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(71) Applicant (for all designated States except US): AREVA
NP [FR/FR]; Tour Areva 1, Place Jean Millier, F-92400
Courbevoie (FR).

(72) Inventors; and

(75) Inventors/Applicants (for US only): FRIEDRICH, Erhard [DE/DE]; Brander Hauptstrasse 21, 90542 Eckental (DE). SCHNEIDER, Manfred [DE/DE]; In den Wickengärten 2, 63814 Mainaschaff (DE).

(74) Agents: DOMENEGO, Bertrand et al.; Cabinet Lavoix, 2 place d'Estienne d'Orves, F-75441 Paris Cedex 09 (FR).

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(54) Title: TIE PLATE AND CORRESPONDING FUEL ASSEMBLY

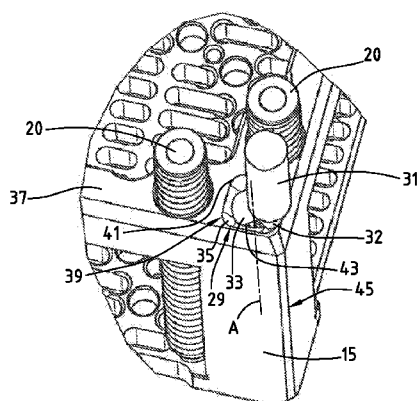


FIG. 2

(57) Abstract: A tie plate (15) for a PWR nuclear fuel assembly has at least one positioning hole (29) for receiving and surrounding a positioning pin (31) projecting from a nuclear core plate (7). The positioning hole (29) extends along a central axis (A) and has a maintaining portion (33) and a guiding portion (35). The guiding portion (35) widens radially in each radial direction from the maintaining portion (33) to an end surface (37) of the tie plate (15). The guiding portion (35) is connected to the end surface (37) by a capture contour (39). The capture contour (39) is substantially polygonal and has at least a part (41) of increased radial distance (R3) with respect to the central axis (A).

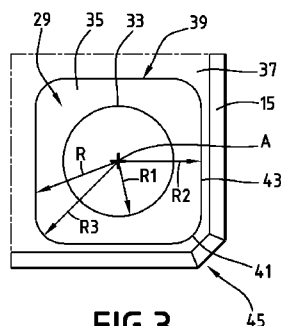


FIG. 3



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Tie plate and corresponding fuel assembly

The present invention relates to a tie plate according to the preamble of claim 1.

5 Such a tie plate is disclosed by US-5 812 624 and US-5 490 190.

A pressurized water reactor (PWR) nuclear fuel assembly generally comprises a skeleton and a bundle of fuel rods. The skeleton comprises a lower tie plate, an upper tie plate, guide-tubes connecting said lower and upper tie plates and spacer grids maintaining the fuel rods.

10 Once loaded into a fuel reactor, the lower tie plate of the nuclear fuel assembly rests on a lower core plate. The lower tie plate receives positioning pins which project upwardly from the lower core plate. These positioning pins are received in positioning holes usually provided in feet of the lower tie plate.

15 The upper tie plate is also provided with positioning holes which receive upper positioning pins projecting downwardly from an upper core plate.

The positioning holes may also receive positioning pins projecting from the handling grippers used to insert and remove the fuel assembly from a nuclear reactor core or from a storage cell.

20 During refueling or during some service operations of the nuclear reactor, the upper core plate is removed and reinstalled once the necessary operations have been performed on the nuclear core.

The upper positioning pins serve to position laterally the fuel assemblies of the core accurately with respect to the upper core plate and to the other fuel assemblies of the core.

25 In order to ease the insertion of the upper positioning pins and compensate for misalignments, the positioning holes of each upper tie plate have a lower maintaining portion and an upper guiding portion which opens in an upper end surface of the upper tie plate.

