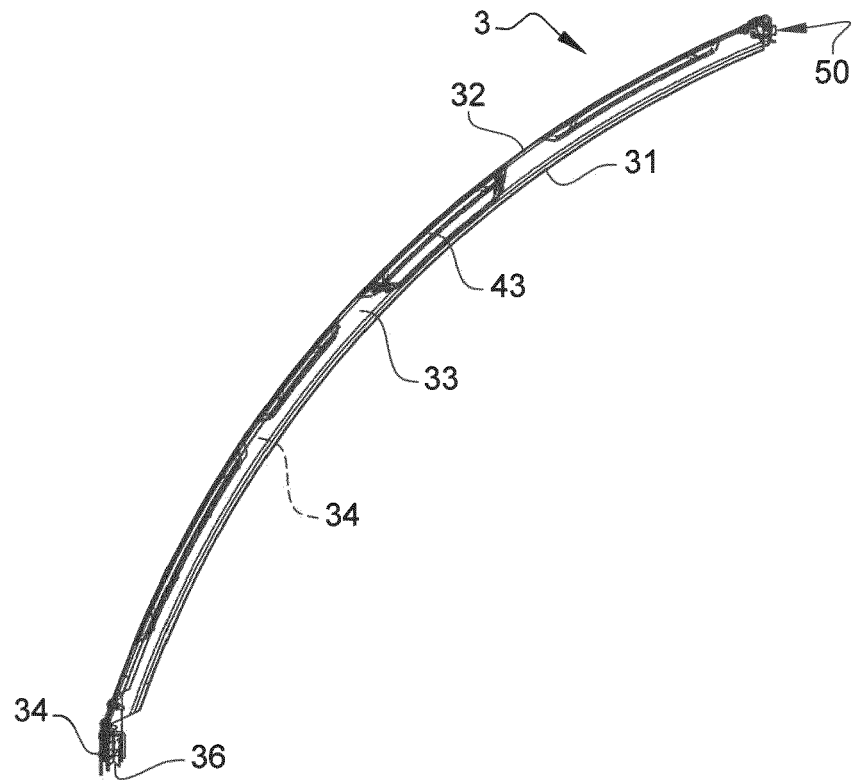


Fig. 15

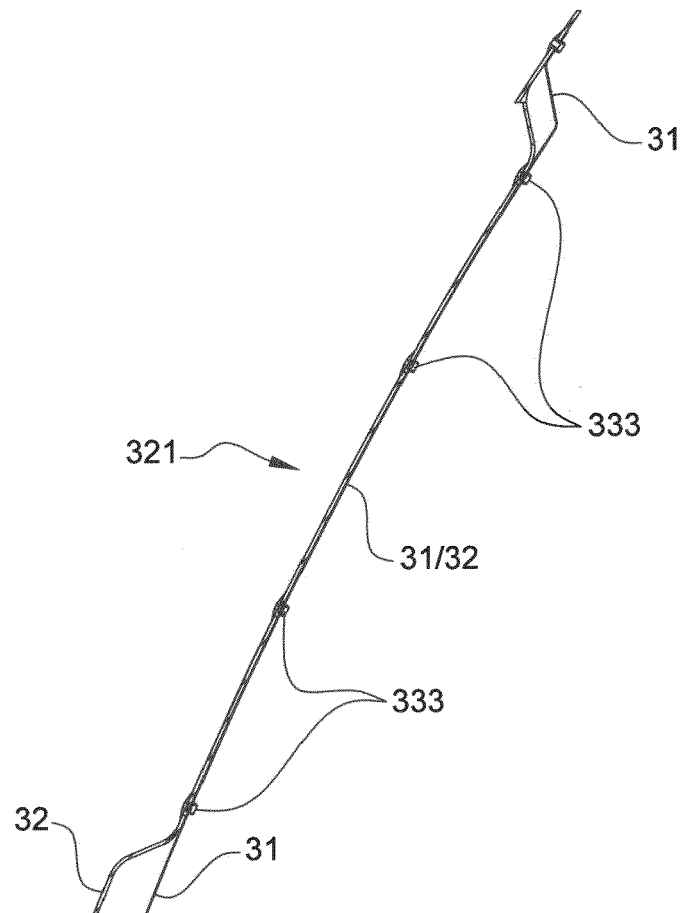


Fig. 11

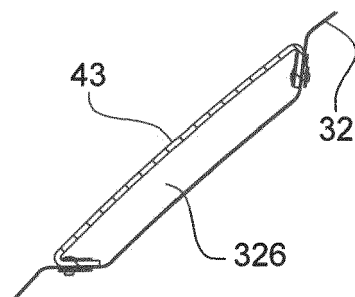


Fig. 12

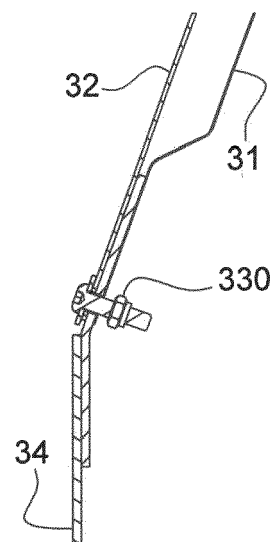


Fig. 13

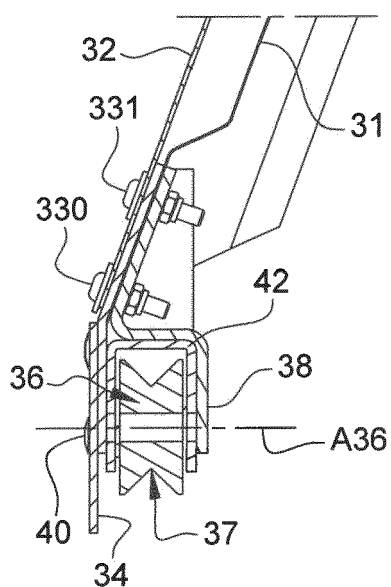


Fig. 14

