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(19)

(54) NUCLEAR REACTOR FUEL ELEMENT ASSEMBLIES

(71) We, UNITED KINGDOM ATOMIC ENERGY AUTHORITY, London, a British Authority do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to nuclear reactor fuel element assemblies and to axial flow cavitation suppressing impedances therefor. The invention is concerned with the problem of cavitation arising from impedances inserted in coolant flow channels in order to regulate the pressure drop in the channels and with flow induced fatigue problems. Cavitation is particularly objectionable in fluid flow channels of a nuclear reactor because it creates 'noise', erosion and vibration of components. It is known to put impedances in the coolant flow channels of a nuclear reactor core to regulate the flow of coolant through fuel elements and thereby control the operating temperatures of the fuel. Early forms of impedance were of the orifice plate type but these gave rise to severe cavitation with large coolant flows and large pressure drops across the orifice. An improved impedance for fluid flow is disclosed in British Patent No. 1,288,258 the impedance comprising a tubular body member housing a series of flow-defining plates arranged transverse to the longitudinal axis of the body member, the series being formed from a first and a second set of plates arranged so that a plate of one set alternates, as viewed in the direction of flow, with a plate of the other set, the first set of plates being of woven wire mesh form and there being a downstream space between plates of the first set to define a flow which is cavitation suppressed by virtue of eddy-induced pressure drops developed in the downstream spaces and the second set of plates being apertured to define the presented flow area of the impedance. An impedance of the improved kind will be referred to hereinafter as an axial flow cavitation suppressing impedance of the described kind. It is an object of the present invention to provide a nuclear reactor fuel element assembly incorporating an axial flow cavitation suppressing impedance generally of the described kind but which offers more resistance to vibration.

A nuclear reactor fuel element assembly according to the present invention has an axial flow cavitation suppressing impedance comprising a tubular body member housing a series of flow defining plates arranged transversely to the longitudinal axis of the body member, the series being formed from a first and a second set of plates clamped into face-to-face abutment and arranged so that a plate of one set alternates, as viewed in the direction of flow, with a plate of the other set, the first set of plates being of woven wire mesh form and the plates of the second set having aligned cylindrical apertures to define the presented flow area of impedance. The cylindrical apertures in the plates of second set define downstream spaces between plates of the first set wherein flow is cavitation suppressed by virtue of eddy induced pressure drops.

The invention finds application in a liquid metal cooled fast breeder reactor. the fuel element assembly comprising, in addition to an axial flow cavitation suppressing impedance of the described kind, a bundle of spaced fuel elements housed within a tubular wrapper, the wrapper forming an extension of the body member at one end and there being spike means disposed at the other end of the body member for locating the fuel assembly in a nuclear reactor core. The fuel element assemblies are disposed side-by-side on a diagrid and the coolant is flowed upwardly through the wrappers in heat exchange with the fuel elements. The impedances are variable by varying the quantity of flow defining plates and are required to provide optimum flow of coolant throughout the reactor core. The impedances according to the present invention minimise cavitation in the coolant

flow and are sufficiently robust to withstand vibration forces generated by the restricted flow of coolant.

A constructional embodiment of the present invention is described by way of example with reference to the drawings accompanying the Provisional Specification and designated Figures 1 and 2 and to the accompanying drawings wherein:

Figure 1 is a fragmentary sectional view of an axial flow cavitation suppressing impedance for a nuclear reactor fuel element assembly,

Figure 2 is a half plan view,

Figure 3 is a fragmentary view of a fuel element assembly for a liquid metal cooled fast breeder reactor, and

Figure 4 is a fragmentary sectional view of a liquid metal cooled fast breeder nuclear reactor.

The axial flow cavitation suppressing impedance shown in the drawings comprises a tubular body member 1 housing a series of flow-defining plates 2 and 3 transverse to the longitudinal axis of the body member. The series of plates is formed from a first set of plates 2 and a second set of plates 3 arranged so that a plate 2 alternates, as viewed in the direction of flow, with a plate 3, each end plate of the series being a plate 3. The series of plates are clamped into face-to-face abutment by means of jacking screws 4 reacting through a retaining ring 5 and a structure 6 to which the body member 1 is secured. The retaining ring 5 is secured to the body member 1 by means of dowels 7. The plates 2 are woven wire mesh and the plates 3 have cylindrical apertures 8 which define downstream spaces between the plates. The number of apertures in the plates 3 and the number of plates 2 and 3 may be varied on assembly to obtain a pre-selected pressure drop through the impedance. Positions in the body which are unoccupied by plates 2, 3 are occupied by spacer rings 9. On assembly all the plates 2 and 3 are located at the downstream end of the body and the plates 3 are orientated by a wire key 10 so that corresponding apertures in adjoining plates are held in alignment to provide continuous flow passages.

