

12 **EUROPEAN PATENT APPLICATION**

21 Application number: 84301467.1

51 Int. Cl.³: **F 28 B 9/04**
F 22 B 37/74

22 Date of filing: 06.03.84

30 Priority: 18.03.83 GB 8307568

43 Date of publication of application:
03.10.84 Bulletin 84/40

84 Designated Contracting States:
DE FR GB IT NL SE

71 Applicant: **The Secretary of State for Trade and Industry**
in Her Britannic Majesty's Government of the United
Kingdom of Great Britain and
Northern Ireland 1 Victoria Street
London SW1H 0ET(GB)

72 Inventor: **Henry, John Alexander Richardson**
92 Whitecart Tower
St Leonards East Kilbride Scotland(GB)

74 Representative: **Beckham, Robert William**
Procurement Executive Ministry of Defence Patents
1A(4), Room 2014
Empress State Building Lillie Road London SW6 1TR(GB)

54 **In-tube condensation process.**

57 A heat exchange process of the kind in which a condensing vapour flows in parallel paths through a bundle of tubes (1), while coolant fluid flows over the exterior of the tubes. Each tube is provided with a flow restrictor (4) at its outlet, the degree of flow restrictions being such in relation to the fluid mass flow rate, that the restrictors are maintained full of condensate (5) across their entire cross-section. A reverse flow of vapour via the outlet manifold (3) into the outlets of certain tubes is thus prevented by the presence of condensate filling the restrictors and thermal inefficiency resulting from consequent occlusion by non-condensing gas of certain tubes is thus avoided.

In-Tube Condensation Process

This invention relates to a heat exchange process of the kind in which a vapour is caused to flow in parallel paths through a number of tubes, so as to transfer heat to an external fluid flowing over the outer surface of the tubes. The fluid within the tubes thus
5 condenses as it gives up latent heat to the external fluid. This arrangement is common in air-cooled or shell and tube condensers which are often used, for example, in chemical plants.

It often happens in operation of a heat exchange process of this kind that the flow of vapour may not be evenly distributed so that
10 some tubes take a greater flow than others. This may result, for example, from differing pipe friction in different tubes, from different tube lengths, from differing flow conditions over the external surfaces of individual tubes, etc.

Whatever the reason, the result can be that in some tubes,
15 all of the vapour is condensed before it reaches the far end of the tube. In other tubes, condensation may be incomplete so that a mixture of vapour and condensed liquid issues from the far end, and enters the outlet manifold. Such vapour may partially condense on supercooled liquid issuing from other tubes. Some of the vapour which has failed
20 to condense may also, however, enter other tubes, in which condensation is complete before reaching the far end. This latter vapour then travels along such tubes in the reverse direction, and condenses. There will thus be a point in such tubes where vapour flows meet from both directions. This leads to a severe problem, in that a small proportion
25 non-condensable gas is inevitably present in the vapour. Because this gas is caught between two flows, it is not swept out of the tube, but tends to accumulate at the meeting point, so that eventually a substantial length of the tube becomes occluded by an immobile body of non-condensing gas. This length of the tube thus becomes ineffective
30 for condensing vapour, and the thermal efficiency of the heat exchanger is thus substantially reduced. Furthermore, the condensate flowing through this length of tube continues to be cooled, and in some cases may freeze leading to total occlusion of the whole tube. The problem is particularly acute where the vapour is at less than
35 atmospheric pressure, since any leaks will result in an increase in the

proportion of non-condensable gas present.

In the past, the only real solution to the problem has been to ensure that reverse flow into the vapour tubes did not occur, by supplying excess vapour to all tubes. A mixture of vapour and condensate is thus caused to issue from each tube, and each tube
5 operates at maximum thermal efficiency. However, the separation and recirculation of the uncondensed vapour poses a difficulty, and creates undesirable complication in the design of the heat exchanger.

The present invention provides a different solution to the problem.

10 Accordingly, the present invention provides a heat exchange process comprising the steps of

- causing a condensing vapour to flow in parallel paths through a plurality of tubes;
- causing a fluid coolant to flow over the external surfaces of
15 the tubes;
- providing a fluid flow restrictor at the outlet end of each tube; and
- ensuring that the mass flow rate of the condensing vapour through the tubes is sufficient to maintain the restrictor in each tube
20 substantially full of condensate.

The restriction provided by the fluid flow restrictors should normally not be substantially more severe than necessary in order to meet the objective. This will have the effect of preventing any reverse flow of vapour into a tube from the outlet manifold. The restrictors
25 will also have the effect of increasing the pressure drop in each tube, which can have a beneficial effect on flow distribution in the tubes.

Preferably, the restrictors are provided in the form of removable inserts. Cleaning of the vapour tubes is thus facilitated.

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

Figure 1 is a simplified schematic view of an air-cooled heat exchanger in accordance with the invention, and
Figure 2 is a detailed view of a part of Figure 1,
35 showing a flow restrictor in place, and showing a flow of condensate therein.

As shown in the drawings, an air-cooled heat exchanger comprises a plurality of vapour tubes 1, through which a vapour to be condensed flows from a common inlet manifold 2 to a common outlet manifold 3. Although only a single row of tubes 1 is shown in Figure 1, it will be appreciated that the heat exchanger may have several such rows, all
5 connected to the same inlet and outlet manifolds 2, 3.

