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(54) IMPROVEMENTS IN OR RELATING TO LIQUID METAL
 COOLED NUCLEAR REACTORS

(71) We, INTERATOM, INTERNATIONALE ATOMREAKTORBAU GMBH, a German company, of 5060 Bergisch Gladbach 1, Germany, 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 a liquid metal cooled nuclear reactor plant.

It has been shown that during the operation of nuclear reactors cooled with liquid metal, for example liquid sodium, large volumes of metal vapour and aerosols form in the protective gas blanket above the pool of liquid metal. Thus the lower layers of the protective gas blanket are strongly heated by the underlying hot metal coolant, whilst the upper portions of the protective gas atmosphere and the walls bounding it, for example the cover of the nuclear reactor, are at a substantially lower temperature this temperature distribution leads to upwardly directed convection currents in the protective gas atmosphere by means of which saturated metal vapour comes into contact with the relatively cool surfaces of the nuclear reactor vessel and its components where it can condense and possibly even freeze to solid metal. As a result the operation of important components of the nuclear reactor, for example of the control rods, and the rotation of the reactor cover can be severely hindered. At best this necessitates costly trace heating at important points in order to melt the melt again. A more disadvantageous occurrence than the deposition of pure metal is the deposition of metal compounds or reaction products, for example oxides. These metal compounds cannot be removed even by heating. It is therefore desirable to prevent the transfer and convection of such metal vapour and aerosols in the protective gas atmosphere. It must be borne in mind that a substantial free space is required between the liquid metal surface and the cover of

the reactor container for handling devices and instruments.

According to the present invention there is provided a nuclear reactor plant comprising a vessel containing a nuclear reactor core, a liquid metal coolant for the nuclear reactor core in a lower zone of the vessel, a gas in an upper zone of the vessel and one or more barriers which subdivide the upper zone into two or more regions, the thermal flow system of each region being substantially independent of the thermal flow system of the adjacent region(s). This type of arrangement requires only a small constructional expenditure and should be robust even in operation. Nevertheless the transfer, produced by convection, of metal vapour to the cooler parts of the plant is reduced, although gaps of a width which excludes blocking by condensate are present between the edges of the barriers and the inner wall of the vessel and the openings required for the passing through of control rods, handling equipment etc. Preferably the one or more barriers divide the upper zone substantially horizontally into a plurality of regions.

Preferably the one or more barriers has to or have a conical shape. Advantageously the point of the cone is located approximately on the vertical axis of the vessel. In this way a more advantageous form of flow is achieved and furthermore the inclination of the barriers makes it possible for the liquid metal deposited on the barriers to drain away easily to the lowest points thereof from where it can drain off into the liquid metal plenum of the reactor.

The present invention also provides a nuclear reactor plant, wherein the vessel is sealed at its upper end by a plurality of covers, at least two of said covers being substantially cylindrical and rotatable about their axes, at least one of said rotatable covers being supported in another of said rotatable covers, wherein each of said covers has associated therewith one or more part barriers (corresponding to said one or

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more barriers) and wherein the part barriers associated with the rotatable covers each have a horizontal projection corresponding to the horizontal cross-section of the cover with which they are associated and each can rotate coaxially with its respective cover. The passing through of the components, for example control rods or handling devices, attached to the rotary covers therefore presents few problems as the different thermal expansions are compensated.

For a better understanding of the present invention and to show more clearly how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawing which shows a vertical section of a liquid metal cooled nuclear reactor plant according to the present invention.

Inside a reactor vessel 1 the lower zone of which is filled up to a level 2 with liquid metal, which in this example is sodium, a core 3 of the nuclear reactor is disposed. The power release of the core 3 is controlled with the aid of control rods 4 which can be moved up and down in a known way with the aid of control rod devices 5. The reactor vessel 1 is closed above with a cover 6 which is rotatable on bearings 7 with the aid of a drive (not shown). Inside the rotary cover 6 and eccentric to its central axis is a second rotary cover 8 which has openings 9 through which the control rods 4 are guided. The second cover 8 can be rotated on bearings 10 and with the aid of a drive (not shown).