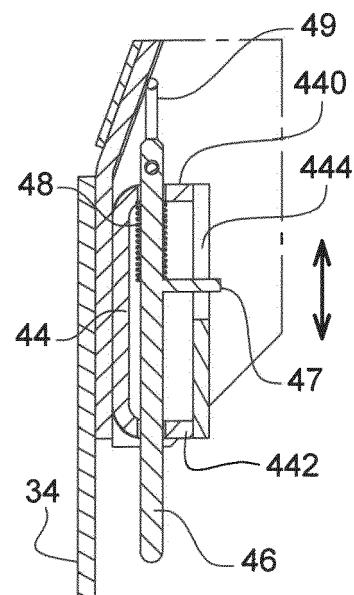


Fig. 16

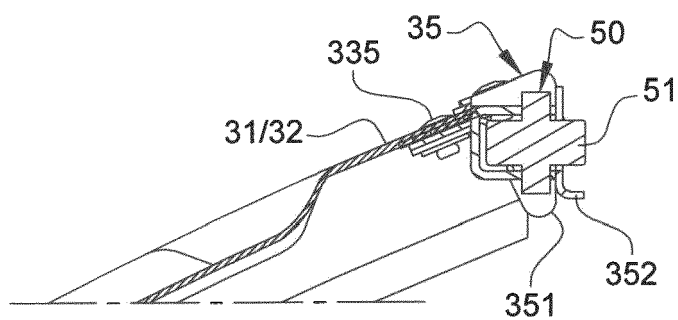


Fig. 17

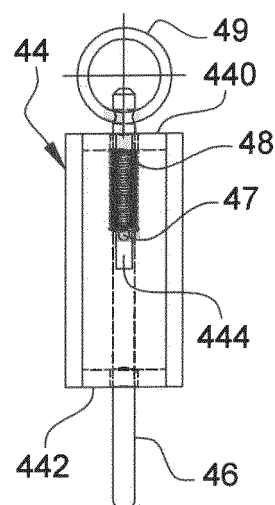


Fig. 20

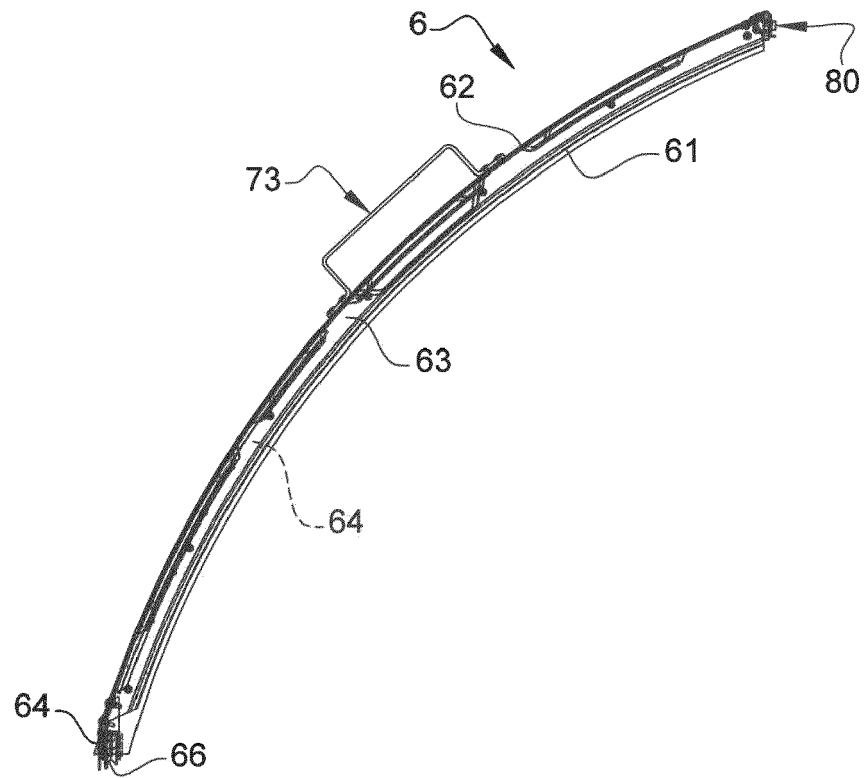


Fig. 25

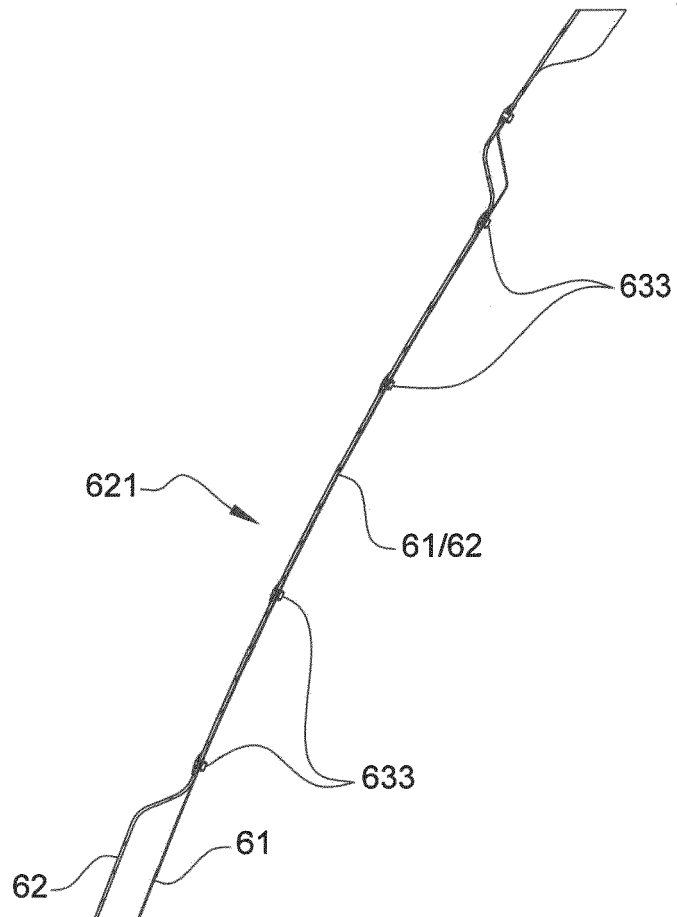


Fig. 21

