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(54) IMPROVEMENTS IN OR RELATING TO  
HEAT EXCHANGERS

(71) We, BABCOCK & WILCOX LIMITED, a British Company of Cleveland House, 19 St. James's Square, London SW1Y 4LN, 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:-

5 It has been proposed to use liquid sodium as the coolant in a nuclear reactor, to heat secondary sodium by the sodium that has circulated in the reactor and then use the heat in the secondary sodium in the generation and heating of steam. The present invention arose from a consideration of the design problems involved in seeking to use the heat in sodium that has served as the coolant in a sodium-cooled fast reactor to produce superheated steam. One problem centres on the risk of an explosion resulting in the event that sodium and water come into contact with each other.

10 According to the present invention there is provided a method of producing superheated steam by use of the heat in liquid sodium, in which liquid sodium is caused to flow through a space having boundaries of which no part is common with the boundaries of a space in which vapour is produced, a fluid that is inert to sodium is heated by heat exchange at the boundaries of the space through which the liquid sodium flows and serves as the heating medium for the production of vapour, and the vapour is subsequently heated to the final degree of superheat by heat exchange with liquid sodium in a space that has a common boundary with a space through which liquid sodium is passed.

15 According to the present invention, there is also provided apparatus in which superheated steam may be produced, including first heat exchanging means that provides a flow path connected to a source of liquid sodium

and a flow path connected to a source of water, the boundaries of the flow paths being such that no part of the boundaries of one is part of the boundaries of the other, and means is provided for circulating a fluid that is inert to sodium successively in heat exchange with the former flow path and the latter, additional heat exchanging means providing two flow paths having a boundary wall common to each, means connecting one of the flow paths of the additional heat exchanging means to the outlet of the flow path of the first heat exchanging means that is connected to a source of water, and means connecting the other of the flow paths of the additional heat exchanging means to a source of liquid sodium.

20 By way of example an embodiment of the invention will now be described with reference to the accompanying drawing which is a diagram illustrating apparatus in which vapour may be generated and superheated by use of the heat in liquid sodium.

25 The illustrated apparatus includes a cylindrical container 1 containing a cylindrical baffle (not shown) to facilitate the circulation of gas within the container. The circulation is indicated by the arrows; flow is in one axial direction within the baffle and in the reverse direction in the annular space between the baffle and the container, and a fan, or pump, 2 is provided to promote the circulation of the gas. A bank of tubes 3 is disposed within the baffle and a further bank of tubes 4 is disposed within the annular space.

30 In a further container, or shell, 10, a bank of tubes 11 through which vapour can flow is disposed within a space through which liquid sodium can flow. The space is indicated by a bank of tubes 12 but it is to be understood that the bank of tubes 11 and the space 12 have a common boundary so that one side of the boundary is in contact with vapour and the other side of the boundary is in contact

with sodium. A connection 14 is provided to lead sodium that has passed through that space 12 to the tube bank 3 in the container 1. The other tube bank in the container is connected to a water supply through the duct 5.

In operation of the apparatus, liquid sodium that has been heated by heat exchange with liquid sodium that has served as coolant in a sodium cooled fast reactor is passed through the space 12 in the shell 10, then through the tube bank 3 in the cylindrical container 1, and then returned to the reactor. Water is supplied to the other bank of tubes 4 in the cylindrical container 1 and the gas in the container is circulated to transfer heat from the sodium to the water to produce vapour, which may be saturated or superheated. The vapour then passes through the tubes 11 in the shell 10 to achieve its final degree of superheat. Between leaving the cylindrical container 1 and entering the shell 10 the steam may be used, provided that the fluid that subsequently enters the tubes 11 in the shell 10 is not in a liquid condition.