The cavitation suppressing impedance shown in the drawings is used as a component designated 26 of a fuel element assembly 14 (shown in Figure 3) for a liquid metal cooled fast reactor. The fuel element assembly 14 comprises a bundle 13 of spaced fuel elements (only one element designated 13*a* being shown) housed within a tubular wrapper 12 of hexagonal cross-section. The wrapper 12 forms an extension of the body member 1 at one end and there is spike means 11 disposed at the other end of the body member for locating the fuel element assembly in a nuclear reactor core. The fuel elements 13*a* are spaced apart by a series of spaced cellular grids 15 and the bundle is surmounted by a bundle 16 of breeder elements 16*a*. The spike means 11 is surrounded by a filter element 17.

In Figure 4 there is shown a liquid metal cooled nuclear reactor core. The core comprises a plurality of upstanding fuel element assemblies 14 closely arranged side-by-side and secured at their lower ends to a support member 18. The support member 18 comprises a diagrid 19 and a plurality of fuel assembly carriers 20 each of which is adapted to carry a group of fuel element assemblies. The diagrid 19 also serves as a distributor for coolant flow to the fuel element assemblies the coolant being delivered to the diagrid 19 by way of pipes 21. At the centre of each group of fuel element assemblies 14 there is a control rod guide tube 22 and the entire assembly of fuel assemblies and control rod guide tubes is surrounded by a plurality of neutron shield rods 23. The entire assembly of fuel assemblies 14, control rod guide tubes 22 and neutron shield rods 23 is engirdled in the upper region of the core by a fixed ring girder which is not shown in Figure 4. A fuel charge chute and fuel storage rotor are shown at 24 and 25. On assembly of the core the fuel element assemblies are free standing with small clearances between neighbouring assemblies. Liquid sodium coolant is flowed upwardly from the diagrid through the filter elements 17 the cavitation suppressing impedance 26 and the tubular wrapper 12 in heat exchange with the fuel elements. Each fuel element assembly of the nuclear reactor has a cavitation suppressing flow impedance and the impedances are varied in order to achieve optimum rates of flow throughout the reactor core. Because the presented flow area of the impedance is divided into multiple discrete small areas the wire mesh is well supported and subject to little vibration, consequently reducing the severity of the flow fatigue problem.

WHAT WE CLAIM IS:—

1. A nuclear reactor fuel element assembly having an axial flow cavitation suppressing impedance comprising a tubular body member housing a series of flow defining plates arranged transversely to the longitudinal axis of the body member, the series being formed from a first and a second set of plates clamped into face-to-face abutment and arranged so that a plate of one set alternates, as viewed in the direction of flow, with a plate of the other set, the first set of plates being of woven wire mesh form and the plates of the second set having aligned cylindrical apertures to define the presented flow area of impedance.

2. A nuclear reactor fuel element

assembly according to claim 1 and comprising a bundle of spaced fuel elements housed within a tubular wrapper, the wrapper forming an extension of the body member at one end and there being spike means disposed at the other end of the body member for locating the fuel element assembly in a diagrid of a nuclear reactor core.

3. A liquid metal cooled fast breeder nuclear reactor comprising a plurality of fuel element assemblies according to claim 2 disposed side-by-side, on a diagrid and arranged for upward flow of coolant through the wrappers in heat exchange with the fuel elements.

4. A nuclear reactor fuel element assembly substantially as hereinbefore described with reference to the drawings accompanying Provisional Specification and to Figure 3 of the accompanying drawings.

