(12) UK Patent Application (19) GB (11) 2 082 375 A

(21) Application No **8123410**
(22) Date of filing
30 Jul 1981
(30) Priority data
(31) **8026716**
(32) **15 Aug 1980**
(33) **United Kingdom (GB)**
(43) Application published
3 Mar 1982
(51) **INT CL³ G21C 3/32**
(52) Domestic classification
G6C 39Y 405 680 684 UW
(56) Documents cited
GB 1596787
GB 2022909A
GB 1563766
GB 1551027
GB 1501870
GB 1489964
GB 1423058
GB 1402197
GB 1190046
(58) Field of search
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(54) **Nuclear fuel assemblies and fuel pins usable in such assemblies**

(57) A trisection arrangement (26, 27, 28) for the end fitting for a fuel pin bottom end cap (20, 21, 22, 23, 24). The trisection arrangement is received within a cell of a cellular grid. The cell contains abutment means (16, 17, 18) with which the trisection comes into abutment. The grid also contains an abutment means (19) for preventing the trisection from being inserted into the cell in an incorrect orientation.

Fig.3.

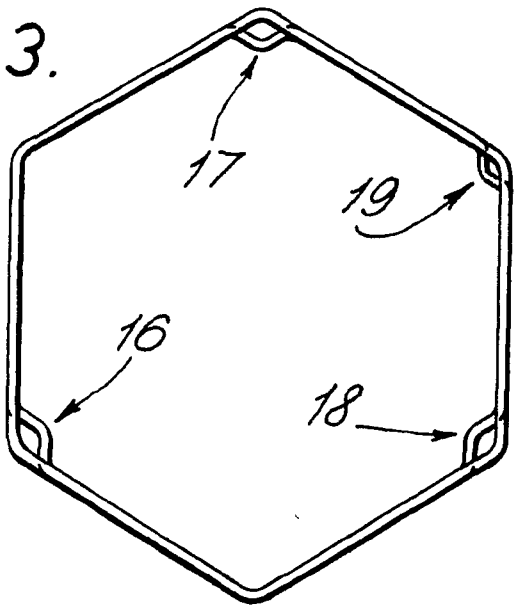

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Fig.1.

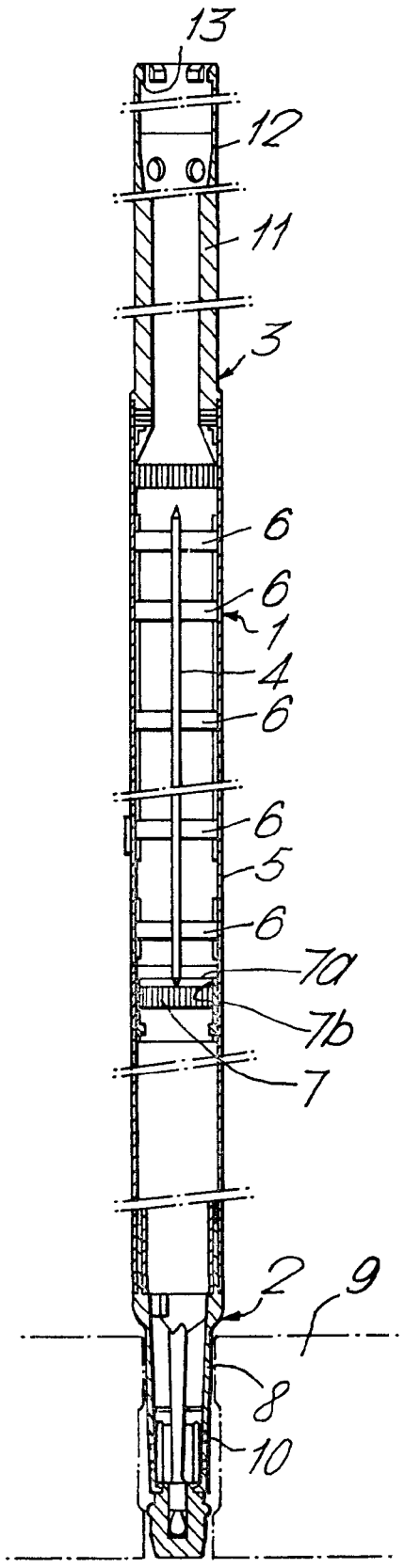


Fig.2.

