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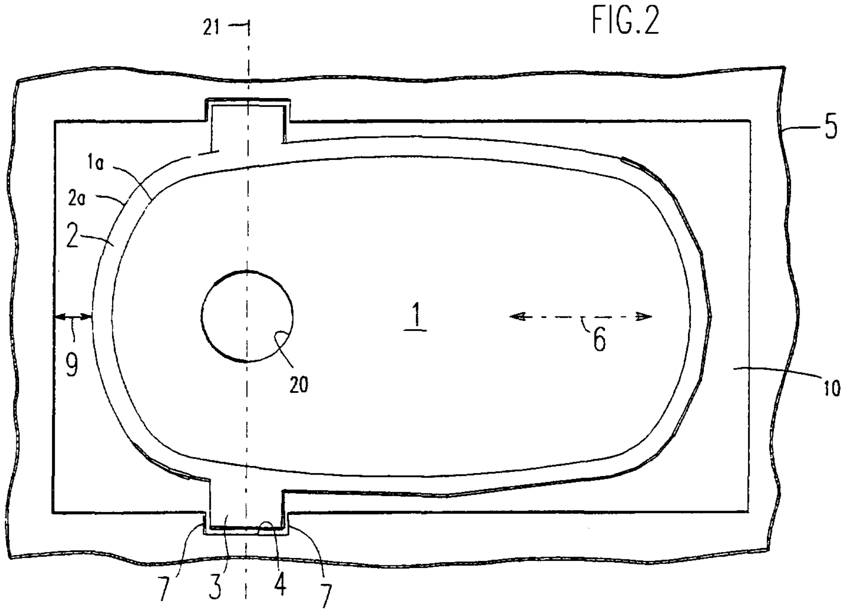
(54) Self-clamping refractory plate

(57) A self-clamping plate for use in a slide gate mechanism is described. The plate comprises a refractory plate having at least one sliding surface and a metal sheath around the peripheral edge of the plate. The metal sheath is adapted to secure the plate to the slide gate mechanism using at least two lugs cooperating with corresponding indentations. The lugs may be arranged or shaped to prevent misinsertion of the plate in the slide gate mechanism. An alternative embodiment describes a metal clamping ring having an inner chamfered edge mated to a similarly chamfered edge on the peripheral edge of a refractory plate. An outer edge of the clamping ring is adapted to be secured to the slide gate mechanism by at least two lugs cooperatively engaging corresponding indentations. A mounting means urges together the chamfered edges of the clamping ring and the refractory plate.

FIG.2



EP 0 995 524 A1

Description

FIELD OF THE INVENTION

[0001] This invention relates to slide gate mechanisms for use in the casting of molten metal. In particular, the present invention describes an article for securely, yet removably, mounting a refractory plate into such a mechanism.

DESCRIPTION OF THE PRIOR ART

[0002] In the casting of molten metal, a slide gate mechanism is commonly employed to control flow of the molten metal from a bottom orifice of a metallurgical vessel. A slide gate mechanism comprises at least two plates and a supporting frame for each plate. Each plate fits inside a plate location of a supporting frame. The supporting frames compressively engage the sliding surfaces of the plates and permit the plates to slide across one another. Each plate contains at least one throughbore opening that, when aligned with a throughbore opening on the other plate, permits flow of the molten metal.

[0003] A plate comprises a refractory plate and a metal sheath for securing the plate in the supporting frame. The metal sheath may be a can or band. A can will cover at least parts of the peripheral edge of the refractory plate and the non-sliding surface. The plate is typically secured in the can with mortar. The metal sheath may also be a band that circumscribes the peripheral edge of the refractory plate. The band may optionally be placed in tension to exert a compressive force on the refractory plate. Tension creates a compressive force on the plate thereby reducing crack opening and crack propagation. Tension is accomplished by a tightening means. One tightening means is hot banding, which places a heated band around the refractory. As the band cools, it shrinks to create a compressive force around the plate. The band may also be a split ring. The split ring may be a single piece or multiple pieces that may be spread to fit around the peripheral edge of the refractory plate before tightening. The tightening means will then comprise bolts, springs, clamps or other mechanical fasteners. The band may also, for example, be wrapped around the plate and welded in place.

[0004] A two-plate slide gate mechanism comprises a top plate and a bottom plate. The top plate is typically fixed in place and attached to an inner nozzle. The inner nozzle is fixedly secured within the bottom orifice but may protrude beyond the bottom orifice of the vessel. The bottom plate is movable and attached to a collector nozzle. Both top and bottom plates are typically fixedly attached to their respective nozzles by, for example, mortar.