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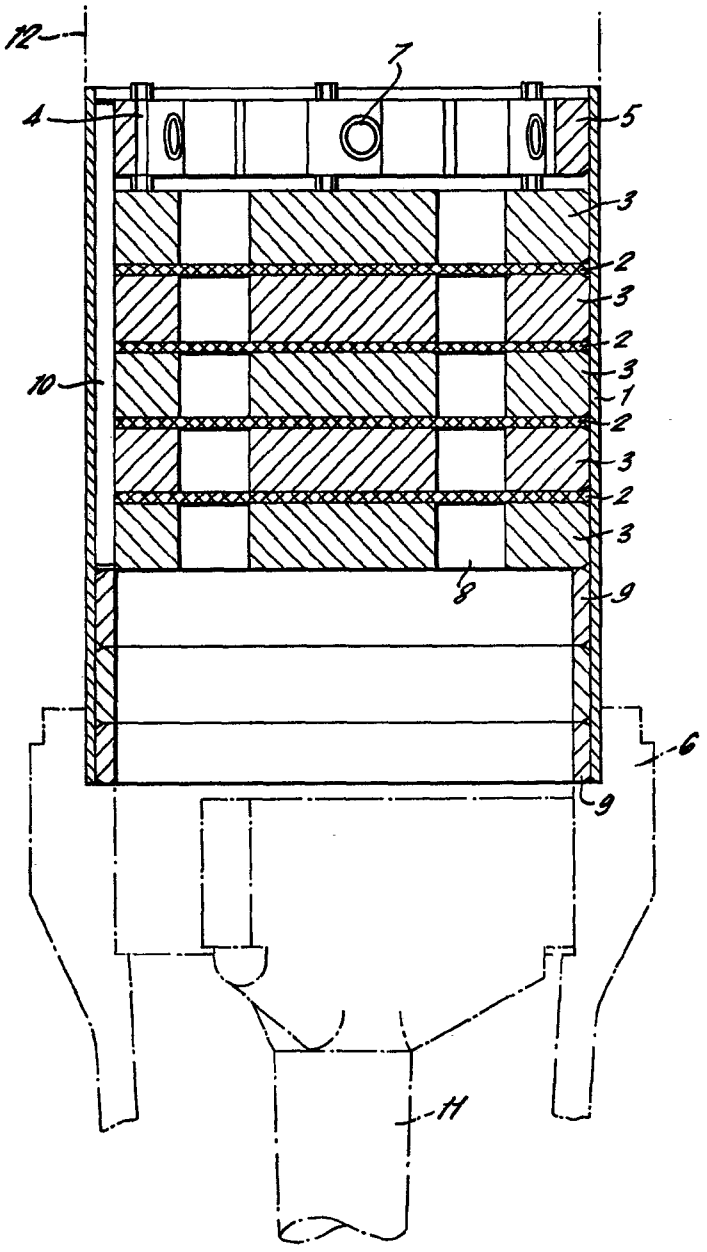
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

FIG.1.



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PROVISIONAL SPECIFICATION

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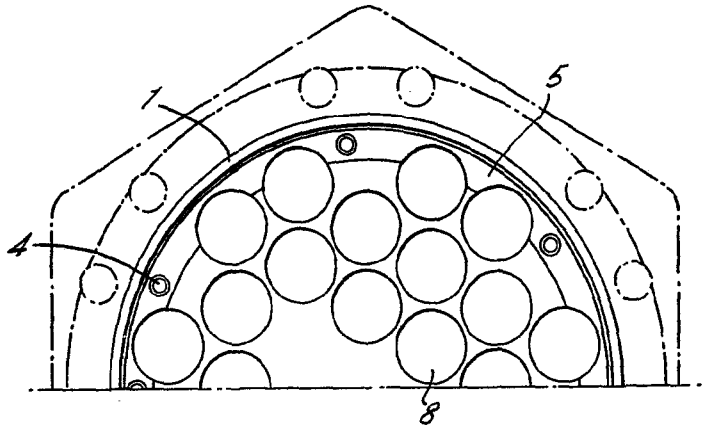
Sheet 2

FIG.2.



