(12) UK Patent Application (19) GB (11) 2 060 840 A

(21) Application No **8028038**
(22) Date of filing
29 Aug 1980
(30) Priority data
(31) **7930210**
(32) **31 Aug 1979**
(33) **United Kingdom (GB)**
(43) Application published
7 May 1981
(51) **INT CL³ F22B 1/06**
(52) Domestic classification
F4A 8C
(56) Documents cited
GB 1564821
GB 1562642
GB 1060961
(58) Field of search
F4A
(71) Applicant
Babcock Power Limited
Maypole House
128–132 Borough High Street
London SE1 1LB
(72) Inventor
John William Edmund Campbell
(74) Agents
D O Lewis
C/ Babcock International Ltd
Cleveland House
19 St James's Square
London SW1Y 4LN

(54) Water tube liquid metal control

(57) A heat exchanger in which liquid to be wholly or partly vaporized flows in U-tubes 14 from inlets 17 to outlets 19 and liquid metal to be cooled is caused to flow externally of the U-tubes from inlet 4 to outlets 5 through annular passages 10, 12 in counterflow to the fluid within the U-tubes, the flow turning space 13 between the passages 10, 12 is provided with liquid metal bypass means 21–27 for controllably reducing the liquid metal flow over the U-tube downflow limbs in passage 12. By the use of said bypass means when necessary it is intended to retain the initial vaporizing zone within the U-tube upflow limbs.