[0005] While the plates may move relative to each other, they should not move relative to the nozzle to which they are attached. Movement may destroy the attachment of the plate to the nozzle and open an interface between the two pieces. Molten metal may then issue from such an opening and catastrophically affect the function of the slide gate and the casting of the metal. Consequently, the supporting frame typically prevents the plate from moving relative to the nozzle.

[0006] Although secured within the supporting frame, the plates must also be easily removable as wear and the corrosive and erosive effects of molten metal require the plates to be replaced periodically. A number of clamping means are used to securely, yet removably, mount a refractory plate into a slide gate mechanism while maintaining positive attachment of the plate to the nozzle. For example, the plate and nozzle may have a boss and complimentary indentation to lock the two pieces together. The presence of a boss or indentation on the non-sliding surface of the plate necessarily creates a plate that has only one sliding surface. Additionally, the boss is a ceramic and may crack under the stresses imposed by the slide gate mechanism.

[0007] A common technique to secure a plate involves clamping the plate within the supporting frame by immobilizing the plate with one or more screws, bolts, eccentric fasteners or other mechanical fasteners. The use of such fasteners requires an additional operation when clamping the plate in the supporting frame. Such fasteners can also create high stress concentrations and lead to fracture of the refractory plate. Certain metal sheathing can reduce stress concentrations. A rigid, metal can, for example, is able to diffuse stresses over a broad area, and the elasticity of the mortar may further reduce stresses transmitted to the plate. Stress concentrations may be greater in banded plates because a band is typically less rigid than a can and no mortar is present between the band and the refractory plate. Slits or recesses in the refractory plate beneath the metal band and at the point of loading have been used to reduce such stress concentrations. Metal sheathing does not completely eliminate stress concentrations and still requires an additional operation to secure the plate in the supporting frame.

[0008] Protrusions or indentations have been included on a plate's non-sliding surface to reduce the number of mechanical operations necessary to clamp the plate in the frame. The protrusions and indentations act to lock the plate in place by cooperating with corresponding features in the supporting frame. The protrusions and indentations are not coplanar with the sliding surface and, therefore, create torsional forces on the refractory plate. Such forces can create unacceptable stress concentrations, which may fracture or distort the can or plate.

[0009] Thermal expansion disparities between the refractory plate, metal sheath and supporting frame also produces stress concentrations in the plate. For example, a plate at around room temperature may be clamped in a supporting frame, which is at relatively high temperature. As the plate approaches operating temperatures, it expands against the clamping means to generate stresses that could crack, warp or destroy the plate or supporting frame.

[0010] Prior art attempts to securely, yet removably, mount a plate in a supporting frame of a slide gate mechanism have several deficiencies. Multiple mechanical operations can be involved in securing the plate in the mechanism. Mechanical clamps, such as screws or bolts, typically involve point loading, which create stress concentrations. Cracking and fracture of the refractory plates may follow. Thermal expansion may also generate stresses between the plate and the metal supporting frame. A metal sheath may reduce stresses on the refractory plate but has not eliminated fracture caused by the clamping means. A need persists for a plate, which may be reliably and removably secured in a slide gate mechanism without additional operations or concentrating mechanical or thermal stresses in the plate.

SUMMARY OF THE INVENTION

[0011] The present invention describes a self-clamping plate for use in a slide gate mechanism. One object of the invention is to secure a plate in a supporting frame of a slide gate mechanism without the need to perform additional mechanical operations. A second object of the invention is to reduce stress concentrations and torsional forces in a refractory plate secured in a supporting frame.

[0012] One aspect of the invention describes a refractory plate circumscribed by a metal sheath that may be secured to a supporting frame of a slide gate mechanism by at least two lugs cooperatively engaging corresponding indentations. The lugs may be either on the plate or the frame. At least one lug will be on either side of an axis defined by the direction of the plate's motion when the plate is in the slide gate mechanism.

[0013] Another aspect of the invention teaches having the lugs near the centerline of the plate's throughbore opening. Still another aspect of the invention discloses at least one lug designed to prevent misinsertion of the plate in the slide gate mechanism. Such a lug may be positioned or vary in shape to prevent misinsertion.

[0014] One embodiment of the metal sheath is described as a metal can into which the plate is fixedly secured. Alternatively, the invention describes the metal sheath as a metal band. The metal band may be a continuous band or a split ring secured to the refractory plate with a tightening means.

[0015] An alternative embodiment of the invention describes a plate having a refractory plate with a chamfered edge. The metal sheath is a clamping ring having an inner chamfered edge cooperatively engaging the chamfered edge of the refractory plate. The clamping ring also has an outer peripheral edge that may be secured in a plate location of a supporting frame by at least two lugs cooperatively engaging corresponding indentations. The lugs may be either on the supporting frame or the clamping ring. A mounting means is adapted to secure the clamping ring in the plate location so that the clamping ring may move freely perpendicular to the working face. The mounting means also urges the chamfered inner edge of the clamping ring against the chamfered edge of the refractory plate, so that as the metal and ceramic expand and contract, good contact will be maintained between the clamping ring and the plate.

