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(54) **METHOD FOR SECURING AND CONFINING THE GASKET PLANE OF A VESSEL OF A NUCLEAR REACTOR AND A GASKET FOR APPLYING THIS METHOD**

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(57) **ABSTRACT**

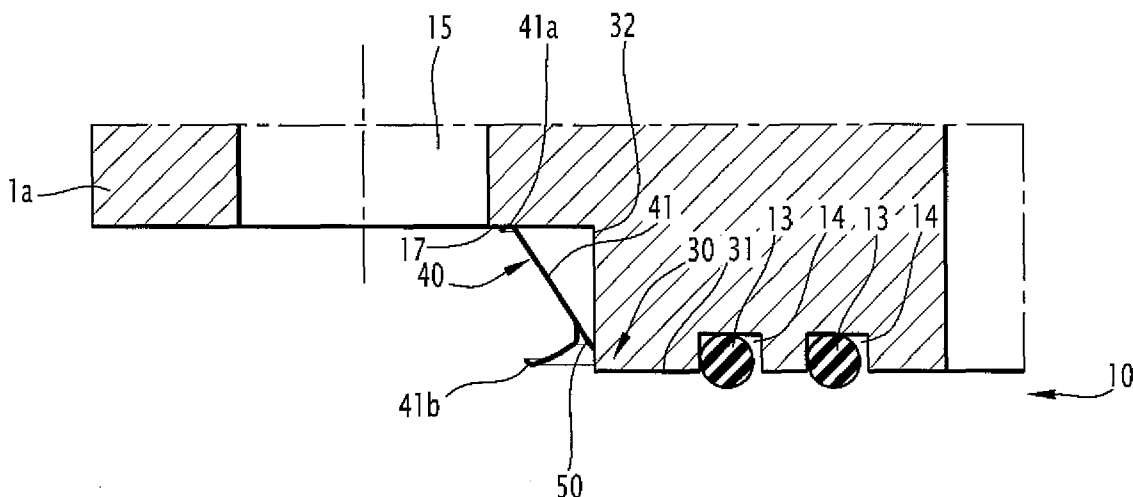
A method including placing around the shoulder of the lid a ring-shaped gasket formed by a metal strip maintained on the vertical wall of the shoulder by self-maintaining members firmly attached to the strip, placing the lid bearing the ring-shaped gasket above the vessel by positioning it at a determined height, carrying out a cleanliness inspection of the gasket plane, lowering and laying the lid on the vessel so that the end side edges of the strip will come into contact with a horizontal wall of the lid and of the vessel flange respectively and attaching this lid on the vessel.

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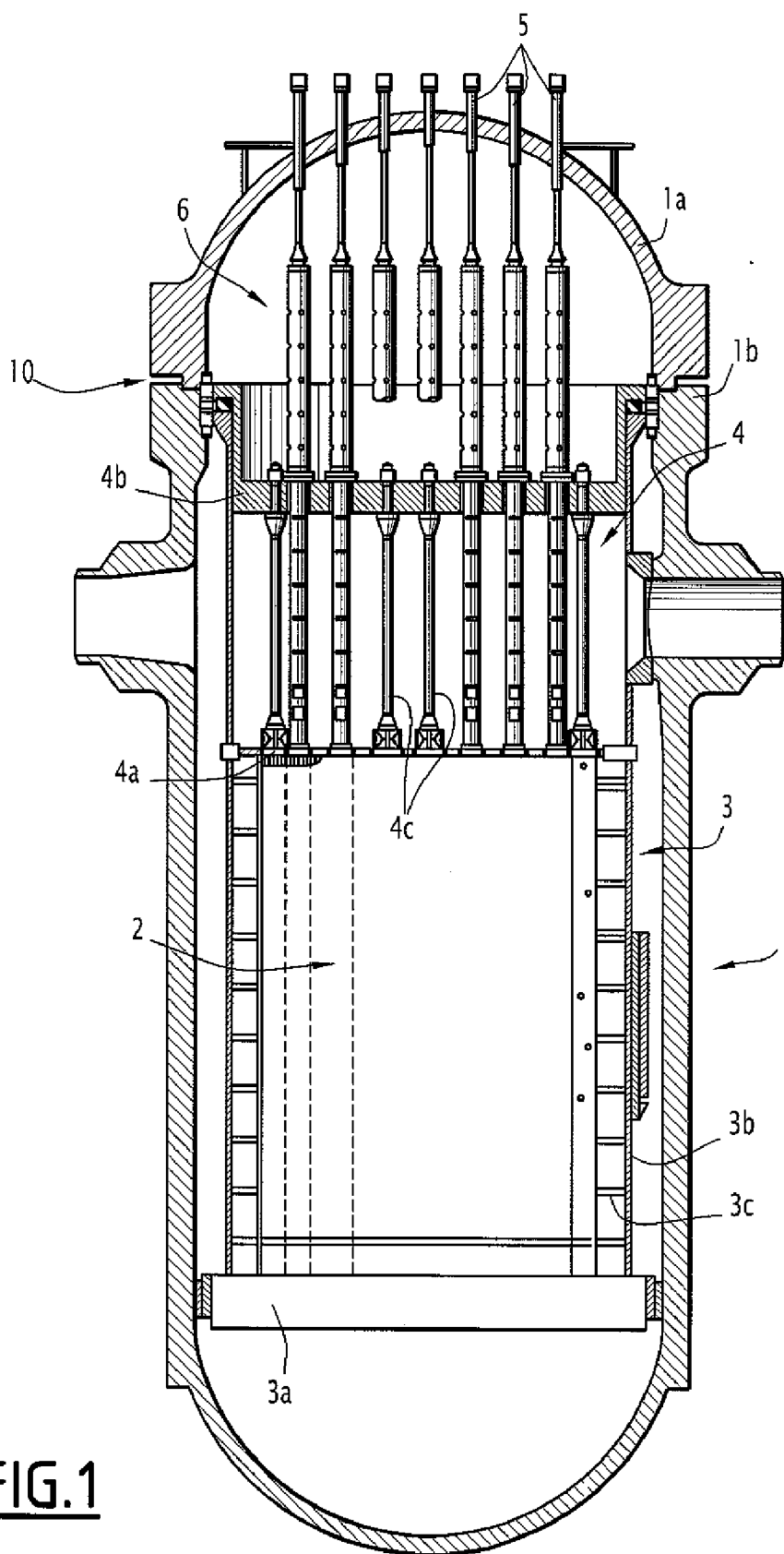