A supply of coolant fluid, in this instance ambient air, is caused to flow over and around the exterior surfaces of the tubes 1, in the direction indicated in Fig 1 by the arrow 'A'. This can be arranged, for example by means of a fan, or by natural convection,
10 and the tubes 1 can if desired be positioned within a duct for constraining the coolant flow.

Each tube 1 is provided with a flow restrictor 4, in the form of a removable insert positioned in the downstream end of each tube.

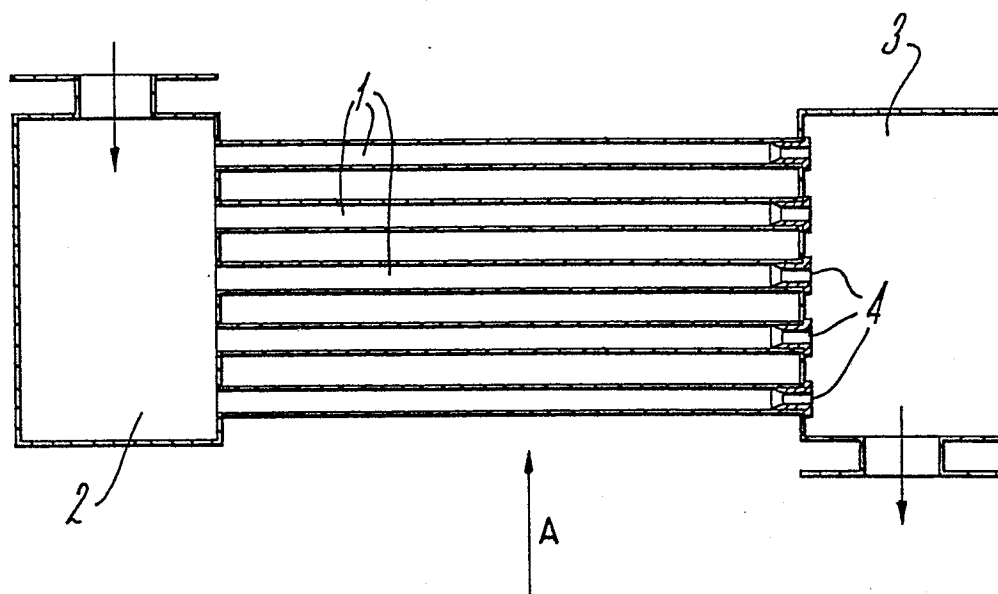
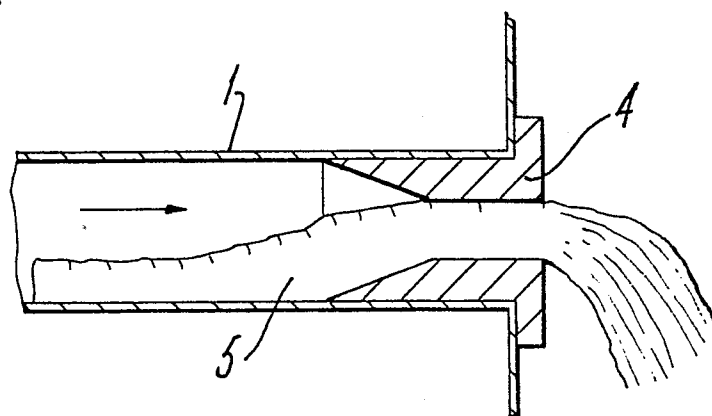
The inserts 4 are all identical, and the size of the restriction
15 therein is such that for the intended conditions of operation of the heat exchanger, the flow rate of vapour in each tube 1 will result in a flow of condensate at the downstream end just sufficient to fill the restrictor substantially completely with condensate 5 (ie across its entire cross-section). If the degree of restriction is
20 insufficient the flow of condensate will not be enough to fill the restrictor and vapour will then be able to flow back down the tube concerned in the reverse direction with the disadvantages noted hereinbefore. A greater degree of restriction can be tolerated more readily, but should be avoided as far as possible, in that
25 any undue restriction of the flow is undesirable.

Of course, if appropriate to the flow conditions, different sized restrictors can be used in different tubes.

- 4 -

Claims:

1. A heat exchange process comprising the steps of
 - causing a condensing vapour to flow in parallel paths through a plurality of tubes (1); and
 - causing a fluid coolant to flow over the external surfaces of the tubes; characterised by
 - providing a fluid flow restrictor (4) at the outlet end of each tube; and
 - ensuring that the mass flow rate of the condensing vapour through the tubes is sufficient to maintain the restrictor in each tube substantially full of condensate (5).
2. A heat exchange process according to claim 1 wherein the restrictors (4) are provided in the form of removable inserts.

Fig.1.*Fig.2.*



European Patent
Office

EUROPEAN SEARCH REPORT

01 20630

Application number

EP 84 30 1467

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
X	US-A-2 310 234 (HAUG) * Page 2, left-hand column, line 65 - right-hand column, line 49; figures 1-4 *	1,2	F 28 B 9/04 F 22 B 37/74
A	FR-A- 795 801 (BUGATTI) * Page 2, lines 46-50; figures 1,3 *	1,2	
A	DE-A-1 811 596 (WAAGNER-BIRO) * Page 3, paragraph 3; figure 4 *	2	
A	US-A-2 694 385 (WITZKE)		
A	FR-A-1 079 141 (THERMO-MECANIQUE)		
			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
			F 28 B F 28 F F 28 D F 22 B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 25-06-1984	Examiner SCHOUFOUR F.L.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			