[0016] One aspect of the alternative embodiment describes the mounting means as comprising a plurality of bolts loosely connecting the clamping ring and the supporting frame, and a plurality of springs between the frame and the clamping ring that urge the clamping ring against the refractory plate.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 shows a prior art metal-sheathed refractory plate secured to the slide gate mechanism with eccentric fasteners.

[0018] FIG. 2 shows a metal-sheathed refractory plate of the present invention having lugs on the outside surface of a metal band which lugs engage indentations in the slide gate mechanism.

[0019] FIG. 3 shows a metal-sheathed refractory plate of the present invention having lugs shaped and located to prevent misinsertion of the plate in the slide gate mechanism.

[0020] FIG. 4 shows a refractory plate circumscribed by a two-piece, split ring metal band tightened against the peripheral edge of the plate with a pair of bolts.

[0021] FIG. 4A shows a non-planar interface between the metal sheath and the peripheral edge of the refractory plate.

[0022] FIG. 5 shows a refractory plate having a chamfered peripheral edge fitting into a clamp ring having the inverse chamfer. Springs urge the clamp ring against the plate and lugs on the clamp ring secure the plate in the slide gate mechanism.

[0023] FIG. 6 is a cross-sectional view of Fig. 5 along the A-A plane showing the plate, clamping ring, bolts holding the ring in place and springs urging the chamfered edge of the clamping ring against the corresponding chamfered edge of the plate.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] As shown in FIG. 1, prior art commonly secures a refractory plate **1** to a supporting frame **5** by clamping the refractory plate **1** into a plate location **10** of the frame **5**. Clamping may involve an eccentric fastener **11** impinging on a metal sheath **2** surrounding the peripheral edge **1A** of the refractory plate **1**. Pressure from the fasteners **11** may create stress concentrations within the refractory plate **1** leading to fracture.

[0025] One embodiment of the article of the present invention is shown in FIG. 2. A metal sheath **2** circumscribes at least part of the peripheral edge **1A** of a refractory plate **1,** which also has at least one throughbore opening **20** to permit the passage of molten metal. The throughbore opening **20** has a centerline **21** perpendicular to the axis of motion **6** of the plate **1**. The metal sheath **2** is shown seated at a plate location **10** in a supporting frame **5** of a slide gate mechanism (not shown). It is to be distinctly understood that whenever reference is made to a plate location in a slide gate mechanism, the presence of a supporting frame is implied.

[0026] A space **9** should be present to accommodate thermal expansion of the metal sheath **2** and refractory plate **1**. At least two lugs **3** are present to secure the outer peripheral edge **2A** of the metal sheath **2** to the supporting frame **5**. The lugs **3** are adapted to fit into indentations **4**. It should be appreciated that the lugs **3** could be on the supporting frame **5** or the outer peripheral edge **2A** of the metal sheath **2** with the indentations **4** in the metal sheath **2** or frame **5**, respectively. For clarity and simplicity, any reference to a lug on the metal sheath will subsume the alternative embodiment with the lug on the frame. This includes various combinations of lugs and indentations including, for example, where at least one lug and at least one indentation are each on the plate.

[0027] Placement of the lugs along the outer peripheral edge of the plate permits the lugs to be placed near the sliding surface of the plate. Prior art has described protrusions on the non-sliding surface of the plate that are inherently distant from the sliding surface. Torsional stresses increase proportionally to the distance of a protrusion from the sliding surface. Therefore, lugs on the outer peripheral edge will generate lower torsional stresses than protrusions on the non-sliding surface. In the present invention, the lugs will preferably be near the sliding surface.

[0028] Lugs should fit in the indentations with a mechanical tolerance between 0.1 mm and 1 mm, preferably 0.1 mm to 0.5 mm. The lugs **3** should be located on each side of the axis of motion **6**. Movement of the frame **5** will cause the lugs **3** to contact faces **7** in the indentation **4** thereby moving the metal sheath **2** and refractory plate **1**. The metal sheath **2** around the peripheral edge **1A** of the refractory plate **1** disperses the stresses generated by this contact. Stress concentrations at any single point in the refractory plate **1** are thereby reduced.

[0029] Lugs may be created by a number of processes. Lugs may be formed from or welded onto the metal sheath. Lugs may also be attached using adhesive or mechanical fasteners. Lugs may be machined from the metal sheath or formed by bending, stamping or pressing. Lugs may even be positioned or machined after the metal sheath is fixed on the refractory plate. Obviously, numerous methods of forming lugs may be employed so long as the completed lug is operable.