FIG. 1

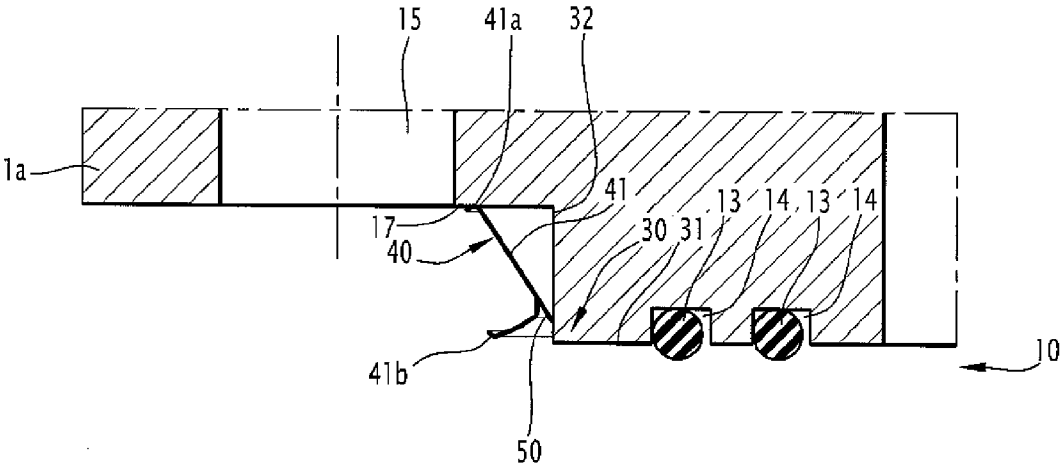


FIG. 2

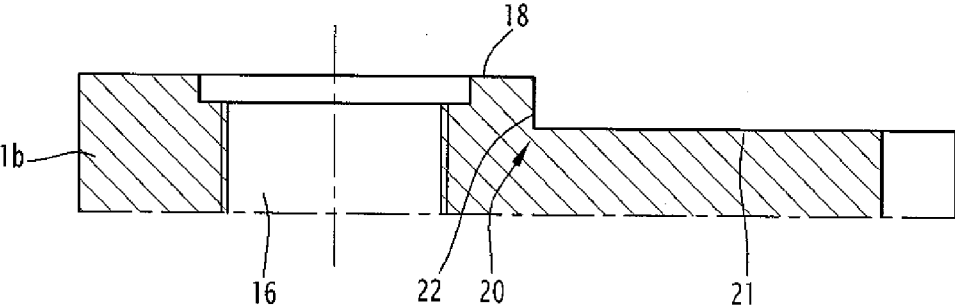


FIG. 3

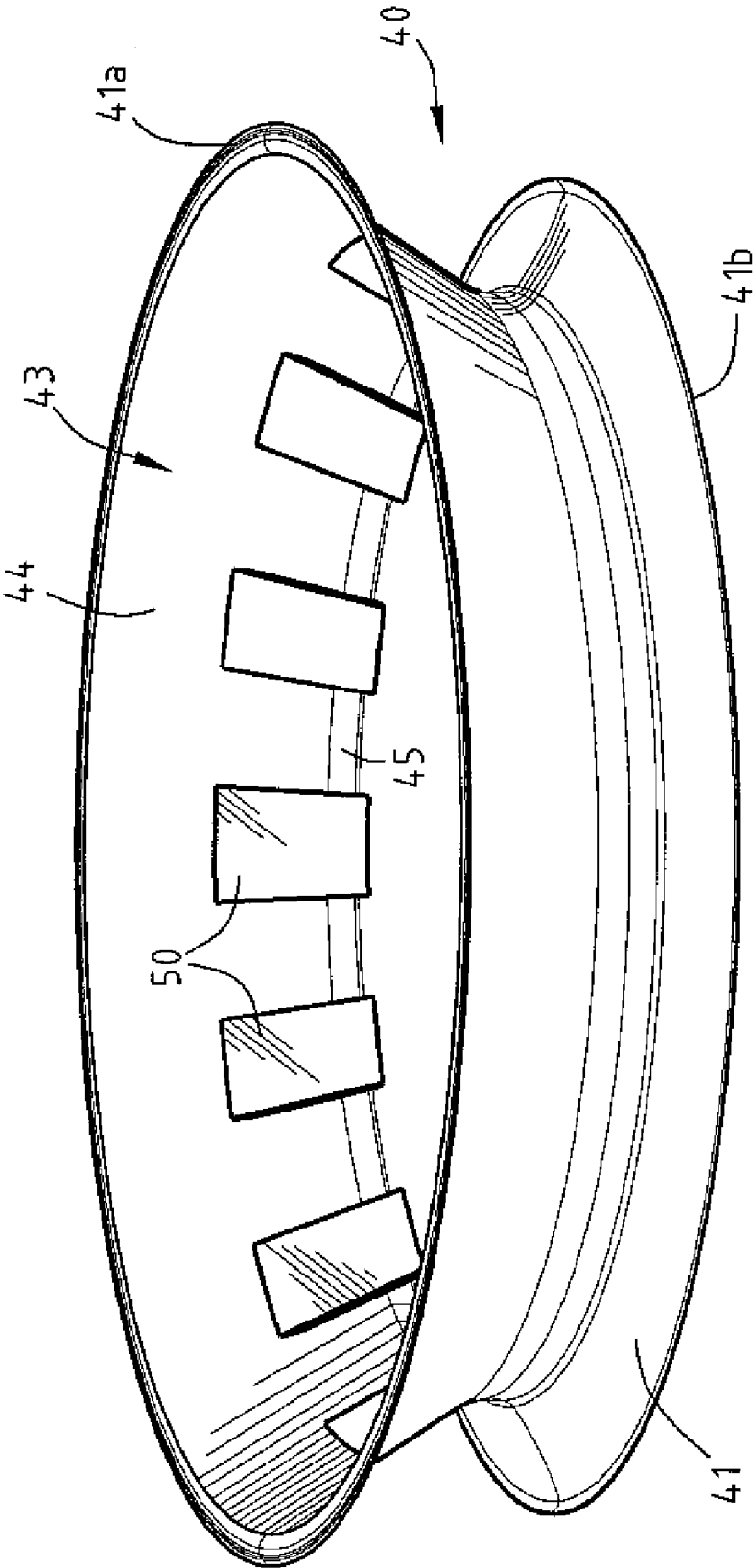


FIG.4

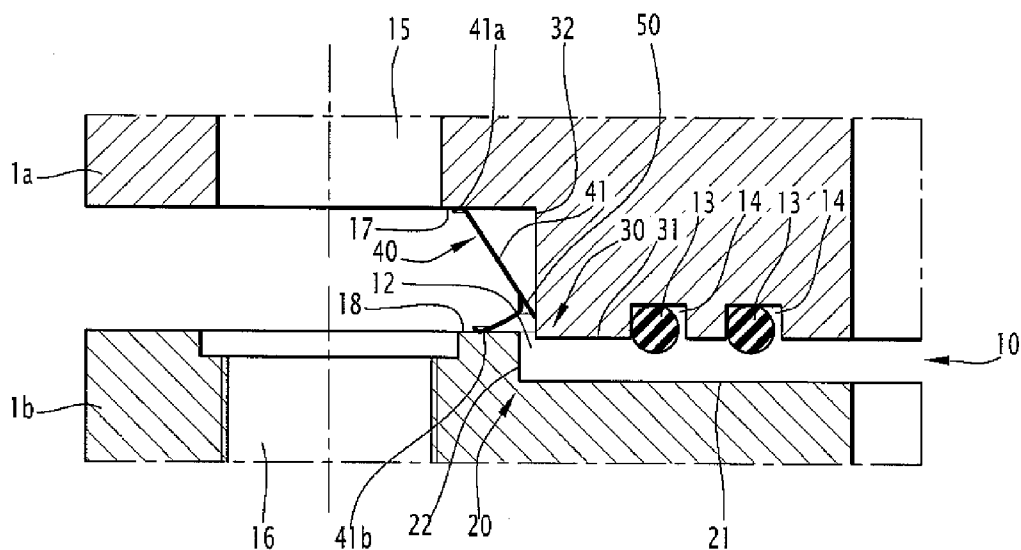


FIG. 5

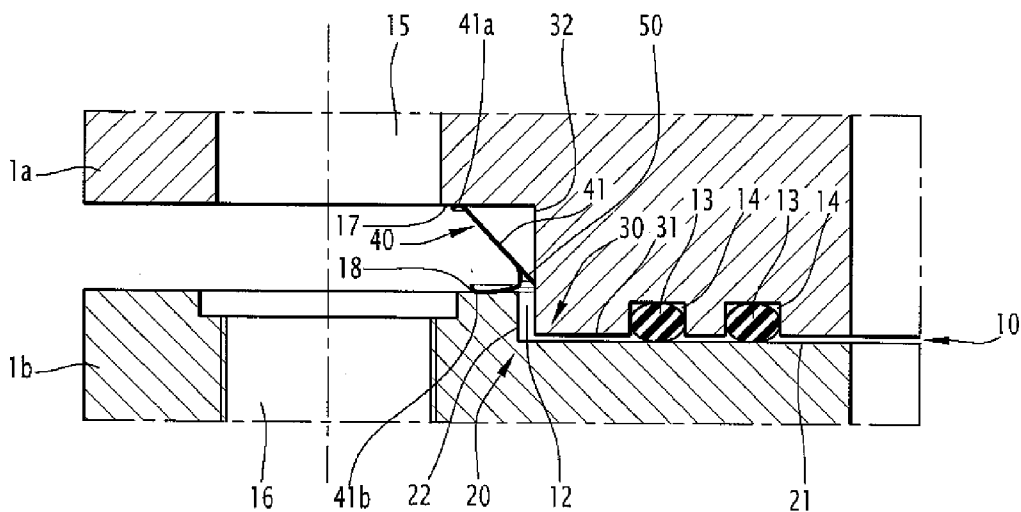


FIG. 6

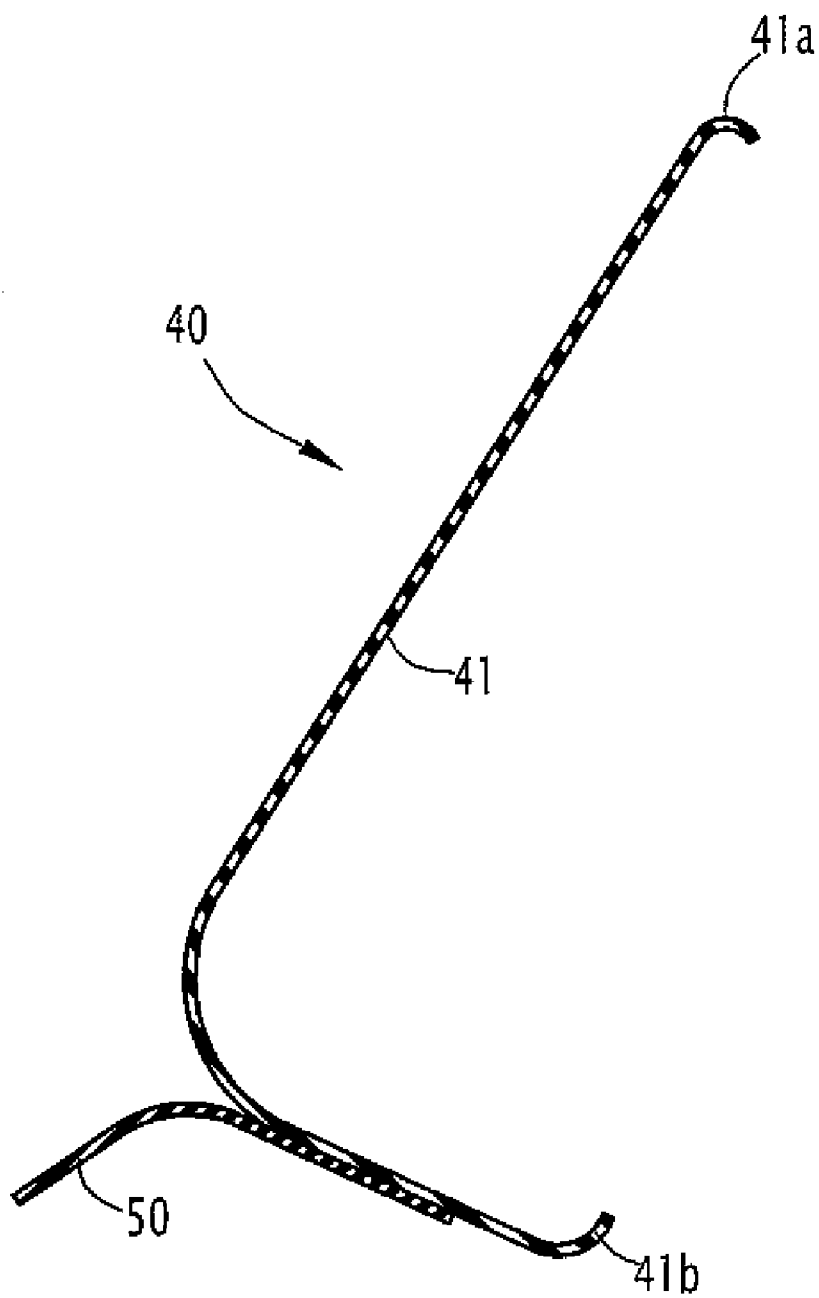


FIG. 7

**METHOD FOR SECURING AND CONFINING
THE GASKET PLANE OF A VESSEL OF A
NUCLEAR REACTOR AND A GASKET FOR
APPLYING THIS METHOD**

[0001] This application claims priority to French application FR 09 58128, filed Nov. 18, 2009, the entire disclosure of which is incorporated by reference herein.

[0002] The present invention relates to a method for securing and confining the gasket plane of a vessel of a nuclear reactor upon an operation for closing this vessel.

[0003] The invention also relates to a ring-shaped gasket for applying this method.

BACKGROUND

[0004] Pressurized water nuclear reactors include inside the building of the reactor, a vessel containing the core of the nuclear reactor formed by combustible assemblies, generally of prismatic form, arranged vertically and in a juxtaposed way.

[0005] Inside the vessel of the reactor, are arranged internal pieces of equipment in particular ensuring support and maintaining the combustible assemblies of the core of the nuclear reactor.

[0006] The vessel of a general cylindrical shape, is formed at its lower portion with a convex bottom and includes an upper end which is closed during the operation of the nuclear reactor by a convex lid. This lid of the vessel is crossed by tubes having a vertical arrangement, called adaptors used for ensuring the passage of extenders allowing displacement of control clusters in certain assemblies of the core.