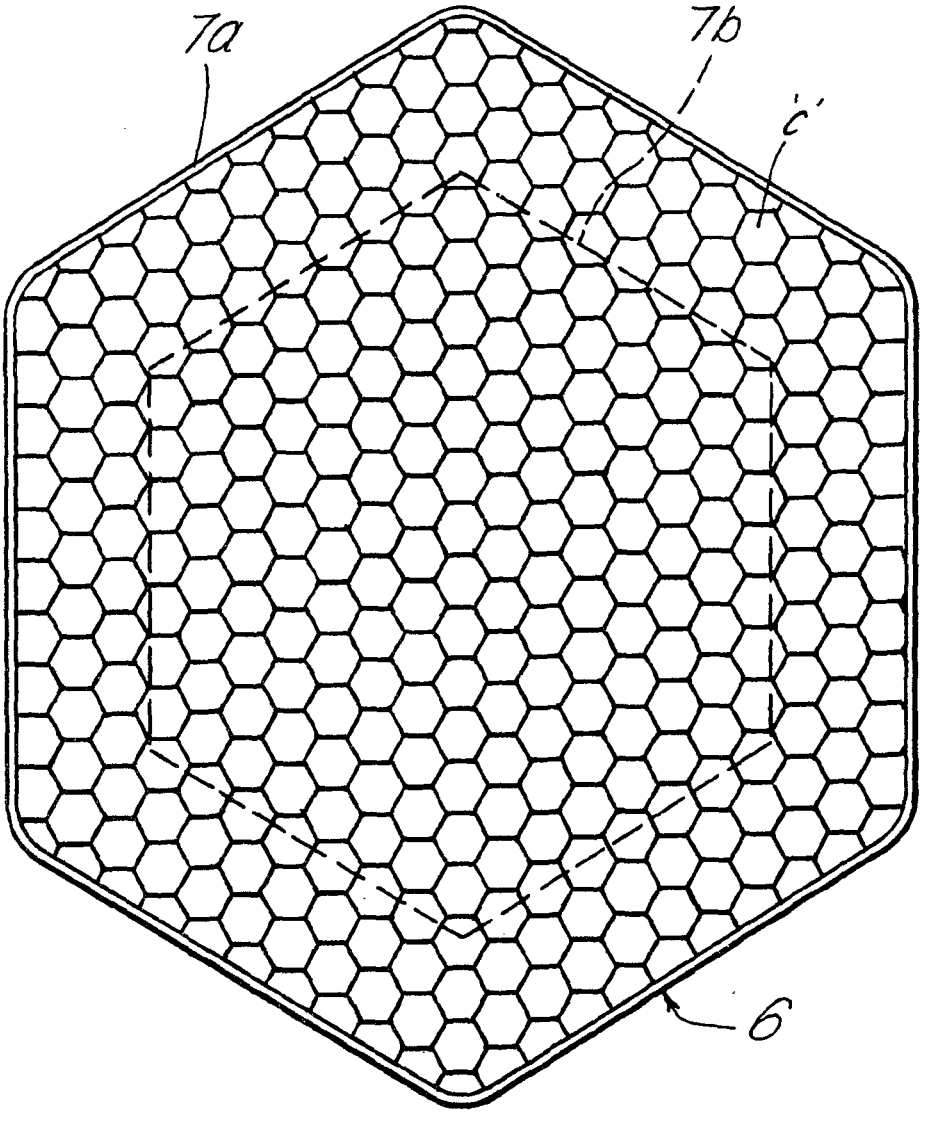


Fig.3.

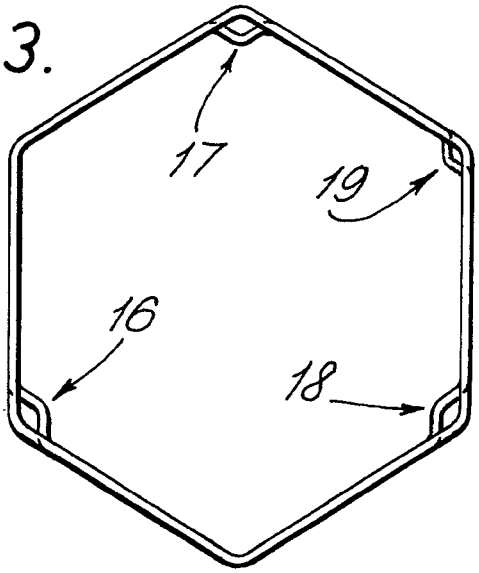


Fig.4.