FIG. 1

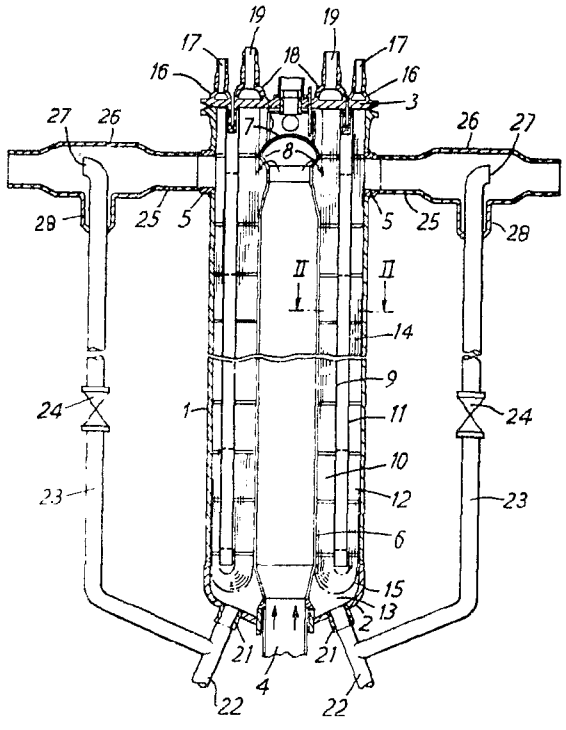


FIG. 1

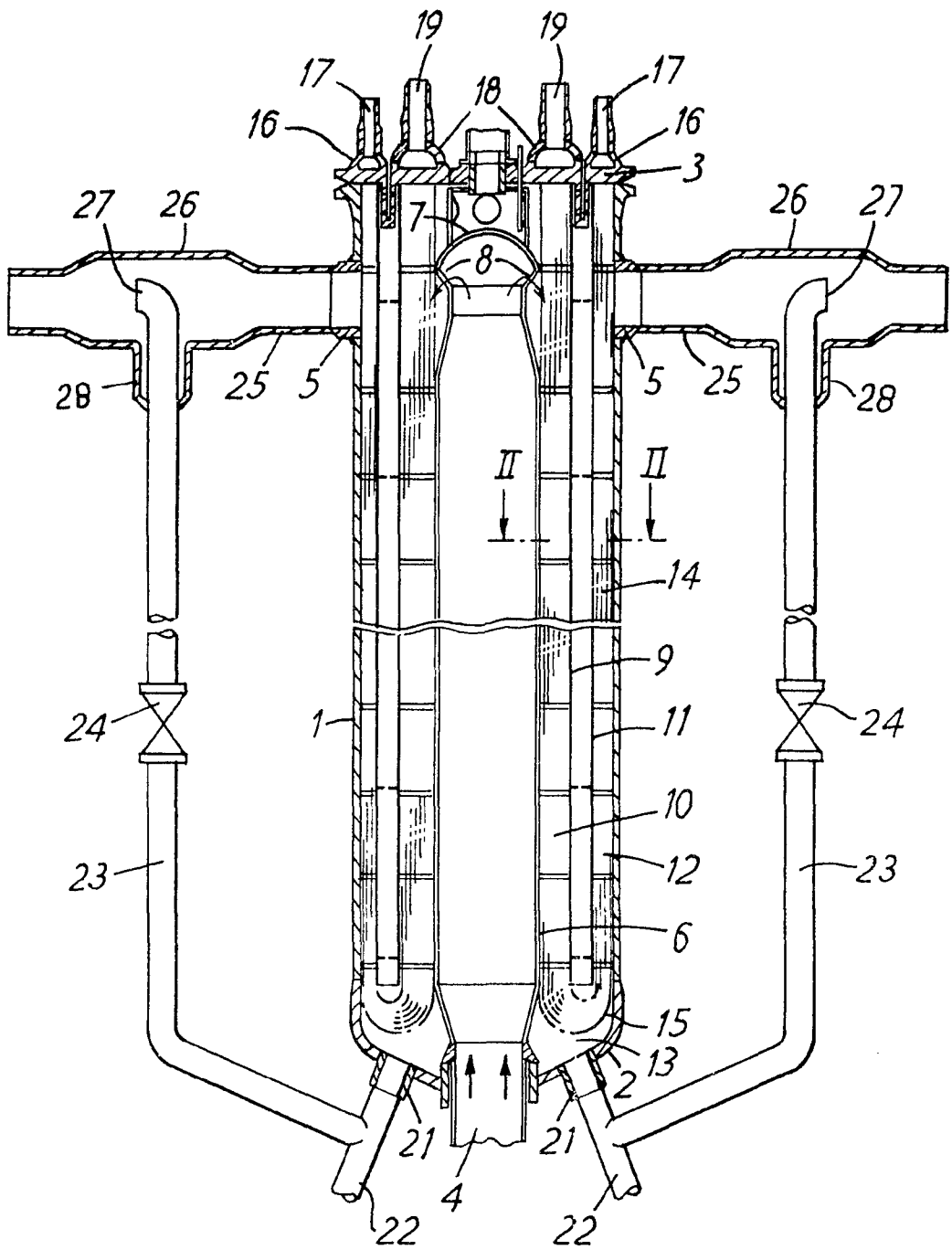
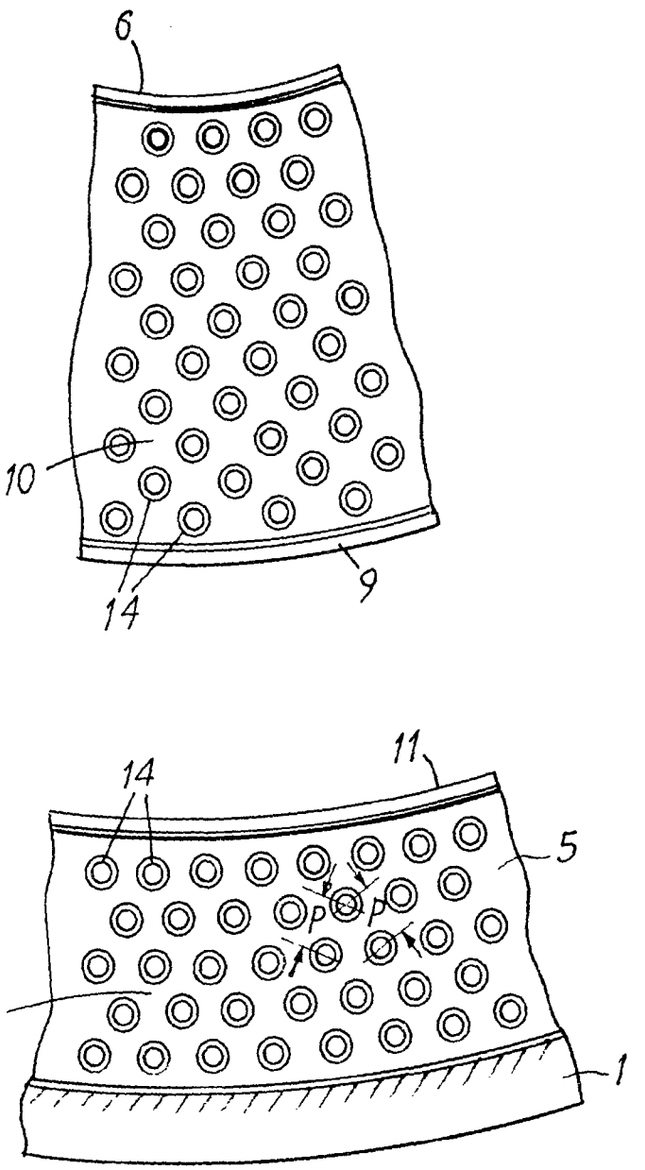