1510127 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

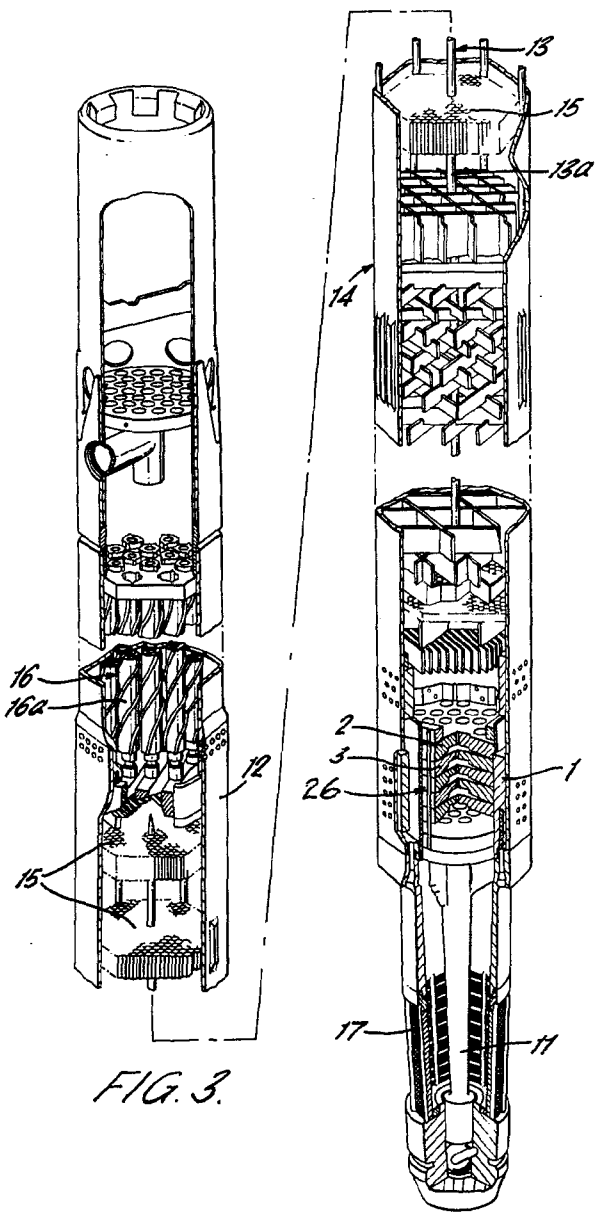


FIG. 3.

1510127 COMPLETE SPECIFICATION
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Sheet 2

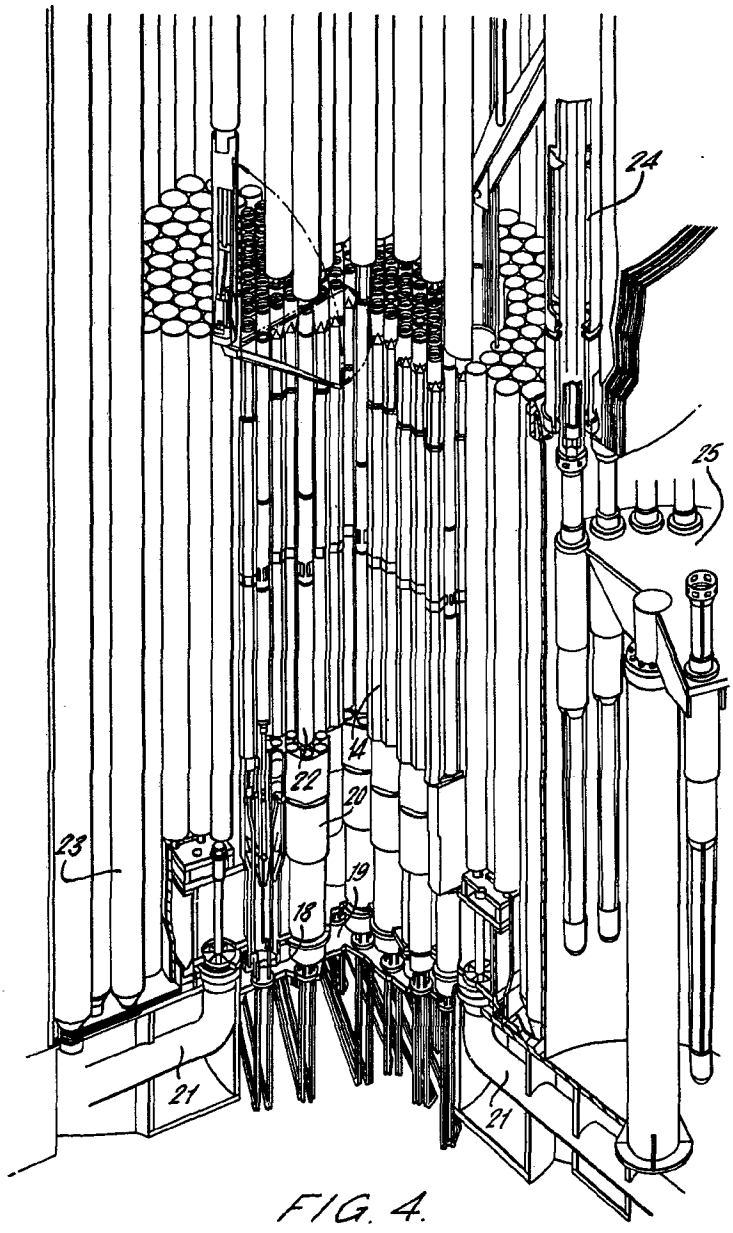

FIG. 4.