PATENT SPECIFICATION (11) 1 500 436

1 500 436

(21) Application No. 15509/75 (22) Filed 15 April 1975 (19)
(23) Complete Specification Filed 9 April 1976
(44) Complete Specification published 8 Feb. 1978
(51) INT. CL.² G21C 15/02
(52) Index at acceptance
G6C 39Y 402 40Y LB

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(54) NUCLEAR REACTOR COOLANT CHANNELS

(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 coolant channels wherein a plurality of nuclear fuel rods are supported and through which a heat receiving liquid passes and, as a result, undergoes boiling. Boiling in this context includes 'subcooled boiling' such as is allowed in pressurised liquid cooling systems, e.g. nuclear reactors, as well as bulk boiling which occurs in boiling water nuclear reactors. The invention aims to improve heat transfer between the heat emitting members and the fluid.

According to the present invention there is provided a nuclear reactor coolant channel having an axially extending channel wall with a liquid coolant entering an inlet at one end and a two-phase fluid passing through an outlet at the other, a cluster of nuclear fuel rods supported within the channel in spaced apart relationship axes parallel to one another and to the axis of the channel so as to define paths for the axially flowing two phase coolant and baffle means extending axially within the channel and disposed relative to the fuel rods so as to restrict flow oscillations occurring within the two phase coolant from being propagated transversely to the axis of the channel.

It has been noted that in a forced convection heat transfer channel wherein the heat emitting bodies takes the form of a cluster of parallel, but spaced apart, rods, a two phase coolant which enters as liquid at the inlet at the bottom of the channel and emerges as a two phase liquid/vapour mixture at the top, undergoes a transverse oscillatory motion superimposed on its axial motion. Such transverse oscillatory motion can become a synchronous wave which may extend throughout the whole flow cross section of the channel over at least a part of its length. The interposition of baffle means within the channel to impede the propagation of these transverse motions can improve heat flux between rods and the liquid vapour mixture.

Examples of this structure will now be given and described with reference to the drawings accompanying the Provisional Specification in which

Figure 1 shows a transverse cross section through a pressurised water nuclear reactor channel in which the water is allowed to boil to produce steam,

Figure 2 is an axial view of Figure 1,

Figures 3 is a view similar to Figure 1 but with a square array of nine nuclear fuel rods in a channel and

Figure 4 is a similar view to Figure 1 showing an alternative way of applying the invention.

Referring firstly to Figures 1 and 2, there is shown a nuclear reactor heat transfer channel 1 which is bounded by a vertical cylindrical wall 2 having an inlet 3 for coolant water at the bottom and an outlet 4 for two phase mixture at the top. A cluster of 36 nuclear fuel rods 5 are supported within the channel 1 at spaced positions, by means not shown, axes parallel to one another and to that of the channel. Heat is extracted from the fuel rods by the coolant flowing parallel to the fuel rods and nucleate boiling occurs. Usually the limit of safe heat flux is determined by the change from nucleate boiling to a condition where the surfaces of the fuel rods become blanketed with vapour and do not rewet. This is termed dryout. A factor which can lower the dryout heat flux is local coolant flow deviation from the parallel direction mentioned, the consequence of which becomes very marked if it permeates the whole flow cross section. The effect can then become cumulative due to synchronism. To obviate this a number, in this case three, axial ribs 6 are attached along the inner surface of the channel wall 2 and extend radially into contact with an adjacent fuel rod. Transverse flow oscillations in the perimeter of the cluster are thereby obstructed and the possibility of their having a cumulative effect is minimised. A cumulative effect may come about by synchronism of transverse eddies around the fuel rods nearest the channel wall. It may therefore be supposed that synchronisms more readily occurs where an even number of fuel rods are present in the row of rods nearest the channel wall. Hence the invention has greater significance where an even number is present in the outermost row of the cluster.

In Figure 3 the channel wall 10 is of square cross section normal to its longitudinal axis and contains an array of nine fuel rods 11. Again the channel wall has on each of its four inwardly directed sides a rib 12 extending into contact with the adjacent fuel rod. Axially, the ribs 12 extend the full length of the cluster, as those shown in Figure 2.

Referring now to Figure 4 in which is shown a circular channel bounded by a vertical cylindrical wall 14, a cluster of 36 nuclear fuel rods 15 are arranged with the rods in annular rows. The rods 15 are spaced apart by grids in known manner. But the transverse continuity of the inter-rod spaces (which forms the coolant flow path) is broken, over the whole axial length of the cluster by a partition wall 16. This partition wall may be formed in several ways but the preferred way and that shown here is by providing the outer surface of those rods 16 which lie on a diameter, with radial, axial fins extending throughout their length.

Other ways of effecting an improvement in heat flux by providing baffle means to damp transverse movements of two phase fluid may easily be devised now that the possibility of the deleterious, cumulative effect of these movements on heat flux has been realised.

WHAT WE CLAIM IS:—

1. A nuclear reactor coolant channel having an axially extending channel wall with a liquid coolant entering an inlet at one end and a two phase fluid passing through an outlet at the other, a cluster of nuclear fuel rods supported within the channel in spaced apart relationship axes parallel to one another and to the axis of the channel so as to define paths for the axially flowing two phase coolant and baffle means extending axially within the channel and disposed relative to the fuel rods so as to restrict flow oscillations occurring within the two phase coolant from being propagated transversely to the axis of the channel.

2. A nuclear reactor coolant channel as claimed in claim 1 in which the baffle means are disposed at the cluster boundary and take the form of axially extending ribs protruding from the channel wall towards the channel axis.

3. A nuclear reactor coolant channel as claimed in claim 1 in which the baffle means comprises a transverse partition extending across the cluster for the whole of the axial length of the cluster.

4. A nuclear reactor coolant channel as claimed in any of claims 1—3 in which there is an annular row of fuel rods of the cluster located adjacent the channel wall containing an even number of fuel rods.

5. A nuclear reactor coolant channel as claimed in any of claims 1 to 4 substantially as herein described with reference to the drawings accompanying the Provisional Specification.

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Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1978.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY
from which copies may be obtained.

1500436 PROVISIONAL SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

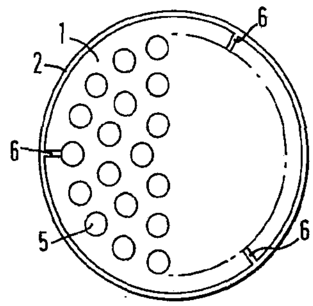

FIG.1.

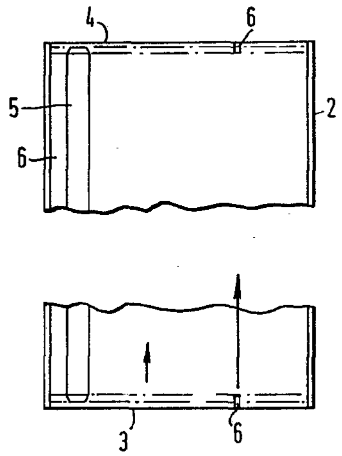

FIG.2.

FIG.3.

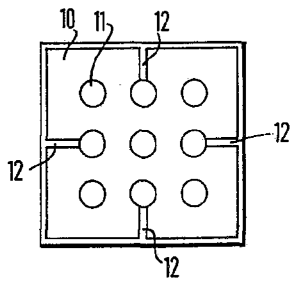

FIG.4.