19
19
17
17
18
16
16
3
27
26
7
26
27
8
28
25
5
5
25
28
II
II
14
9
24
1
11
24
10
23
12
23
6
15
13
2
21
21
4
22
22

FIG.2



SPECIFICATION

Heat exchange arrangements

This invention relates to arrangements for heat exchange between a flow of liquid metal to be cooled and a forced flow of liquid to be wholly or partly evaporated.

The core of a nuclear reactor of fast-neutron type is usually cooled by a flow of liquid sodium or of liquid sodium and potassium alloy the heat in which, usually after it has first been transferred to a secondary liquid metal flow, may be exploited for raising, superheating and possibly also reheating steam for driving turbines. For the steam-generating and superheating purposes heat exchangers, examples of which are described and illustrated in Patent Specifications 1,101,772 and 1,101,773, have been designed comprising an elongated cylindrical vessel of upright axis, partitions defining within the vessel a liquid metal flow path which includes a down flow through an annular passage to a flow turning space and from the flow turning space an upflow through a further annular passage and a plurality of forced-flow U-tubes all arranged in parallel as regards the working fluid flow and for working fluid downflow in the second-mentioned of the annular passages and for working fluid upflow in the first-mentioned of the annular passages. There may be one such heat exchanger for steam generating with or without some superheating and another such heat exchanger for superheating the steam generated.

The steam generating heat exchanger will be designed with reference to the desired rate of heat transfer at normal load to the working fluid under desired boiler pressure and so that at normal load the zone of the U-tubes in which steam generating commences lies in the upflow limbs of the U-tubes, a condition that tends towards the equalization of the flows in the parallel-connected U-tubes. If the power plant is required to operate at reduced load, however, and for any of various reasons it is impracticable or undesirable to re-adjust the boiler working fluid flow rate in relation to the reduced liquid sodium flow rate, or the liquid sodium flow rate in relation to the reduced water boiler working fluid flow rate, exactly to an extent which causes the said zone to retain its location, then it may be that the said zone assumes at reduced load a new location in the U-tube bends or even in the downflow limbs of the U-tubes.

In an arrangement for heat exchange between a flow of liquid metal to be cooled and a forced flow of liquid to be wholly or partly vaporized, including an elongated cylindrical vessel of upright axis, partitions defining within the vessel a liquid metal flow path which includes a downflow through an annular passage to a flow turning space and from the flow turning space an upflow through a further annular passage and a plurality of parallel-connected forced-flow vapour generating U-tubes arranged for downflow in the second-mentioned of the annular passages and for upflow in the first-mentioned of the annular passages, according to the present invention means allow for the withdrawing at an adjustable rate of some of the liquid metal entering the flow turning space and by-passing it in relation to the annular passage into which the remaining liquid metal turns from the said flow turning space.