[0030] Lugs have width, length and height dimensions. Length refers to the dimension parallel to the peripheral edge and along the axis of motion. Width refers to the dimension perpendicular to the peripheral edge and axis of motion, that is, the distance a lug projects from the sheath's outer peripheral edge. Height refers to the remaining orthogonal axis dimension, that is, along the thickness of the plate.

[0031] Lugs should be large enough to provide the mechanical strength necessary to move the refractory plate but small enough that differential thermal expansion between the lugs and the indentations does not impair a strong mechanical connection. Larger lugs will be less likely to detach from the metal sheath and will also be stronger and less subject to mechanical stresses. However, larger lugs will thermally expand a greater amount and decrease the fit at any temperature. Additionally, wider lugs tend to induce a greater torsional stress on the plate force because such stress is roughly proportional to the width of the lug.

[0032] To satisfy these competing criteria, a lug should be between 50 and 150, preferably about 80 to 120, millimeters long, and between 1 and 10, preferably about 4 to 6, millimeters wide. The height of the lug will typically be at least one-half the thickness of the plate. Preferably, the lug is at least two-thirds the thickness of the plate.

[0033] Lugs should extend perpendicular to the motion of the plate. With reference to FIG. 2, lugs **3** perpendicular to the axis of motion **6** engage the supporting frame **5** through contact faces **7**, thereby moving the plate **1**. The lugs **3** should be positioned to minimize torsional forces on the plate **1**. Lugs **3** will preferably be on both sides of the axis of motion **6**. Lugs near the centerline **21** of the plate's throughbore opening **20** may reduce misalignment of the plate and the nozzle caused by thermal variation, thereby reducing the chance of joint fracture. Near in this case is defined as within 100 mm of the centerline **21**. Lugs away from the centerline may reduce the working temperature of the lugs during pouring and improve mechanical tolerances. In a preferred embodiment, two lugs **3** on opposite sides of the axis of motion **6** will be at the centerline **21** of the plate's throughbore opening **20**.

[0034] The placement and dimensions of the lugs can be varied to prevent misinsertion of the plate. For example, asymmetrical placement of the lugs will prevent the plate from being inserted improperly. Varying the length or the width of the lugs will also prevent misinsertion. FIG. 3 shows a metal sheath **2** having a first lug **3A** cooperating with a first indentation **4A**. A second lug **3B** is located along the metal sheath **2** asymmetrically from the first lug **3A** and, in this example, the second lug **3B** is also differently shaped from the first lug **3A**. The second lug **3B** cooperates with a second indentation **4B**. The different placement and shape of the lugs prevent misinsertion.

[0035] The plate's metal sheath may comprise a metal can or band. When using a metal can, a refractory plate is typically mortared into the can so that the peripheral edge and at least part of the non-sliding surface is metal-sheathed. On the non-sliding surface, the metal can may also have protrusions to align the plate within the mechanism. Instead of a metal can, a metal band, which is mechanically secured to the plate, may also be used. Physical dimensions of the sheath are dictated by the need for the sheath to handle stresses transmitted through the lugs. The sheath may cover the entire peripheral edge of the refractory plate. Preferably, the sheath covers at least one-half the thickness of the plate. The thickness of the metal comprising the sheath should be at least about 3 mm for strength. Preferably, the sheath is about 5-10 mm thick.

[0036] A metal band may be secured to the plate by a number of known tightening means. A tightening means is any sort of procedure or fastener intended to secure the band around the plate, and may include, for example, hot banding, welding, adhesives, and mechanical fasteners such as clamps, bolts, rivets and the like. Particularly useful are mechanical fasteners that permit removal of the metal band from the plate. The metal band may comprise a single piece or multiple pieces. Commonly, the band is an unbroken, continuous band secured by hot banding or welding. The band may also be a split ring. A split ring means any discontinuous ring comprising either one or more pieces. A split ring may be easily fitted around the plate and can later be secured to the plate by a tightening means. For example, FIG. 4 shows a metal band comprising a first piece **2A** and a second piece **2B**. The pieces are tightened around the refractory plate **1** by a pair of bolts **11** that draw the two pieces together and secure the pieces around the peripheral edge **1A** of the refractory plate **1**. When the plate is spent, the bolts **11** may be loosened and the refractory plate 1 removed from the metal band **2**. The metal band **2** may be reused and a new refractory plate may be clamped in the metal band. As shown in FIG. 4A, the metal band **2** and peripheral edge **1A** may have a non-linear interface **12**. Such an interface **12** may be grooved or notched to secure the plate **1** to the metal band **2**.