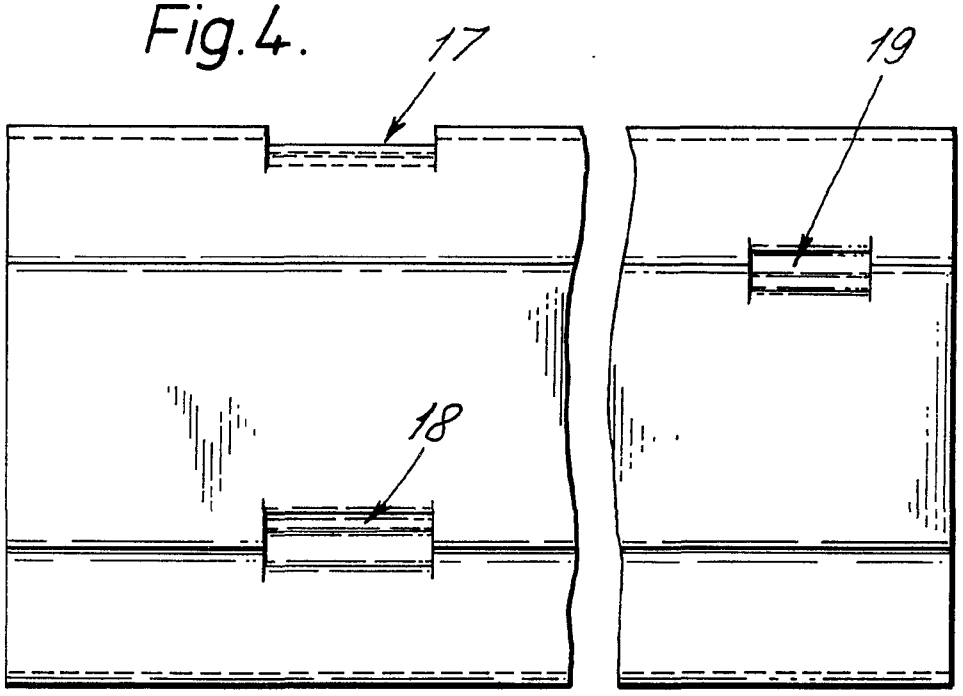


Fig.5.

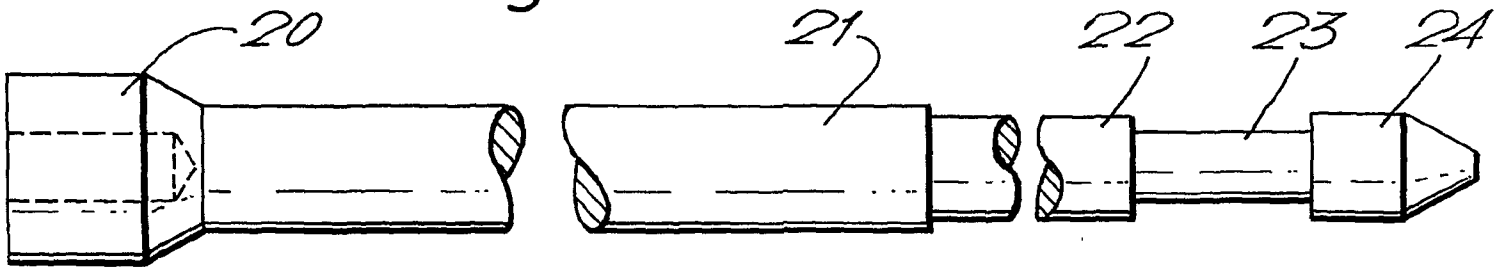
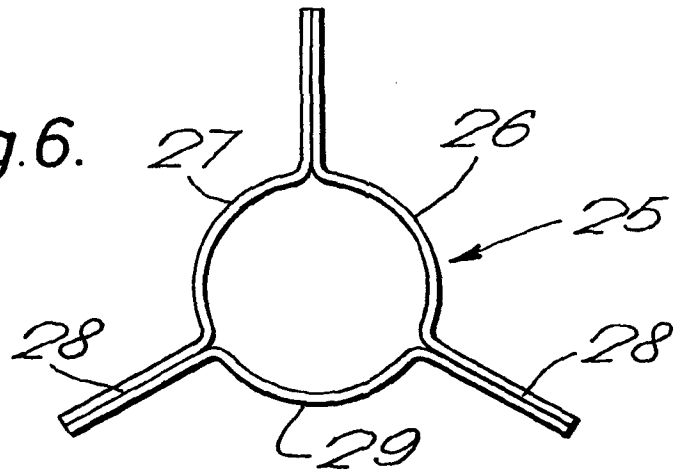


Fig.6.