If a bypassing is effected in relation to the said annular passage less heat is carried by liquid metal into the annular passage per unit time than otherwise and therefore the liquid downflow in the U-tubes receives less heat per unit time than otherwise and the zone in which vaporization commences in the U-tubes is caused to retreat from the U-tube inlets; therefore, if at part load it would otherwise move into the U-tube bends or into the U-tube downflow limbs, then by appropriate adjustment of the liquid metal bypass rate the said zone may be caused to retain a location in the U-tube upflow limbs.

In the case of a power plant forced-flow steam boiler designed for operation with the forced flow of the working fluid through steam generating tubes and including a steam and water separating vessel or drum and arranged for a continuous withdrawal or letdown of some or all of the separated water from the drum and its passage through demineralizing means for removal or reduction of solids and solid solutes therefrom, it is known to recover much of the heat in the letdown water by passing the letdown water through a heat exchanger cooled by boiler feedwater which is on its way from the condenser back to be re-heated and re-vaporized. If, as may be desirable, at least a minimum letdown water flow is maintained whatever the load, then this manner of letdown water cooling may well have as one result that the final feedwater temperature is higher at some reduced loads than at normal load. If the steam generating part of the boiler is a heat exchanger of the kind mentioned and receives such higher temperature feedwater at reduced loads, the present invention will be of utility in providing means for retaining in the U-tube upflow limbs the zone in which evaporation commences.

The invention will now be described by way of example with reference to the accompanying drawings, in which

Figure 1 is a sectional elevation of an arrangement for heat exchange between liquid sodium to be cooled and water to be wholly or partly vaporized and

Figure 2 is a plan to a larger scale of part of the arrangement in section on the line II-II of Fig. 1.

With reference to the drawings, an arrangement for heat exchange between a flow of liquid sodium to be cooled and a forced flow of water to be wholly or partly vaporized includes an elongate cylindrical pressure vessel 1 of upright axis having a convex or dished lowermost end wall 2 and its upper end closed by a horizontal upper plate 3. In the centre of the lowermost end wall 2 there is positioned an inlet 4 for the liquid sodium and near the top of the vessel there are positioned two outlet nozzles 5 for the liquid sodium, one diametrically opposite to the other in relation to the vessel axis. Within the vessel there are arranged a partition 6 which is co-axial with the vessel and is mainly cylindrical and extends from the liquid sodium inlet 4 to a domed cover 7 at its upper end below which liquid sodium outlet apertures 8 are formed; a cylindrical partition 9 of greater diameter than the partition 6 and which is also co-axial with the vessel and extends downwardly from the upper plate 3 to terminate at the level of the upper end of the dished lowermost end wall 2, and defines between itself and the partition 6 an annular liquid sodium downflow passage 10; a cylindrical partition 11 of greater diameter than the partition 9 and which is also co-axial with the vessel and extends downwardly from the upper plate 3 to terminate at the same level as the lower end of the partition 9 and defines between itself and the side wall of the vessel an annular liquid sodium upflow passage 12 with which the liquid sodium outlets 5 communicate. The partitions together define a liquid sodium flow path from the inlet 4 upwardly in the space within the partition 6, through the aperture 8, downwardly through the annular passage 10 to an annular flow turning space 13 provided by that part of the space embraced by the vessel lowermost end wall 3 that lies radially outside the partition 6 and upwardly through the second mentioned annular passage 12 to the liquid sodium outlet nozzles 5.

Also within the vessel there are arranged a plurality of forced-flow steam generating U-tubes 14 each having one of its limbs extending vertically within the annular passage 12 and the other extending vertically within the annular passage 10 and a bend 15 joining the two limbs and housed in the liquid sodium flow turning space 13. The upper ends of the tubes in the annular passage 12 terminate at respective apertures (not shown) in the upper plate 3, to which plate they are welded, and all the said apertures communicate with the annular space within a semi-toroidal cover 16 carrying inlet nozzles 17 and welded to the upper plate 3 and serving as the water inlet manifold for all the U-tubes. The upper ends of the tubes in the annular passage 10 terminate at respective apertures (not shown) in the upper plate 3, to which plate they are welded, and all these latter apertures communicate with the annular space within a second semi-toroidal cover 18 carrying outlet nozzles 19 and welded to the upper plate 3 and serving as the steam or steam and water outlet manifold for all the U-tubes.