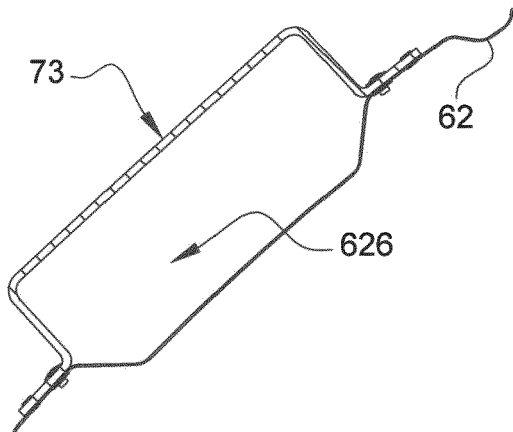


Fig. 22

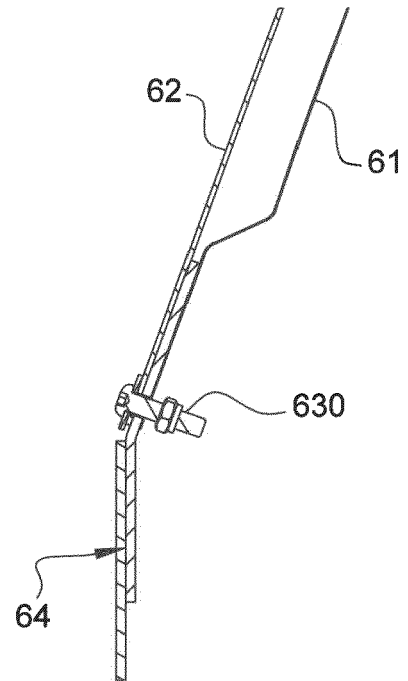


Fig. 23

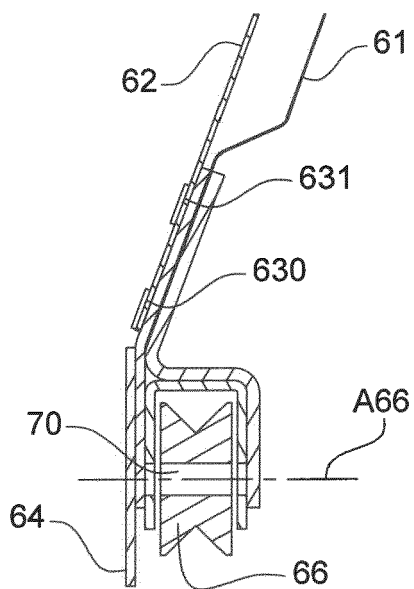


Fig. 24

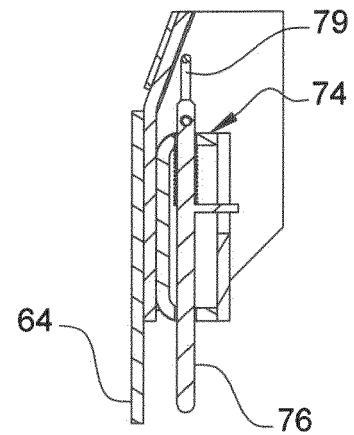


Fig. 26

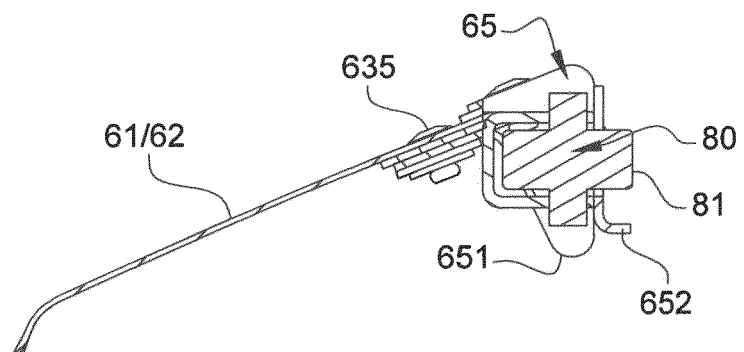


Fig. 28