[0007] When the lid is laid on the vessel, it determines a gasket plane formed by a ring-shaped recess made on a flange of the vessel and by a ring-shaped shoulder with a shape matching said recess and made on the vessel lid.

[0008] The recess and the shoulder of the vessel flange and of the lid respectively, determine two substantially horizontal planar surfaces facing each other and between which two O-ring gaskets are slightly crushed when the lid is clamped on the vessel.

[0009] The lid is attached on the vessel of the reactor by pins which are screwed into the flange of the vessel and which pass through in smooth holes provided in a flange ring of the lid.

[0010] These pins are generally in a relatively large number and relatively close to each other, disassembling and reassembling the lid therefore requires unscrewing and screwing of all these pins.

[0011] Moreover, during the screwing and unscrewing operations, by means of a tension device, traction is exerted on the pins in order to put them into a pre-stressed condition.

[0012] The seal during operation of the reactor between the vessel and the lid is therefore achieved by both of the O-rings, most often in "Inconel" (registered trade mark) or in stainless steel plated with silver. These gaskets are placed in two concentric grooves provided on the planar surface of the shoulder of the lid.

[0013] These gaskets bear on the planar surface facing the vessel flange and the spans of these gaskets are machined to as to obtain a perfect surface which does not accept any mark, any flaw.

[0014] Tightening the lid with the pins slightly crushes the gaskets, the supporting surface of which is about 1 mm wide and generally of the order of 3 mm.

[0015] The recess and the shoulder of the vessel flange and of the lid, respectively, each include a vertical wall delimiting between them a gap after the laying of the lid on the vessel flange.

[0016] During operations for reloading a portion of the nuclear reactor, cold shut-down of the reactor is performed and the lid closing the upper end portion of the vessel is disassembled.

[0017] After removing this lid, a temporary lid is placed on the vessel by placing a temporary inflatable gasket on the edge of the recess of the flange of the vessel in order to ensure a temporary seal.

[0018] During the laying of the lid on the flange of the vessel after reloading the core of the nuclear reactor, the temporary inflatable gasket is removed after performing decontamination of the pool by means of a pressure cleaner.

[0019] At the beginning of the operation for tightening the pins, the lid is slightly lifted relatively to the vessel flange due to the force produced by the springs of the combustible assemblies and the clamping ring. So there is a play from about 2 mm to 3 mm between the gaskets positioned below the lid and the gasket span over the vessel flange.

[0020] It is found that after maintenance operations a leak was noticed upon closing a vessel of a nuclear reactor and this leak was justified by the probable presence of metal microchips or other particles over the span of the seal gaskets of the vessel flange when clamping pins of the lid on said vessel flange are tensioned by a machine for tightening and loosening the pins.

[0021] The formation of these microchips probably results from the friction of the tops of the threads of the pins on the wall of the smooth holes of the lid during the mounting of said pins on the vessel flange with the tightening and loosening machine.

[0022] Because of the withdrawal of the temporary inflatable gasket before the operations for screwing the pins, these microchips might have made their way right under the gasket span by passing through the gap made between the shoulder of the lid and the recess of the vessel and reached the span of said gaskets during the phase for screwing the pin.

[0023] Upon restarting the unit at a primary pressure of the order of 25 bars and at a temperature of the order of 30° C., a leak may thus occur at the gasket span.

[0024] In GB 877,277, an annular C-shaped gasket is known which is placed at the gasket plane formed by the ring-shaped recess made on the flange of the vessel and by the ring-shaped shoulder with a shape mating said recess made in the vessel lid. Each end side edge of the annular gasket is welded on a horizontal wall, of the lid and of the vessel flange respectively.

[0025] The annular gasket is welded after laying the lid on the vessel so that during the welding operation, microparticles or foreign bodies may make their way right under the gasket span by passing through the gap.

[0026] Further, during a new operation for loading a portion of the nuclear reactor, before removing the lid, at least one of the welding beads has to be removed in situ which consider-

ably complicates the operations, increases the shut-down time of the reactor and generates potentially bothersome chips.

SUMMARY OF THE INVENTION

[0027] An object of the invention is to provide a method for securing and confining the gasket plane of a vessel of a nuclear reactor during an operation for closing this vessel with which it is possible by simple means to apply to avoid these drawbacks and prevent migration of solid material particles towards the inside of the vessel of the nuclear reactor.

[0028] An object of the invention is therefore to provide a method for securing and confining a gasket plane of a vessel of a nuclear reactor during an operation for closing this vessel in order to prevent migration of solid material particles towards the inside of said vessel, said gasket plane being formed by a ring-shaped recess made on a flange of the vessel and by a ring-shaped shoulder made on a vessel lid and said recess and said shoulder each including a vertical wall delimiting between them a gap after laying the lid on the vessel flange, the shoulder including a horizontal wall provided with two O-ring seal gaskets, characterized in that after having disassembled the lid and having laid this lid on a support, the method consists of:

[0029] placing around the shoulder of the lid a ring-shaped gasket formed by a metal strip maintained on the vertical wall of the shoulder by self-maintaining members of said strip,

[0030] placing the lid bearing the ring-shaped gasket above the vessel by positioning it at a determined height and performing a cleanliness inspection of the gasket plane,

[0031] lowering and laying the lid on the vessel so that the end side edges of the strip come into contact with a horizontal wall, of the lid and of the vessel flange, respectively,

[0032] attaching this lid on the vessel flange, and

[0033] leaving the ring-shaped gasket in place during the whole operating cycle of the reactor.