[0037] The metal sheath, as either a can or band, may be made from more than one layer of metal. It is known that the heat transfer coefficient perpendicular to a layer of metal is lower than parallel to the same layer. Layers of metal within the metal sheath parallel to the height of the refractory plate and perpendicular to the width of the lug can decrease heat transfer through the sheath. Lower heat transfer may result in lower operating temperatures for the lugs and, consequently, lower thermally induced mechanical stresses.

[0038] An alternative embodiment of the present invention is shown in Figs. 5 and 6. A metal band is present as a clamping ring **2** having a working face **25** and an inner chamfered edge **14**, which preferably has an angle perpendicular to the working face **25** of between about ten (10) and twenty (20) degrees. The refractory plate **1** is thicker than the clamping ring 2 and has a peripheral edge **1A** chamfered to mate with the inner edge **14** of the clamping ring **2**. A mounting means secures the clamping ring **2** to a plate location **10** in a supporting frame **5** of the slide gate mechanism (not shown) so that in operation the clamping ring **2** is urged against the plate 1 and can move only perpendicular to the working surface **2A**. As the plate 1 and the clamping ring **2** expand, the clamping ring **2** slides along the chamfered edge to remain in alignment with the plate **1**.

[0039] FIG. 6 shows a mounting means comprising bolts **21** and springs **22**, which continuously urge together the chamfered edges of the plate **1A** and the clamping ring **14**. Not shown is a second refractory plate that would compressively engage the plate **1** while the slide gate is in operation. This arrangement permits a secure contact between the plate **1** and the clamping ring **2** regardless of the dissimilar thermal expansion or contraction of the plate **1,** ring **2** or mechanism **5**. Contact around the entire peripheral edge **1A** of the plate **1** is expected to reduce stress concentrations in the plate **1**. Such contact may also impart a crack-closing pre-load on the plate.

[0040] The mounting means can be any arrangement of mechanical elements that secures the clamping plate to the slide gate mechanism and urges the clamping plate against the plate. Obvious variations include bolts, rivet or dowels in combination with any elastic material or spring that would push the clamping ring against the plate.

[0041] Obviously, numerous modifications and variations of the present invention are possible. It is, therefore, to be understood that within the scope of the following claims, the invention may be practiced otherwise than as specifically described.

Claims

1. Self-clamping plate for use in a slide gate mechanism having at least a plate location and permitting relative motion of at least two plates along an axis of motion, the self-clamping plate comprising:

(a) a refractory plate having at least one sliding surface, a peripheral edge, a throughbore opening with a centerline perpendicular to the axis of motion, and two sides defined by the axis of motion; and

(b) a metal sheath having an inner surface and an outer peripheral edge, the inner surface secured against the refractory plate and the outer peripheral edge adapted to be secured in the plate location on each side of the refractory plate **characterised in that** the outer peripheral edge is adapted to be secured in the plate location on each side of the refractory plate by at least one lug cooperating with a corresponding indentation, the lugs having dimensions of length parallel to the axis and width perpendicular to the axis.

2. Self-clamping plate according to claim 1, **characterised in that** at least one lug is on the outer peripheral edge of the metal sheath.

3. Self-clamping plate according to claim 1 or 2, **characterised in that** the outer peripheral edge has at least one lug on each side of the refractory plate cooperating with a corresponding indentation in the plate location thereby securing the self-clamping plate in the plate location.

4. Self-clamping plate according to anyone of claims 1 to 3, **characterised in that** at least one indentation is on the outer peripheral edge of the metal sheath.

5. Self-clamping plate according to anyone of claims 1 to 4, **characterised in that** the lugs are between about 50 and 200 millimeters long.

6. Self-clamping plate according to anyone of claims 1 to 5, **characterised in that** the lugs are between about 3 and 20 millimeters wide.

7. Self-clamping plate according to anyone of claims 1 to 6, **characterised in that** the lugs are positioned to reduce torsional forces on the refractory plate.

8. Self-clamping plate according to anyone of claims 1 to 7, **characterised in that** the lugs are shaped to reduce torsional forces on the refractory plate.

9. Self-clamping plate according to anyone of claims 1 to 8, **characterised in that** the lugs are positioned near the centerline of the throughbore opening.

10. Self-clamping plate according to anyone of claims 1 to 9, **characterised in that** at least one lug is positioned to prevent misinsertion of the plate in the plate location.

11. Self-clamping plate according to anyone of claims 1 to 10, **characterised in that** at least one lug is shaped to prevent misinsertion of the plate in the slide gate mechanism.

12. Self-clamping plate according to anyone of claims 1 to 11, **characterized in that** the metal sheath is between 3 and 20 millimeters thick along the outer peripheral edge.