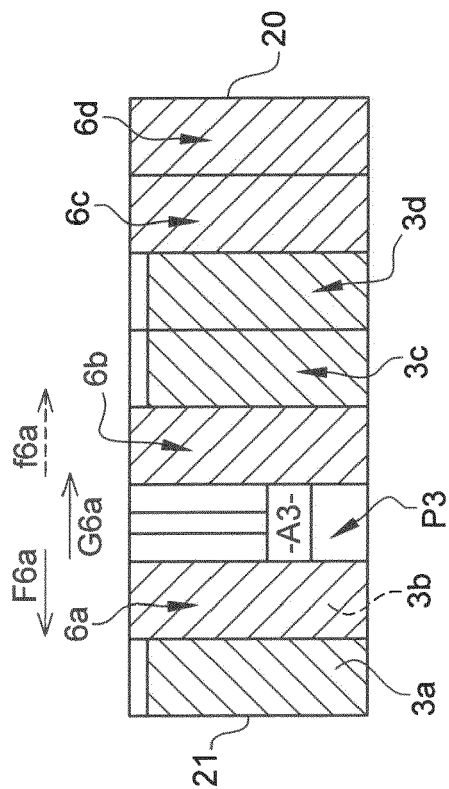


Fig. 29

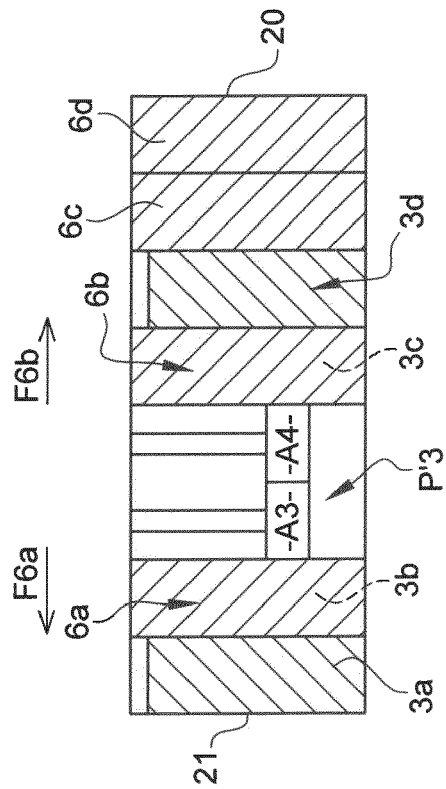


Fig. 30

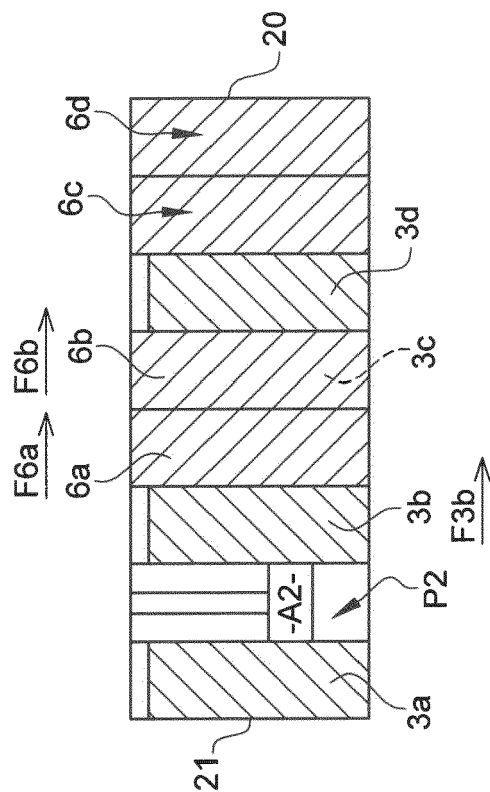


Fig. 31

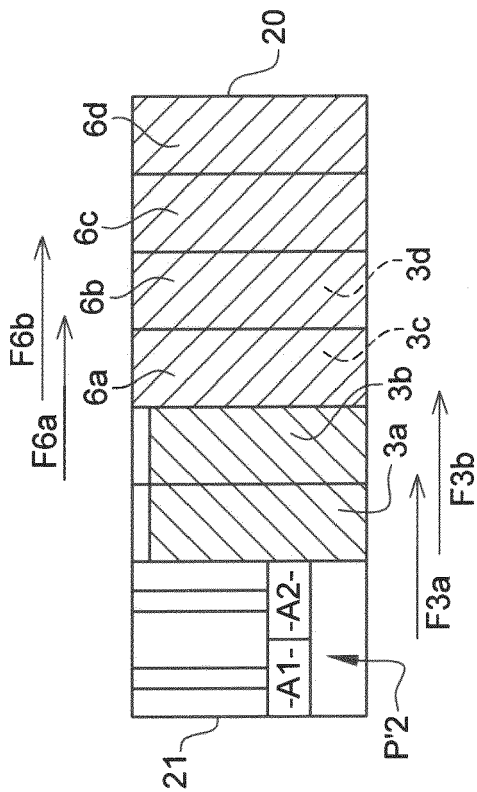


Fig. 33

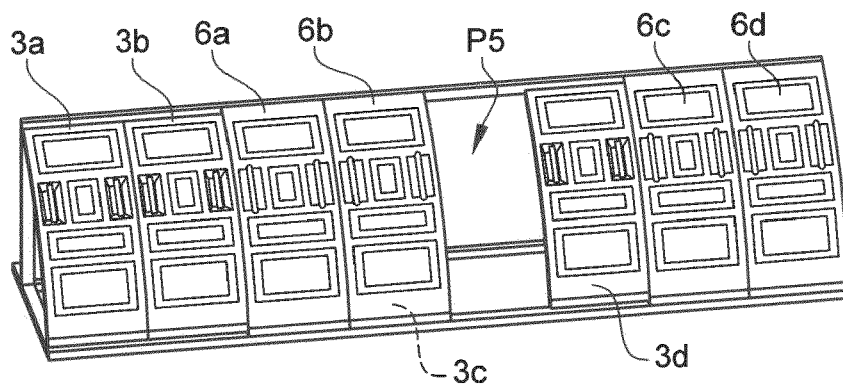


Fig. 34