[0034] Another object of the invention is to provide a ring-shaped gasket for securing and confining the gasket plane of a vessel of a nuclear reactor during an operation for closing this vessel in order to prevent migration of solid material particles towards the inside of said vessel, said gasket plane being formed by a ring-shaped recess made on a flange of the vessel and by a ring-shaped shoulder made on a vessel lid and said recess and said shoulder each including a vertical wall delimiting between them a gap, the shoulder including a horizontal wall provided with two O-ring seal gaskets characterized in that the ring-shaped gasket is formed by a metal strip including two end side edges each capable of bearing upon a horizontal wall, of the lid and of the vessel flange, respectively, on the one hand and self-maintaining members of said ring-shaped gasket on the vertical wall of the shoulder of the lid on the other hand.

[0035] According to other features of the invention:

[0036] self-maintaining members comprise at least two metal tabs opposite to each other and attached on the outer face of the strip facing the vertical wall of the shoulder of the lid,

[0037] the self-maintaining members comprise several metal tabs uniformly distributed over the perimeter of the strip and attached on the outer face of said strip facing the vertical wall of the shoulder of the lid,

[0038] each tab is attached on the outer face of the strip by welding and with a thickness comprised between 0.2 mm and 0.5 mm and preferably of the order of 0.25 mm,

[0039] the strip of the ring-shaped gasket has the shape of a flexible ring with a small thickness comprised between 0.3 mm and 1 mm and preferably of the order of 0.5 mm,

[0040] the strip of the ring-shaped gasket has an L-shaped cross-section including two walls forming between them an angle, respectively an upper wall, the end side edge of which bears upon the horizontal wall of the lid and a lower wall of smaller width than the upper wall and the end side edge of which bears upon the horizontal wall of the vessel flange,

[0041] the tabs are attached on the outer face of the upper wall of the strip, and

[0042] the tabs are attached on the outer face of the lower wall of the strip.

BRIEF DESCRIPTION OF THE DRAWINGS

[0043] The invention and its advantages will be better understood upon reading the description which follows, given as an example and made with reference to the appended drawings, wherein:

[0044] FIG. 1 is a schematic actual sectional view of a vessel of a nuclear reactor containing the core and the internal structures of the reactor,

[0045] FIGS. 2 and 3 are partial and sectional views in a vertical plane, of the lid with a ring-shaped gasket and of the vessel flange, respectively,

[0046] FIG. 4 is a schematic perspective view of a first embodiment of the ring-shaped gasket,

[0047] FIG. 5 is a partial sectional view in a vertical plane of the vessel flange and of the lid with the ring-shaped gasket, before tightening the lid,

[0048] FIG. 6 is a partial and sectional view in a vertical plane of the vessel flange and of the lid with the ring-shaped gasket, after tightening the lid, and

[0049] FIG. 7 is a schematic sectional view in a vertical plane of a second embodiment of the ring-shaped gasket.

DETAILED DESCRIPTION

[0050] In FIG. 1, a vessel of a pressure water nuclear reactor is illustrated, designated generally by reference 1.

[0051] The vessel 1, of general cylindrical shape, is formed at its lower portion by a convex bottom and includes an upper end which is closed during the operation of the nuclear reactor, by a convex lid 1a bearing upon a vessel flange 1b.

[0052] The vessel 1 contains the core 2 of the reactor formed by combustible assemblies, not shown, with a general prismatic shape arranged vertically and in a juxtaposed way inside the internal structures generally designated by the mark 3. These internal structures form the lower internal pieces of equipment of the nuclear reactor.

[0053] The lower internal pieces of equipment 3 in particular include a plate for supporting the core 3a, a core shell 3b and a partition 3c for laterally maintaining the core 2 of the nuclear reactor.

[0054] On the upper portion of the core 2 lies a second set called upper internal pieces of equipment of the nuclear reactor.

[0055] Conventionally, the upper internal pieces of equipment 4 in particular include a lower plate 4a via which the upper internal pieces of equipment rest on the upper portion of the core 2 and which is called an upper core plate.

[0056] The upper internal pieces of equipment further include an upper plate of large thickness 4b forming the plate for supporting the guide tubes 6 of the control bars of the

nuclear reactor. Spacer columns **4c** ensure the assembly and the spacing out of the plates **4a** and **4b** which are parallel with each other and placed horizontally in the nuclear reactor.

[0057] The lid **1a** of the vessel **1** is crossed by tubes **5** having a vertical arrangement, called adaptors, used for ensuring the passage of a displacement extender of control clusters in certain assemblies of the core.

[0058] The lid **1a** delimits with the vessel flange **1b** a gasket plane **10**.

[0059] As shown in FIG. 1 and more particularly at a large scale in FIG. 2, this gasket plane **10** is formed by a ring-shaped recess **20** made on the vessel flange **20b** and by a ring-shaped shoulder **30** made on the lid **1a** of the vessel **1**. The recess **20** and shoulder **30** are facing each other.

[0060] The recess **20** includes a horizontal wall **21** and a vertical wall **22** and the shoulder **30** includes a horizontal wall **31** facing the horizontal wall **21** and a vertical wall **32** facing the vertical wall **22** of the recess **20**.