The vessel lowermost end wall 2 is pierced for two nozzles 21, one diametrically opposite to the other in relation to the vessel axis, to which respective drainage pipes 22 are attached that may be used for emergency liquid sodium removal in the event of a tube leak or a tube failure resulting in a water-sodium reaction. From each drainage pipe 22 there leads a by-pass pipe 23 in which an adjustable valve 24 is placed; to each liquid sodium outlet nozzle 5 there is attached a withdrawal conduit 25 for cooled liquid sodium and a length 26 of the conduit 25 is formed of enlarged diameter; the two by-pass pipes 23 terminate in respective open ends 27 positioned on the respective axes of the respective conduit enlarged lengths 26, which therefore constitute mixing chambers for the rejoining with the liquid sodium flows withdrawn from the vessel 1 through the outlet nozzles 5 of liquid sodium flows that may be permitted to flow through the by-pass pipes 23. The by-pass pipe ends 27 face downstream of the liquid sodium flows in the conduit enlarged lengths 26. The pipes 23 enter the respective mixing chambers 26 through thermal sleeves 28 at the walls thereof.

In operation the liquid sodium entering the vessel 1 through the inlet 4 flows upwardly within an axial passage defined by the partition 6, then radially outwardly through the apertures 8, then downwardly in the annular passage 10 to the flow turning space 13; normally all of it then flows upwardly within the annular passage 12 and through the outlet nozzles 5 and flow away through the withdrawal conduits 25. The water to be wholly or partially evaporated enters the inlet manifold 16 through the nozzles 17, flows in parallel through the U-tubes, of which the limbs in the annular passage 12 are downflow limbs and the limbs in the annular passage 10 are upflow limbs, and the steam or the steam and water mixture is discharged by the tubes into the outlet manifold 18 and is withdrawn through the nozzles 19.

The heat exchanger is designed with reference to the desired rate of heat transfer at normal load to the water under desired boiler pressure and so that at normal load the zone of the U-tubes in which steam generating commences lies in the upflow tube limbs in the annular passage 10. If circumstances arise in which the zone of the U-tube in which steam generating commences would otherwise move, or in which there might be a risk of its moving, into the U-tube bend 15 or into the downflow tube limbs in the annular passage 12, then by permitting by operation of

the valves 24 a sufficient controlled flow of liquid sodium through the by-pass pipes 23 the zone of the U-tubes in which steam generating commences is retained or retained with certainty in the upflow tube limbs in the annular passage 10.

CLAIMS

1. An arrangement for heat exchange between a flow of liquid metal to be cooled and a forced flow of liquid to be wholly or partly vaporized, including an elongated cylindrical vessel of upright axis, partitions defining within the vessel a liquid metal flow path which includes a downflow through an annular passage to a flow turning space and from the flow turning space an upflow through a further annular passage and a plurality of parallel-connected forced-flow vapour generating U-tubes arranged for downflow in the second-mentioned of the annular passages and for upflow in the first-mentioned of the annular passages, wherein means allow for the withdrawing at an adjustable rate of some of the liquid metal entering the flow turning space and by-passing it in relation to the annular passage into which the remaining liquid metal turns from the said flow turning space.

2. An arrangement as claimed in Claim 1, wherein liquid metal by-pass pipes containing respective adjustable valves lead from a vessel wall bounding the flow turning space to debouch within and on the axes of respective mixing chambers comprising respective lengths of enlarged diameter of liquid metal withdrawal conduits.

3. An arrangement as claimed in Claim 2, wherein the liquid metal by-pass pipes enter the respective mixing chambers through thermal sleeves at the walls thereof.

4. An arrangement for heat exchange between a flow of liquid metal to be cooled and a forced flow of liquid to be wholly or partly vaporized, including liquid metal by-pass means arranged substantially as hereinbefore described with reference to the accompanying drawings.

Printed for Her Majesty's Stationery Office
by Burgess & Son (Abingdon) Ltd.—1981.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.