30 Each upper guiding portion is connected to the upper end surface of the upper tie plate by a capture contour. During the upper core plate installation, and in case of a misalignment of an upper positioning pin with its respective positioning hole, the lower end of the upper positioning pin slides on the guiding portion and is thus guided into the maintaining portion.

The positioning holes of each lower tie plate have a similar function and consequently a similar shape.

Usually, the positioning holes are obtained by machining the tie plate. The maintaining portions exhibit a cylindrical shape with a circular basis and the guiding portions have a frustoconical shape.

The guiding portions are efficient to compensate for misalignments between the positioning pins and the corresponding alignment holes.

However, if the misalignment is too large, then the guiding portions are not able to guide the positioning pins into the maintaining portions. The misaligned positioning pins can thus be bent and wedged into their respective positioning holes. This could lead to various problems, including an unexpected lifting of the corresponding fuel assembly by the upper core plate during the next refueling operation.

This is of concern especially since nuclear reactors are operated in ways that may more and more lead to fuel assembly deformations and therefore greater misalignment risks.

The goal of the invention is to solve this problem by reducing further the risks of defective engagement between a core plate and a fuel assembly tie plate.

To this end, the invention relates to a tie plate for a pressurized water reactor nuclear fuel assembly, said tie plate having at least one positioning hole for receiving and surrounding a positioning pin projecting from a nuclear core plate, the positioning hole extending along a central axis and having a maintaining portion and a guiding portion, the guiding portion widening radially in each radial direction from the maintaining portion to an end surface of the tie plate, the guiding portion being connected to the end surface by a capture contour, characterized in that said capture contour is substantially polygonal and has at least a part of increased radial distance with respect to the central axis.

According to specific embodiments, the tie plate may comprise at least one of the following features:

- said capture contour is substantially square,
- said capture contour has rounded corners, and
- said tie plate is an upper tie plate.

According to another aspect, the invention relates to a fuel assembly comprising a skeleton and a bundle of fuel rods, said skeleton comprising a lower tie plate, an upper tie plate, guide-tubes connecting said lower and upper tie plates, and spacer grids maintaining the fuel rods, characterized in that at least one tie plate is a tie plate as previously specified.

- Fig. 1 is a schematic partial view of a conventional PWR nuclear core,

- Fig. 2 is a partial enlarged perspective view of an upper tie plate according to the invention,

- Fig. 3 is a partial schematic top view showing the capture contour of a positioning hole of the upper tie plate of Fig. 2.

As shown on Fig. 1, a nuclear core 1 of a PWR generally comprises nuclear fuel assemblies 3 which extend vertically between a lower core plate 5 and an upper core plate 7. Only one assembly 3 is shown on Fig. 1, but the core usually comprises e.g. between 150 to 220 fuel assemblies 3 placed side-by-side in a substantially circular pattern.

Each fuel assembly 3 comprises a skeleton 9 and a bundle of fuel rods 11. The skeleton 9 comprises a lower tie plate 13, an upper tie plate 15, guide-tubes 17 connecting said lower and upper tie plates 13 and 15, and spacer grids 19 maintaining the fuel rods 11 according to a predetermined pattern. The guide-tubes 17 are intended to receive control rods.

Each fuel rod 11 generally includes nuclear fuel pellets received in a cladding 21 sealed by a lower end plug 23 and an upper end plug 25.

The lower tie plate 13 has feet 27 resting on the lower core plate 5. Two of these feet 27 are provided with lower positioning holes 29 which extend vertically and which receive lower positioning pins 31 projecting upwardly from the lower core plate 5.

The upper tie plate 15 has springs 20 contacting the upper core plate 7.

It should be noted that the conventional upper tie plate 15 of Fig. 1 and the upper tie plate 15 of Fig. 2 are not provided with the same type of springs 20. However, any type of springs 20, or even no spring, can be used with the invention.

Upper positioning pins 31 extend downwardly from the upper core plate 7 to be received into upper positioning holes 29 provided into the upper tie plate 15.