13. Self-clamping plate according to anyone of claims 1 to 12, **characterised in that** the inner surface of the metal sheath and the peripheral edge of the refractory plate form an interface which is non-planar.

14. Self-clamping plate according to anyone of claims 1 to 13, **characterised in that** the metal sheath completely circumscribes the peripheral edge of the refractory plate.

15. Self-clamping plate according to anyone of claims 1 to 14, **characterised in that** at least part of the metal sheath comprises more than one layer of metal parallel to the outer peripheral edge.

16. Self-clamping plate according to anyone of claims 1 to 15, **characterised in that** the metal sheath is a metal band.

17. Self-clamping plate according to claim 16, **characterised in that** the metal band is a split-ring, which is secured against the peripheral edge of the plate by a tightening means.

18. Self-clamping plate according to claim 17, **characterised in that** the tightening means comprises at least one mechanical fastener selected from the group consisting of bolts, clamps, welds, adhesives, and rivets.

19. Self-clamping plate according to anyone of claims 1 to 15, **characterised in that :**

(a) the metal sheath is a clamping ring having a working face, a thickness, and the inner surface is chamfered;
(b) the refractory plate has a thickness greater than the thickness of the clamping ring and is chamfered to cooperatively engage the chamfered inner surface of the clamping ring; and
(c) a mounting means is adapted to urge the clamping ring against the refractory plate and hold the clamping ring in the plate location of the slide gate mechanism so that the clamping ring may move freely perpendicular to the working face.

20. Assembly according to claim 19, **characterised in that** the mounting means comprises a plurality of bolts adapted to loosely attach the clamping means to the slide gate mechanism and at least one spring adapted to urge the clamping means against the refractory plate.