In the apparatus that has been described, heat exchange between water and sodium is effected through the intermediary of a gas, so that the water path and the sodium path do not have a common boundary, and the chances of excessive conditions resulting from the interaction of sodium with water are restricted. In the shell 10, however, no intermediary is used, so that a flaw in the common boundary could result in a reaction between the sodium and steam. The troubles resulting from the leakage of steam into sodium are, however, considered to be less serious in pressure generation and in metal wastage than the troubles likely to result from the leakage of water into sodium. Moreover, the uncertainties associated with the use of sodium as the heating medium in the generation and superheating of steam are mostly connected with the steam generating surfaces.

It will be realised that the size of a heat exchanger in which heat exchange is effected through the intermediary of a gas is greater than that of a heat exchanger in which the use of gas is dispensed with, so that effecting superheating without the use of a gas makes possible the use of a heat exchanger smaller than would be required if the total heat exchange were effected through a circulating gas. The power required to circulate the gas is also less. Moreover, the size of the heat exchanger in which gas acts as a heat exchange medium depends upon the temperature difference between the fluids between which it is transferring heat and this is greater, and the size of the vessel therefore less, when one of the fluids is water than when one of the fluids is

superheated steam. The use of gas would therefore, be comparatively less effective in the heating of steam.

The apparatus that has been described may be used for superheating steam in once through and forced circulation boilers as well as in "hybrid" or partial recirculation boilers.

In the embodiment described, gas has been mentioned as the intermediate fluid in the heating of the water by the heat in sodium. It is envisaged that other fluids, such as a gas suspension, molten salt, or oil, that are inert to liquid sodium, might be used as alternatives.

Attention is drawn under Section 9 of the Patents Act 1949 to patent No. 1,109,395.

WHAT WE CLAIM IS:-

1. A method of producing superheated steam by use of the heat in liquid sodium, in which liquid sodium is caused to flow through a space having boundaries of which no part is common with the boundaries of a space in which vapour is produced, a fluid that is inert to sodium is heated by heat exchange at the boundaries of the space through which the liquid sodium flows and serves as the heating medium for the production of vapour, and the vapour is subsequently heated to the final degree of superheat by heat exchange with liquid sodium in a space that has a common boundary with a space through which liquid sodium is passed.

2. A method as claimed in Claim 1 in which the vapour that is subsequently heated by liquid sodium is initially superheated steam.

3. A method as claimed in either of the preceding claims in which the liquid sodium that has been cooled by heating vapour serves subsequently as the source of heat for the inert fluid.

4. A method as claimed in any of the preceding claims in which the heat in the liquid sodium has been derived by heat exchange with liquid sodium that has served as coolant in a nuclear reactor.

5. Apparatus in which superheated steam may be produced, including first heat exchanging means that provides a flow path connected to a source of liquid sodium and a flow path connected to a source of water, the boundaries of the flow paths being such that no part of the boundaries of one is part of the boundaries of the other, and means is provided for circulating a fluid that is inert to sodium successively in heat exchange with the former flow path and the latter, additional heat exchanging means providing two flow paths having a boundary wall common to each, means connecting one of the flow paths of the additional heat exchanging means to the outlet of the flow path of the first heat exchanging means that is con-

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nected to a source of water, and means connecting the other of the flow paths of the additional heat exchanging means to a source of liquid sodium.

5 6. Apparatus as claimed in Claim 5 in which the flow path of the first heat exchanging means that is connected to a source of liquid sodium is formed from tubes, the  
 10 further flow path that is connected to a source of water is formed from tubes, the tubes are disposed in a single container, and baffle means disposed in the container define a flow path such that the inert fluid may be circulated in the container suc-  
 15 cessively over tubes that are connected to a

source of sodium and over tubes that are connected to a source of water.

7. Apparatus as claimed in either of Claims 5 and 6 in which the source of liquid sodium for the first heat exchange means is the flow path of the additional heat exchange means that is connected to a source of sodium. 20

8. A method of producing superheated steam substantially as described with refer- 25  
 ence to, and as illustrated by, the accompanying drawing.

Agent for the Applicants

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Chartered Patent Agent. 30

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COMPLETE SPECIFICATION

I SHEET

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