In order to ease their introduction into their respective positioning holes 29, the lower and upper positioning pins 31 have tapering ends 32.

Generally, the tie plates 13 and 15 each have a substantially square basis with two positioning holes 29 provided at diagonally opposed corners of the tie plates. However, any number of positioning holes 29, and therefore of positioning pins 31, can be contemplated.

In the disclosed embodiment, all the upper positioning holes 29 have the same structure. Therefore, only one upper positioning hole 29 will be disclosed in more details with reference to Figs. 2 and 3.

The upper positioning hole 29 extends along a vertical central axis A and surrounds the vertical axis A. The upper positioning hole 29 has a lower maintaining portion 33 and an upper guiding portion 35. The lower maintaining portion 33 has a cylindrical shape around axis A with a circular basis of radius R1 (see Fig. 3) in order to closely surround the respective positioning pin 31.

The upper guiding portion 35 surrounds the axis A and opens into the upper end surface 37 of the upper tie plate 15. The upper guiding portion 35 connects to the upper end surface 37 through a capture contour 39. The upper guiding portion 35 widens radially from the lower maintaining portion 33 to the upper end surface 37. This widening takes place in each radial direction. The capture contour 39 therefore has a larger cross section than the lower maintaining portion 33 and the radial distance R between the central axis A and any part of the capture contour 39 is therefore strictly greater than R1.

In the embodiment shown on Figs. 2 and 3, the capture contour 39 has a substantially square shape with rounded corners 41. The lowest value of R is R2 and corresponds to the sides 43 of the capture contour 39. The highest value of R is R3 and corresponds to the corners 41 of the capture contour 39. Therefore, at least a part of the capture contour 39 has a radial distance with respect to the central axis greater than another part.

During the upper core plate 7 installation, and in case of a misalignment between the upper positioning hole 29 and the corresponding upper positioning

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pin 31, the upper positioning pin 31 will engage the lateral wall of the upper guiding portion 35 and slide within the lower maintaining portion 33.

The radial distance R3 being greater than R2, the upper guiding portion 35 can compensate for greater misalignment in the corners 41 despite the narrow space available in the corner 45 of the upper tie plate 15 where the upper positioning hole 29 is placed.

Therefore, the risk of a misengagement of fuel assembly 3 and the upper core plate 7 after a refueling or a service operation is reduced.

This helps reducing the time of fuel assembly handling during a refueling or a service operation.

Other non-circular shapes than a square shape can be contemplated for the capture contour 39, e.g. polygonal shapes, oval shapes...

The above disclosed improved positioning holes 29 may be implemented in lower tie plates.

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CLAIMS

1.- A tie plate (15) for a pressurized water reactor nuclear fuel assembly (3), said tie plate (15) having at least one positioning hole (29) for receiving and surrounding a positioning pin (31) projecting from a nuclear core plate (7), the positioning hole (29) extending along a central axis (A) and having a maintaining portion (33) and a guiding portion (35), the guiding portion (35) widening radially in each radial direction from the maintaining portion (33) to an end surface (37) of the tie plate (15), the guiding portion (35) being connected to the end surface (37) by a capture contour (39), characterized in that said capture contour (39) is substantially polygonal and has at least a part (41) of increased radial distance (R3) with respect to the central axis (A).