FIG.1
PRIOR ART

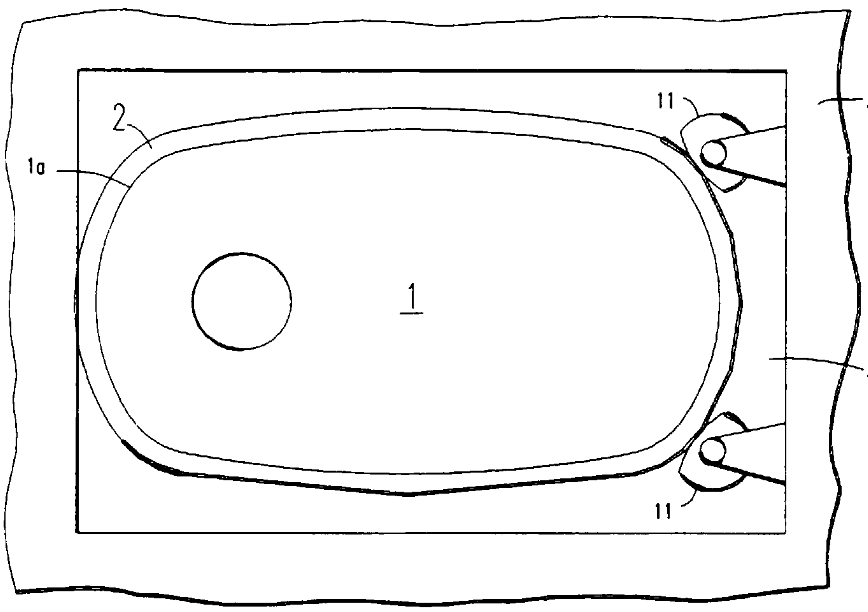


FIG.2

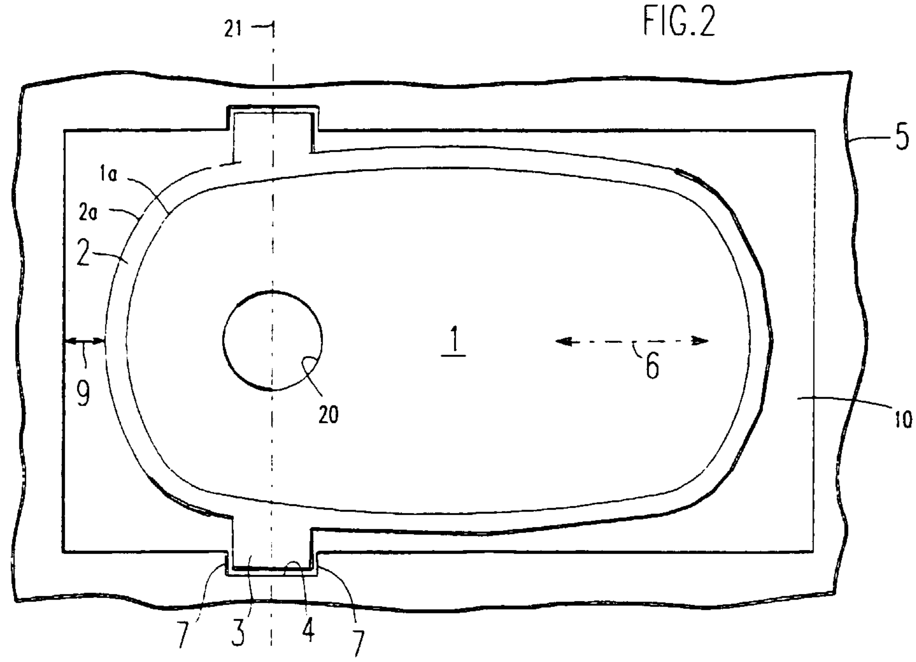


FIG.3

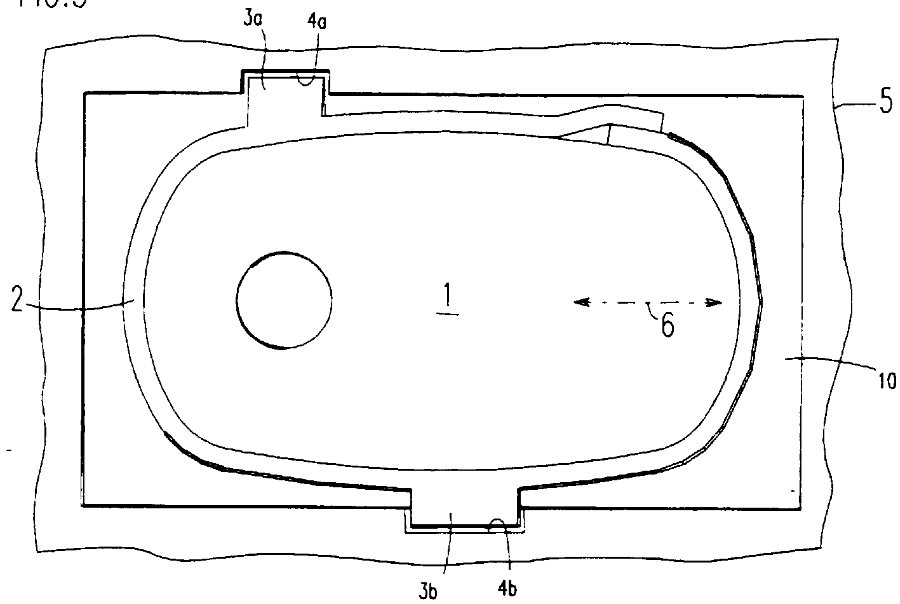
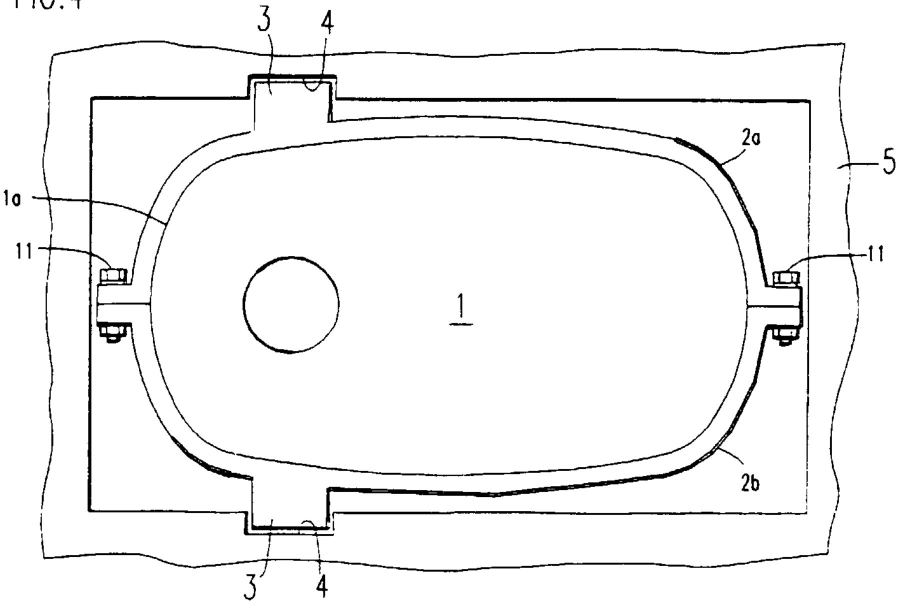