[0061] The vertical walls **22** and **32** of the recess **20** and of the shoulder **30**, respectively, delimit between them a gap **12** after laying the lid **1a** on the vessel flange **1b**, as shown in FIGS. 5 and 6.

[0062] Conventionally, the horizontal wall **31** of the shoulder **30** includes two O-ring gaskets **13** each attached in a groove **14** by means of suitable members like for example lugs, not shown.

[0063] The O-ring gaskets **13** are slightly crushed when the lid **1a** is tightened on the flange **1b** of the vessel **1**. The lid **1a** is attached on the vessel flange **1b** by pins, not shown, which are screwed into tapped holes **16** made in the flange **1b** and which pass through smooth holes **15** provided in a flange ring of the lid **1a**.

[0064] These pins are generally in a relatively large number and relatively close to each other, disassembling and reassembling the lid therefore requires unscrewing and screwing of all these pins.

[0065] During the tightening and loosening operations, a tension device of a known type, not shown, exerts traction on the pins in order to put them into a pre-stressed condition.

[0066] In order to avoid that metal microchips or other solid material particles deposit on the span **21** of the seal gaskets **13** of the vessel flange **1b** during screwing or unscrewing of the pins, which may cause leaks, a ring-shaped gasket designated by the general reference **40** is inserted between the vessel flange **1b** and the lid **1a** at the shoulder **30** of said lid and more particularly at the gap **12**, as well as illustrated in FIGS. 2, 5 and 6.

[0067] The ring-shaped gasket **40** is formed by a metal strip **41** which preferably has the shape of a flexible ring with a small thickness comprised between 0.3 mm and 1 mm and more particular of the order of 0.5 mm.

[0068] Generally, the strip **41** forming the ring-shaped gasket **40** includes a first end side edge **41a** intended to bear upon a horizontal wall **17** of the lid **1a** and a second end side edge **41b** intended to bear upon a horizontal wall **18** of the flange **1b** of the vessel **1** when the lid **1a** is mounted on the vessel flange **1b**, as this will be seen subsequently.

[0069] As illustrated in FIG. 4, the strip **41** of the ring-shaped gasket **40** includes self-maintaining members of said gasket **40** on the vertical wall **32** of the shoulder **30** of the lid **1a**, when this lid **1a** has been removed from the vessel flange **1b** and laid on a support, not shown.

[0070] The self-maintaining members comprise at least two opposite metal tabs **50** and preferably several metal tags **50** uniformly distributed over the perimeter of the strip **41** of the gasket **40**.

[0071] The metal tabs **50** are attached on the outer face of the strip **41** intended to be placed facing the vertical wall **32** of the recess **30** and these tabs **50** are attached by welding.

[0072] Each tab **50** has a thickness comprised between 0.2 mm and 0.5 mm and preferably of the order of 0.25 mm.

[0073] As illustrated in FIG. 4, the strip **41** preferably has an L-shaped cross-section including two walls forming between them an angle, an upper wall **44** and a lower wall **45** with a smaller width than the width of the upper wall **44**, respectively.

[0074] According to a first embodiment illustrated in FIG. 4, the tabs **50** are attached on the outer face **43** of the upper wall **44** of the strip **41**.

[0075] According to a second embodiment illustrated in FIG. 7, the tabs **50** are attached on the outer face **43** of the lower wall **45** of the strip **41**.

[0076] Generally, the metal strip **41** forming the gasket **40** may have any other shape such as for example a C-shaped or V-shaped cross-section.

[0077] Laying the ring-shaped gasket **40** at the gasket plane **10** between the lid **1a** and the vessel flange **1b** is carried out in the following way.

[0078] During a maintenance operation or an operation for reloading the core of the nuclear reactor, the pins are unscrewed and the lid **1a** is removed from the vessel **1**. This lid **1a** is laid on a support, not shown, so as to allow operators to access the O-ring gasket **13** and possibly proceed with their replacement.

[0079] The operators manually place the strip **41** around the vertical wall **32** of the shoulder **30** by applying the upper side edge **41a** against the horizontal wall **17** of this shoulder **30**. The free edges of the self-maintaining tabs **50** bear upon the vertical wall **32** of the shoulder **30** and ensure that the strip **41** is maintained by buttressing this vertical wall **32**. Taking into account the asymmetrical profile of the strip **41** forming the gasket **40** and the weight of this strip, the tabs **50** form elements for blocking and maintaining the gasket **40** in place on the shoulder **30** of the lid **1a**.

[0080] Next, the lid **1a** bearing the ring-shaped gasket **40** is conveyed above the vessel **1b** and during this transport, the ring-shaped gasket **40** is only maintained by the tabs **50** without any other element.

[0081] The lid **1a** is positioned at a determined height of the vessel flange **1b** and a cleanliness inspection of the gasket plane **10** is carried out.

[0082] Next, and as shown in FIG. 5, the lid **1a** is lowered onto the vessel so that the end side edges **41a** and **41b** of the strip **41** come into contact with a horizontal wall, the horizontal wall **17** of the shoulder **30** of the lid **1a** and the horizontal wall **18** of the recess **40** of the vessel flange **1a**, respectively.

[0083] Thus, and before tightening the pins, the strip **41** prevents any migration of microparticles or foreign bodies of solid material towards the inside of the vessel before putting the O-ring gaskets **13** into contact on the span **21**.