Inside the second rotary cover 8 and eccentric to its central axis is a third rotary cover 11 which is rotatable on bearings 12 by means of a drive (not shown) and in which devices 13 of known construction are installed, with the aid of which the fuel elements can be inserted in and removed from the core 3. By appropriate rotation of the covers 6, 8 and 11 the devices 13 can be positioned over each individual element of the core 3. The control rods 4 can be split so that their lower portions comprising absorbers (not shown) remain in the core 3 whilst their upper portions are rotated with the second rotary cover 8. The rotary covers 6, 8 and 11 are provided on their undersides with shields 14, 15, 16. For protecting these shields from the heat radiation from the coolant, the shields 14, 15 and 16 are provided on their undersides with sets of thermal insulation plates 17 or 18 or 19 respectively. The gap 20 between the coolant level 2 and the underside of the rotary cover, i.e. the upper zone of the vessel 1, is filled with an inert protective gas, for example argon. In use, this argon contains considerable quantities of liquid metal vapour and aerosols which can penetrate for example into the clearance between the rotary cover 6 and the reactor vessel 1, into the clearances between the individual rotary covers or into the opening 9. As these parts are at a relatively low temperature condensation of metal vapour or precipitation of impurities such as metal oxides from the argon may result which can endanger the bearings 7, 10 and 12 for example and thus the mobility of the rotary cover or even the mobility of the control rods. This deposition is assisted by the convection which occurs as a result of the temperature gradients in the gap 20 above the liquid metal level 2. In order to restrict this convection, two convection barriers 21 and 22 are installed. The lower convection barrier 21 comprises three individual part barriers 23, 24 and 25 and the upper convection barrier similarly comprises three individual part barriers 26, 27 and 28. The part barriers 24 and 27 have a horizontal projection corresponding to the horizontal cross-section of the second rotary cover 8, the part barriers 25 and 28 have a horizontal projection that corresponds to the horizontal cross-section of the third rotary cover 11, and the part barriers 23 and 26 have a horizontal projection corresponding to the remaining horizontal cross-section within a lateral boundary 29. The part barriers 26, 27 and 28 are suspended by rods 30 from the rotary covers 6, 8 and 11 respectively and rotate with these so that the mobility of the control rods 4 and the fuel element changing devices 13 is not hindered. The part barriers 23, 24 and 25 are supported by rods 31 on an immersed plate, placed just below the coolant level 2, which plate comprises three individual parts 32, 33, 34 co-axial with the rotary covers 6, 8, 11 respectively. The control rods 4 are guided through the immersed plate, which also supports measuring instruments (not shown) for monitoring the core 3. The individual parts 32, 33, 34 are attached to the rotary covers 6, 8, 11 respectively by means of suspended constructions 29, 35, 36 respectively. The barriers 23, 24 and 25 and 26, 27 and 28 respectively are of oblique or conical construction so that the liquid metal condensed on them can drain off more easily, in so far as the condensed liquid metal runs to the lowest points of the barriers and collects there. The barriers are furthermore constructed to overlap somewhat at their boundaries in order to keep the clearances facilitating convection as small as possible. In the case of a particularly large gap between the rotary cover 6 and the reactor vessel 1, a row of additional plates 33 (attached to the reactor vessel 1) and 34 (attached to the rotary cover 6) are provided which alternate with one another so as to form a labyrinth seal. The barriers 21, 22 thus subdivide the

upper zone of the vessel 1 into three regions, the thermal flow systems of which are substantially independent of one another.

WHAT WE CLAIM IS:—

- 5 1. A nuclear reactor plant comprising a vessel containing a nuclear reactor core, a liquid metal coolant for the nuclear reactor core in a lower zone of the vessel, a gas in an upper zone of the vessel and one or more barriers which subdivide the upper zone into two or more regions, the thermal flow system of each region being substantially independent of the thermal flow system of the adjacent region(s).
- 10 2. A nuclear reactor plant as claimed in claim 1, wherein the one or more barriers has or have a conical shape.
- 15 3. A nuclear reactor plant as claimed in claim 1 or 2, wherein the vessel is sealed at its upper end by a plurality of covers, at least two of said covers being substantially cylindrical and rotatable about their axes, at least one of said rotatable covers being supported in another of said rotatable covers, wherein each of said covers has associated therewith one or more part-barriers (corresponding to said one or more barriers) and wherein the part-barriers associated with the rotatable covers each have a horizontal projection corresponding to the horizontal cross-section of the cover
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with which they are associated and each can rotate coaxially with its respective cover.

4. A nuclear reactor plant as claimed in claim 3, wherein each part barrier is secured to its corresponding cover. 35

5. A nuclear reactor plant as claimed in claim 3 or 4, wherein one of said rotatable covers is supported by the upper edge of the vessel and wherein there is a clearance between at least a part of the edge of said cover and the vessel, which clearance is sealed by a plurality of first annular plates secured to the vessel and a plurality of second annular plates secured to said cover, which alternate with the first annular plates so as to form a labyrinth seal. 40 45

6. A nuclear reactor plant substantially as hereinbefore described with reference to and as shown in the accompanying drawing. 50

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