FIG.4



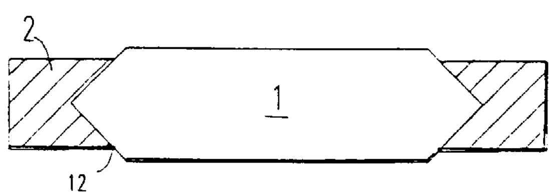
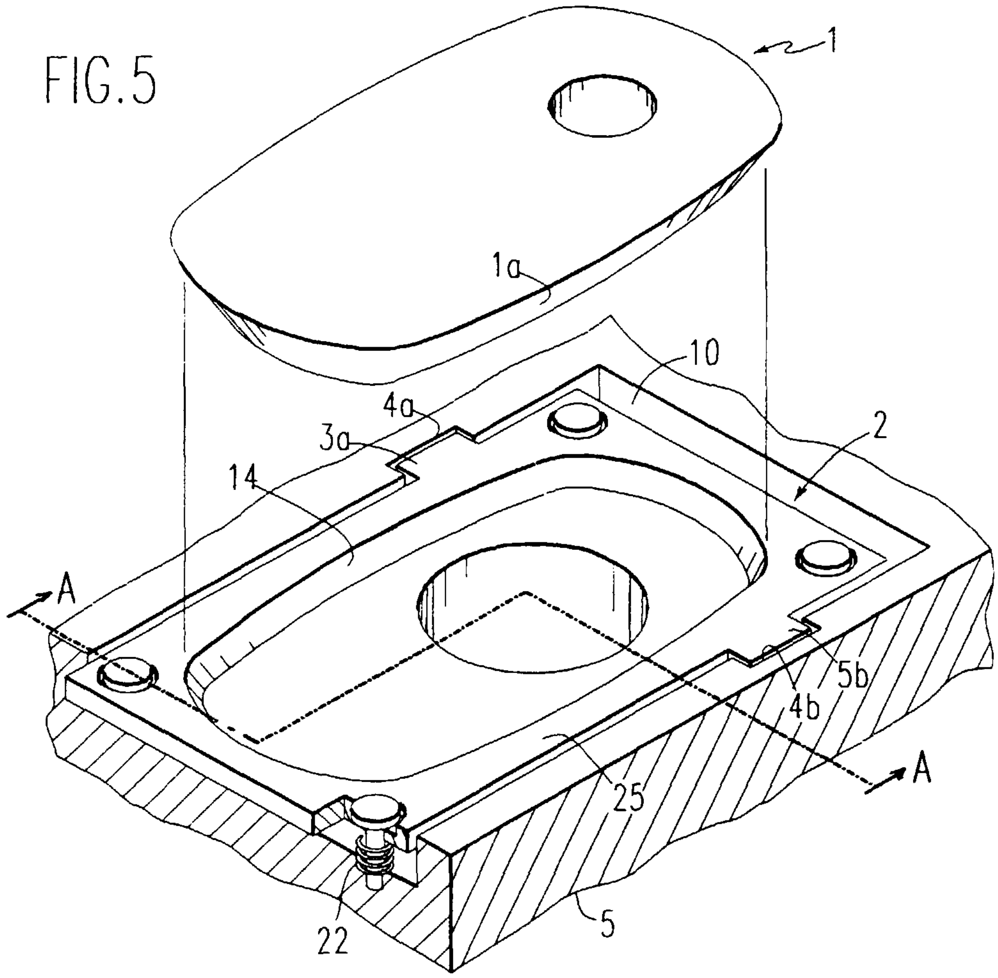


FIG.4A

FIG.5



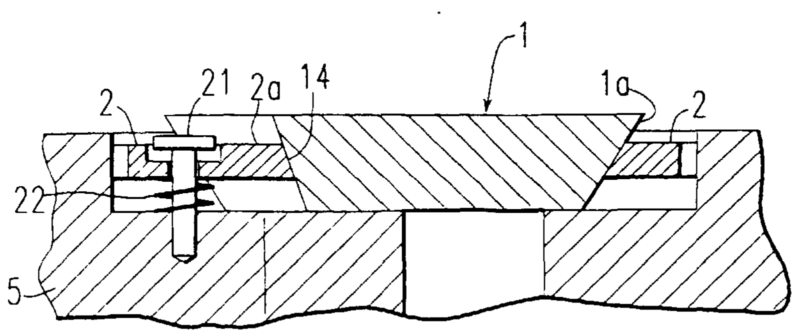


FIG.6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 11 9428

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	GB 2 158 202 A (STOPINC AG) 6 November 1985 * abstract; figures 1-7 *	1	B22D41/34 B22D41/28
A	GB 2 021 741 A (STOPINC AG) 5 December 1979 * abstract; figures 1-5 *	1	
A	US 4 840 296 A (OTSUKA TAKASHI ET AL) 20 June 1989 * abstract; figures 1,2 *	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B22D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 February 1999	Mailliard, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 98 11 9428

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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24-02-1999

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