[0084] The lid **1a** is then attached on the vessel flange **1b**, by tightening the pins, not shown.

[0085] Upon tightening the lid **1a** on the vessel **1**, the strip **41** forming the ring-shaped gasket **40** is gradually crushed as shown in FIG. 5.

[0086] The ring-shaped gasket 40 because of the contacts of the side edges 41a and 41b on the horizontal wall 17 and 18 of the lid 1a and of the vessel flange 1b respectively and also because of the contact of the generatrix 41c on the vertical wall 32 of the shoulder 30 by crushing of the tabs 50, therefore ensures confinement of the gasket plane 10 preventing the migration of microchips or of any other particles towards said gasket plane 10 and towards the inside of the vessel.

[0087] The ring-shaped gasket 40 remains in place during the whole operating cycle of the nuclear reactor following its placement and is replaced during the next cycle.

[0088] Preferably, the strip 41 of the ring-shaped gasket 40 is in stainless steel.

[0089] During a new removal of the lid 1a, the ring-shaped gasket 40 may easily be withdrawn without any special operation. Indeed, during a shut-down, the gasket may be taken off by hand, with view to its replacement. The lid is then placed on its stand, removal of the gasket does not have any particular difficulties and does not generate any pollution in particular at the vessel or the pool of the reactor.

[0090] The ring-shaped gasket according to the invention therefore gives the possibility of securing and confining the gasket plane of a vessel of a nuclear reactor during an operation for closing this vessel in order to avoid any intrusion of microchips or foreign bodies between the gaskets and the span of these gaskets before and during the tightening of the pins ensuring the attachment of the lid on the vessel flange of the nuclear reactor.

[0091] The ring-shaped gasket has the advantage of being able to be easily laid on the shoulder of the lid of the vessel of the nuclear reactor without any particular attachment operation.

What is claimed is:

1. A method for securing and confining a gasket plane of a vessel of a nuclear reactor during an operation for closing the vessel in order to prevent a migration of solid material particles towards an inside of the vessel, the gasket plane being formed by a ring-shaped recess on a flange of the vessel and by a ring shaped shoulder on a lid of the vessel, the ring shaped recess on the flange and the shoulder facing each other and each including a vertical wall delimiting between them a gap after laying the lid on the vessel flange, the shoulder including a horizontal wall provided with two O-ring seal gaskets wherein after having disassembled the lid and laying the lid on a support, the method comprises the following steps:

placing around the shoulder of the lid a ring-shaped gasket formed by a metal strip maintained on the vertical wall of the shoulder by self-maintaining members firmly attached to the metal strip;

placing the lid bearing the ring-shaped gasket above the vessel by positioning it at a determined height and performing a cleanliness inspection of the gasket plane;

lowering and laying the lid on the vessel so that end side edges of the metal strip come into contact with a horizontal wall of the lid and of the vessel flange, respectively;

attaching the lid on the vessel flange; and

leaving the ring-shaped gasket in place during a whole operating cycle of the reactor.

2. A ring-shaped gasket for securing and confining a gasket plane of a vessel of a nuclear reactor during an operation for closing the vessel in order to prevent a migration of solid material particles towards the inside of the vessel, the gasket plane being formed by a ring-shaped recess made on a flange of the vessel and by a ring-shaped shoulder made on a vessel lid, the recess and the shoulder facing each other and each including a vertical wall delimiting between the recess and the shoulder a gap, the shoulder including a horizontal wall provided with two O-ring seal gaskets, wherein the gasket is formed by a metal strip including two end side edges, each edge capable of bearing upon a horizontal wall of the lid and of the vessel flange respectively, and self-maintaining members of the ring-shaped gasket bearing upon the vertical wall of the shoulder of the lid.

3. The ring-shaped gasket according to claim 2 wherein the self-maintaining members include at least two opposite metal tabs attached on an outer face of the metal strip, the metal tabs facing the vertical wall of the shoulder of the lid.

4. The ring-shaped gasket according to claim 2 wherein the self-maintaining members include several metal tabs uniformly distributed over a perimeter of the metal strip and attached on an outer face of the metal strip facing the vertical wall of the shoulder of the lid.

5. The ring-shaped gasket according to claim 3 wherein each metal tab is attached on the outer face of the strip by welding and has a thickness between 0.2 mm and 0.5 mm.

6. The ring-shaped gasket according to claim 2 wherein the metal strip of the ring-shaped gasket has the shape of a flexible ring with a thickness between 0.3 mm and 1 mm.

7. The ring-shaped gasket according to claim 2 wherein the metal strip of the ring-shaped gasket has an L-shaped cross-section including two walls, an upper wall and a lower wall, the upper wall and the lower wall forming an angle between them, the upper wall having an end side edge bearing upon the horizontal wall of the lid and the lower wall having a smaller width than the upper wall, the lower wall having an end side edge bearing upon the horizontal wall of the vessel flange.

8. The ring-shaped gasket according to claim 7 wherein the tabs are attached on an outer face of the upper wall of the metal strip.

9. The ring-shaped gasket according to claim 7 wherein the metal tabs are attached on an outer face of the lower wall of the strip.

10. The ring shaped gasket according to claim 5 wherein the metal tab thickness is 0.25 mm.

11. The ring shaped gasket according to claim 6 wherein the metal tab thickness is 0.5 mm.

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