SPECIFICATION

Nuclear fuel assemblies and fuel pins usable in such assemblies

This invention relates to nuclear fuel assemblies and fuel pins usable in such assemblies.

A fuel assembly for a liquid metal cooled fast breeder nuclear reactor comprises a bundle of spaced fuel pins within a tubular wrapper or sleeve through which liquid metal coolant can be flowed in heat exchange with the fuel pins. The pins may be spaced by a series of cellular grids attached to the wrapper each pin occupying a discrete cell of each grid and the wrapper having a spiked extension at one end whereby the sub-assembly can be located in a support structure and arranged with other sub-assemblies to upstand in side-by-side array to form a fuel assembly.

At its upper end, the wrapper is extended by a tubular neutron shield of massive steel. After irradiation of a fast breeder sub-assembly, it is necessary to reprocess it to recover unused fissile material and to separate newly formed plutonium from the residues, but because of irradiation embrittlement of the pins, dismantling of the sub-assembly is difficult.

One known technique for dismantling a fuel assembly has been to remove the lower end spike extension and end abutment grid from the wrapper and then carefully to withdraw the fuel pins one-by-one for reprocessing, but as the operation must be carried out by remote control because of radioactivity, it is a time consuming and expensive process.

British patent application, serial number 2022909A describes a sub-assembly and method for dismantling such a sub-assembly which facilitates dismantling for reprocessing purposes.

An object of the present invention is to tend to provide a nuclear fuel assembly and a nuclear fuel pin, whereby fuel pins may be securely held in a hold-down grid of such a sub-assembly.

According to one aspect of the present invention, a nuclear fuel assembly comprises a grid comprising a plurality of spaced cells, which cells include regularly spaced crimped abutment means for engaging nuclear fuel pins. The cells may contain further crimped abutment means for preventing a fuel pin from being inserted other than in a pre-selected desired position.

According to another aspect of the present invention, a nuclear fuel pin comprises an elongate body and an end cap, which end cap carries vanes for interacting with complementary abutment means in a nuclear fuel grid. Conveniently, said vanes are disposed at one hundred and twenty degrees relative to one another.

An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic sectional view of a typical fuel sub-assembly,

Figure 2 is a plan view of a hold down grid,

Figure 3 is a plan view of a segment of the grid of Fig. 2,

Figure 4 is an incomplete elevation of Fig. 3,

Figure 5 is an end view of an end cap for a fuel pin, and

Figure 6 is a plan of a trisection fitting for an end cap.

A fuel sub-assembly for a liquid metal cooled fast breeder nuclear reactor is shown in Fig. 1, and comprises a central fuel section 1, a lower end locating section 2 and an upper end neutron shielding section 3. The fuel section comprises a bundle of three hundred and twenty five elongate fuel pins 4 enclosed within a tubular wrapper 5 of hexagonal cross-section and spaced apart by a series of compliant cellular bracing grids 6, each pin occupying a discrete cell of each grid. The cellular grids 6 are welded to the wrapper 5 and the fuel pins 4 are supported within the wrapper at their lower ends by an abutment grid 7. The fuel pins 4 are retained at their lower ends by a stacked cellular hold-down grid comprising two grids 7*a* and 7*b* which are secured to the lower end region of the tubular wrapping 5. The lower end locating section comprises a spike extension 8 for engaging sockets in a fuel assembly support structure 9 and has apertures 10 through which coolant can flow from within the diagrid. The upper section 3 is of massive steel and comprises a tubular member 11 having an extension 12 with an internal lip 13 for engagement by lifting means. In assembly of the sub-assembly, the fuel pins are inserted from the bottom of the assembly through the hold-down grids 7*a* and 7*b*.