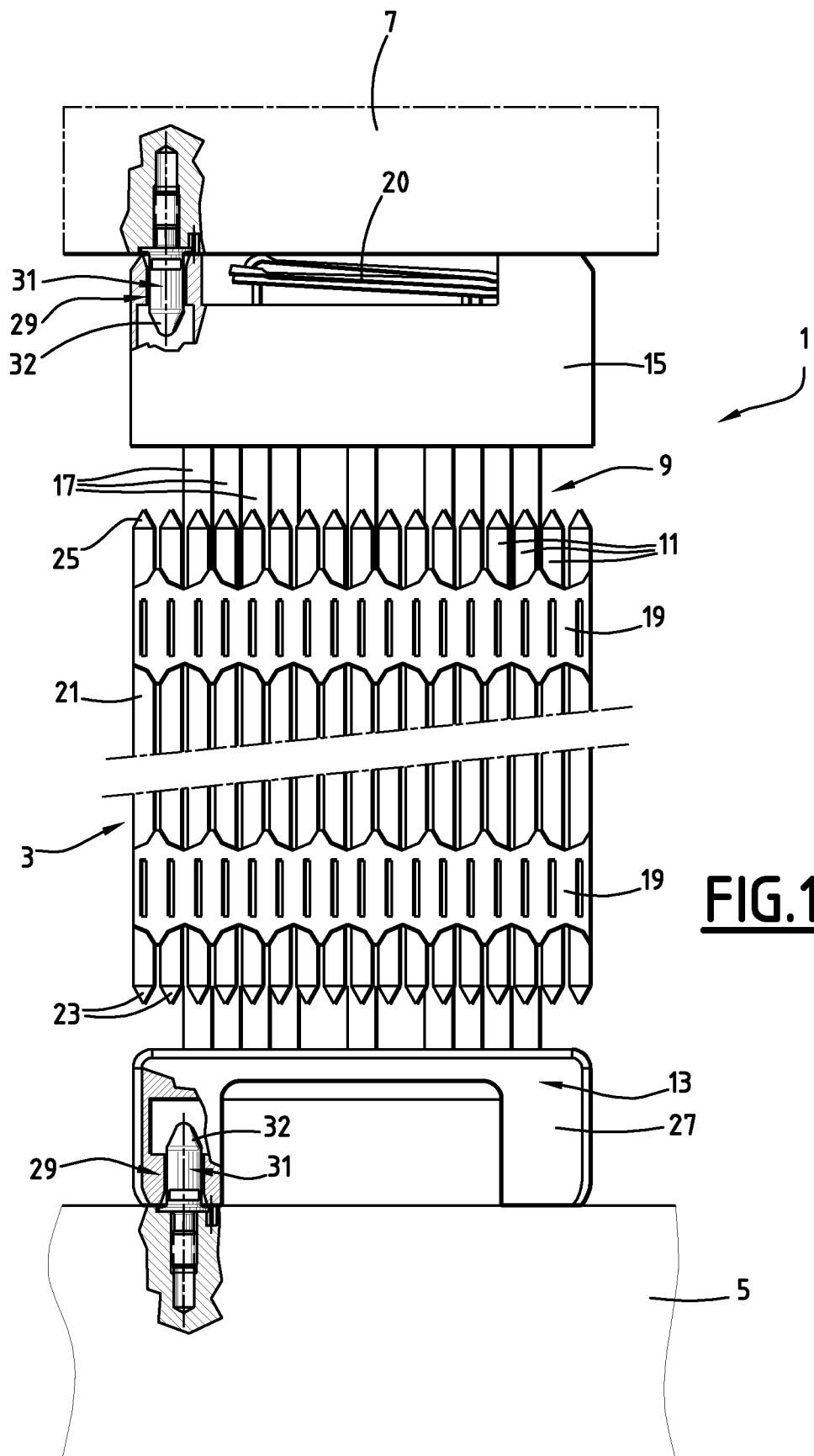
2.-Tie plate according to claim 1, wherein said capture contour (39) is substantially square.

3.-Tie plate according to claim 1 or 2, wherein said capture contour (39) has rounded corners (41).

4.- Tie plate according to any of claims 1 to 3, wherein said tie plate (15) is an upper tie plate.

5.- A nuclear fuel assembly (3) comprising a skeleton (9) and a bundle of fuel rods (11), said skeleton (9) comprising a lower tie plate (13), an upper tie plate (15), guide-tubes (17) connecting said lower and upper tie plates (13, 15), and spacer grids (19) maintaining the fuel rods (11), characterized in that at least one tie plate (13,15) is a tie plate according to any of claims 1 to 4.