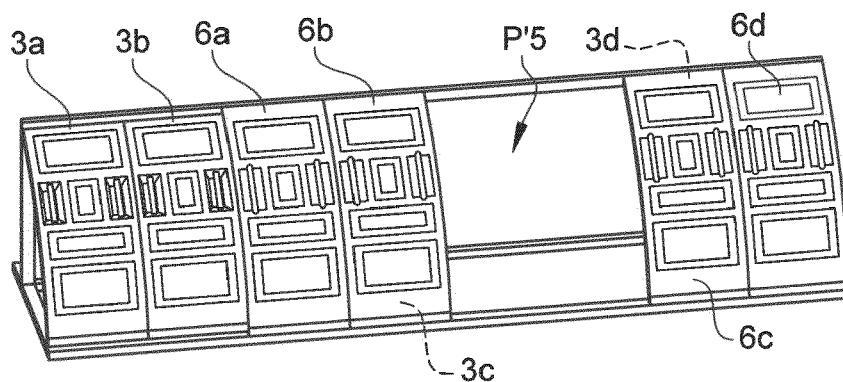


Fig. 35

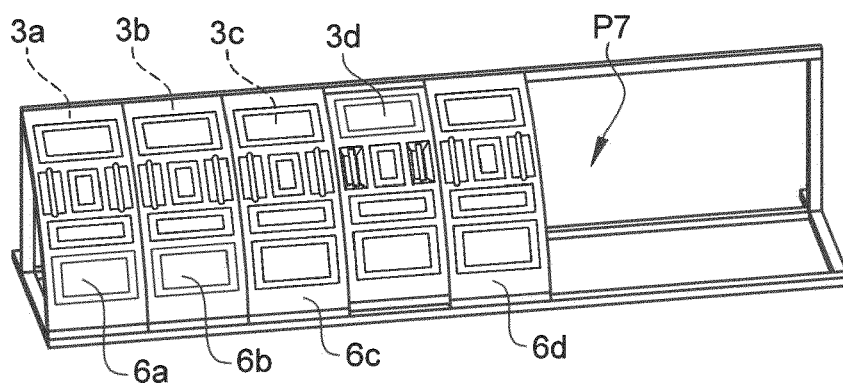
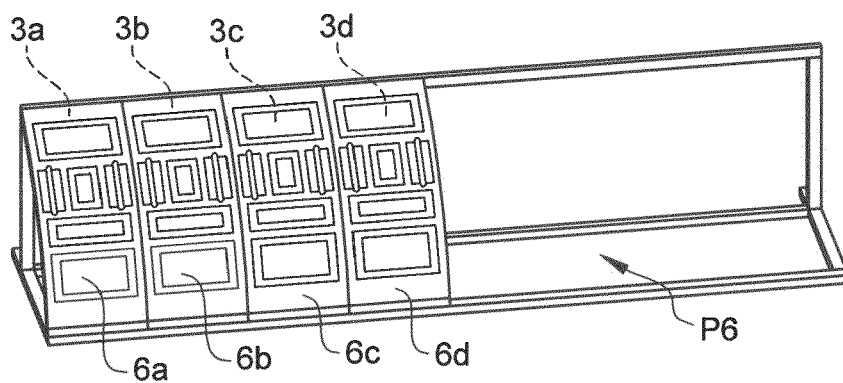


Fig. 36





EUROPEAN SEARCH REPORT

Application Number

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EPO FORM 1503 03.82 (P04C01)

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			C25C
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 8 April 2022	Examiner Juhart, Matjaz
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 21 20 4982

5

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