Reference is now directed to Fig. 2, wherein like reference numerals to Fig. 1 are used for like parts. From this figure, it can be seen that the hold-down grids 7*a*, 7*b* (the latter being shown dotted) contain an outer annulus of fuel pins and an inner hexagonal array of fuel pins, respectively. Reference is now directed to Fig. 3, in which one of the cells of the grids 7*a*, 7*b* is shown in more detail. Such cells are welded together at their upper and lower end. The cell can be seen to comprise an hexagonal tube which has inwardly directed crimps at all of its corners. Three of these crimps, indicated by 16, 17 and 18 are for retaining an end cap (see below) of a fuel assembly within the hold-down grid. The remaining crimp is provided to prevent the end cap from being inserted in the wrong orientation as will be explained below. Reference is now directed also to Fig. 4, which shows the crimps in a segment of grid from the side.

Reference is now directed to Fig. 5, in which an end cap for one of the fuel pins 4 is shown in detail. The end cap comprises a portion 20 for attachment to the fuel pin. Another cylindrical part 21 of narrower diameter than the part 20 extends there from. The part 21 is attached to a further cylindrical part 22, such that the part 21 provides a shoulder for the narrower part 22 and a final narrower section 23. At the end of the end cap, there is provided a shoe 24 for engaging a fuel assembly support structure. Reference is now directed to Fig. 6, in which a trisection vane arrangement is shown. The trisection vane arrangement comprises plates 25, 26 and 27, of similar shape. These parts comprise a sector shape part and wings indicated at 28 and 29 on the part 25. The wings may be welded together as shown in the figure to provide vanes such as vane 28.

The trisection vane arrangement is arranged around a cylindrical part 22 of a fuel pin end cap shown in Fig. 5. The ends of the sector shaped portions of the plates 25, 26 and 27 are crimped into the recess around section 23 before the fuel pin is inserted into the grid so that the trisection is firmly located.

When one of the fuel pins 4 is inserted through the hold-down grid 7*a* or 7*b*, the vanes have to pass into a cell in the grid, such as the cell shown in Fig. 3. The dimensions of the vanes are chosen so that they are a sliding fit in the cell. However, the vanes cannot pass all the way through the cell because they come into abutment with the crimps 16, 17 and 18. Although there are only three such crimps, the fuel pin has to be inserted such that the vanes are in the corners of a cell were the crimps are, because if it should be inserted at an angle of 60° thereto, then the vanes would come into abutment with the crimp 19. As was mentioned previously, the crimp 19 is specifically provided to ensure that the fuel pins are inserted in their correct orientation.

For reprocessing purposes, after irradiation of the fuel assembly, the wrapper is separated from the lower end locating section 2 and the upper end neutron shielding section 3 by severing the upper and lower regions of the wrapper, then the wrapper is severed again immediately above the hold-down grid 7a, 7b. The fuel pin bundle assembly is then removed in two steps. Firstly, those in the grid 7a are removed and then those in the grid 7b. The withdrawal operation is made possible by the compliant nature of the cellular grids 7. By withdrawing the bundle of fuel pins in two steps, the withdrawal load is greatly reduced thereby reducing risk of damage to the irradiation swollen and embrittled pins.

The construction of trisection for the end cap described above is of a shape which offers a minimum of obstruction to coolant flow, ie it is a good aerodynamic shape. Also, positive location of the end cap is provided which may tend to reduce fuel pin vibration. Moreover, the trisection end cap acts as an additional support to the grid structure. The location of the crimped abutment members within the grid is such that the trisection has the end away from the abutment members flush with the grid.

Of course, the end cap can be used in association with any hold-down grid, such as a unitary one which does not have two components divided into a centre part and an outer annulus.

From the above description, it can be seen that an improved nuclear fuel pin assembly and fuel pins usable in such an assembly are provided.

CLAIMS

1. A nuclear fuel assembly comprising a grid comprising a plurality of spaced cells, which cells include regularly spaced crimped abutment means for engaging nuclear fuel pins.

2. A nuclear fuel assembly as claimed in claim 1, in which the cells contain further crimped abutment means for preventing a fuel pin from being inserted other than in a preselected desired position.

3. A nuclear fuel pin comprising an elongate body and an end cap, which end cap carries vanes for interacting with complementary abutment means in a nuclear fuel grid.

4. A nuclear fuel pin as claimed in claim 3, in which said vanes are disclosed at one hundred and twenty degrees relative to one another.

5. A nuclear fuel assembly substantially as herein before described and as shown in the accompanying drawings.

6. A nuclear fuel pin substantially as herein before described and as shown in the accompanying drawings.

Printed for Her Majesty's Stationery Office
by Burgess & Son (Abingdon) Ltd.—1982.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.