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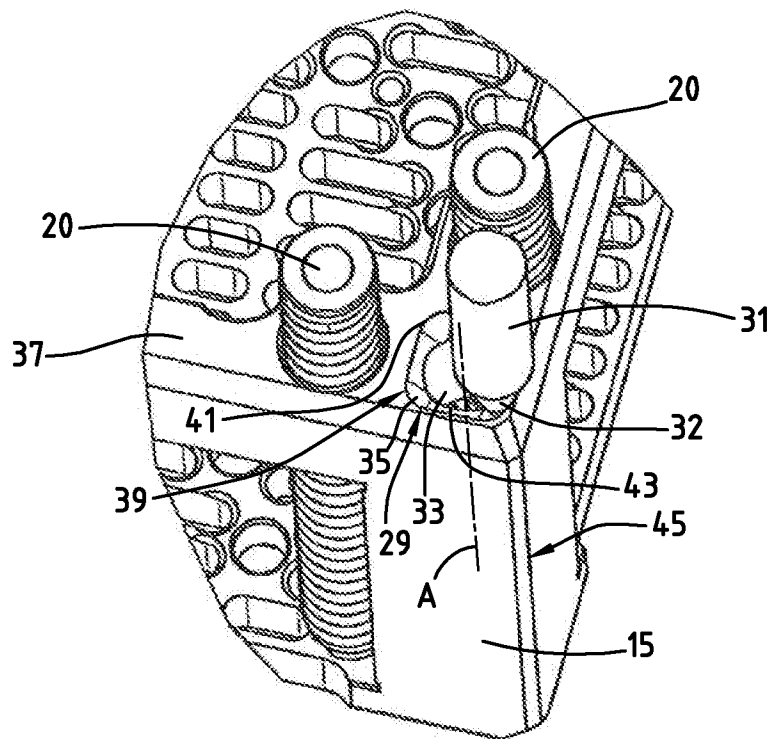


FIG. 2

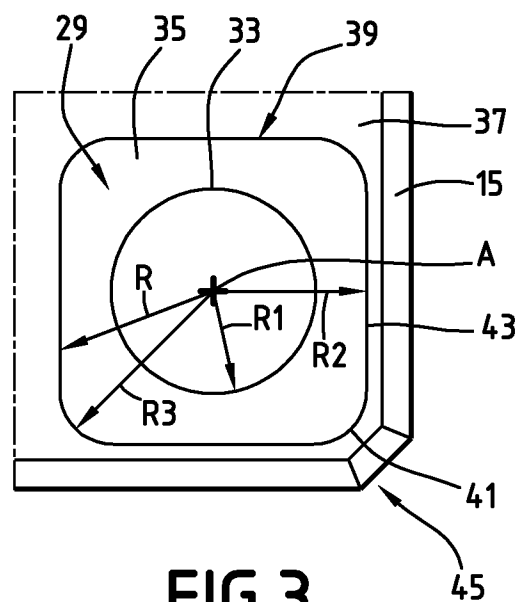


FIG. 3

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER INV. G21C3/12 G21C5/06 G21C19/20		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) G21C		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 543 253 A (SIEMENS AG [DE]) 26 May 1993 (1993-05-26) abstract column 6, line 5 - line 17; figures 8-10 -----	1-5
A	US 2006/068629 A1 (NAKAJIMA TOSHIHIRO [JP]) 30 March 2006 (2006-03-30) abstract paragraph [0067] - paragraph [0074] paragraph [0095] - paragraph [0100]; figures 9-12 -----	1-2
A	US 4 127 445 A (ANTHONY ANDREW J) 28 November 1978 (1978-11-28) abstract column 5, line 16 - line 38; figure 4 ----- -/--	1,4-5
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family		
Date of the actual completion of the international search 19 February 2010		Date of mailing of the international search report 26/02/2010
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Deroubaix, Pierre

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2009/064531

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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