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(71) Applicant: **NORSK HYDRO ASA**
0240 Oslo (NO)

(72) Inventor: **Vestergaard, Björn**
6200 Aabenraa (DK)

(74) Representative: **Bleukx, Luc**
Norsk Hydro Technology B.V.,
Avenue Marcel Thiry 83
1200 Brussels (BE)

(54) Heat exchanger

(57) Heat exchanger, comprising a group of tubes secured to a pack of fins by means of mechanical expansion of the tubes following their insertion in holes aligned in the fins, the tubes having an oblong cross-section without any flat walls, wherein a first ratio between the maximum dimension (b) and the minimum dimension (a) of the cross-section, is of between 2.80 and 5.20 and a second ratio between the maximum dimension (b) of the cross-section and the thickness (s) of the tube is between 15 and 38; and wherein the wall thickness of the tube fulfils the equation

$$\{[S3 + S4) / (S1 + S2)] - 1\}^* 100 > 5$$

wherein S3 and S4 are the wall thickness in the area of the tube with the smallest radius, and S1 and S2 are the wall thickness in the area of the tube with the largest radius.

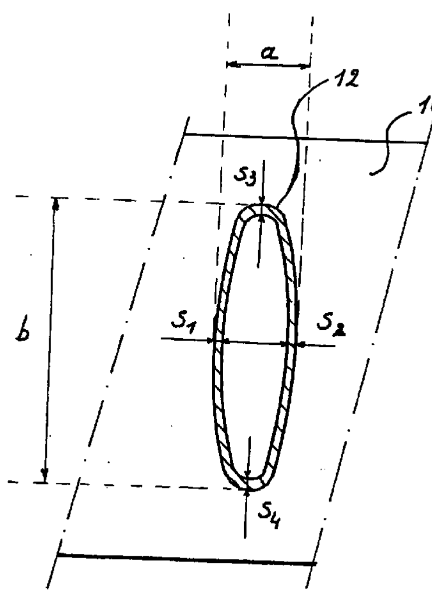

FIG. 1

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Description

The present invention relates to a heat exchanger, more precisely to a heat exchanger of the type defined in the preamble of Claim 1.

Such a heat exchanger is known from EP - A - 0 633 435.
According to said publication the ratio between the maximum dimension of the cross-section and the minimum dimension of the cross section must be between 2.5 and 3.75, the ratio between maximum dimension of the cross-section and the thickness of the tube must be between 15 and 30 and the ratio between the distance between the fins and the thickness of each fin must be less than or equal to 11.

It has been found that the support given by the fins to the tubes when these are filled with a pressurised heat exchanging fluidum is subordinate if compared with the self-supporting characteristics of the tube. It has even been possible to use tubes with different dimensions, provided special measurements are taken with respect to the wall thickness of the tube.

According to the invention an improved heat exchanger is obtained by the characteristic portion of claim 1.
By using the dimensions according to the invention a heat exchanger is obtained in which the pressure transmitted by the tube to the fins is more evenly distributed, thereby obtaining a more evenly distributed heat exchange contact between the tubes and the fins.

Other advantages and characteristics will become obvious from the following description of an example reference being made to the annexed drawing in

- Fig. 1 which is a part of a heat exchanger shown in cross section,.
- Fig. 2 is a schematic representation of the stress on the tube wall in operative and non-operative condition,
- Fig. 3 is a schematic representation of the tube form in operative and non-operative condition, and
- Fig. 4 is a diagram showing the variations in stress in the tube wall.

The heat exchanger shown in the drawing is of the type disclosed in EP - A - 0 633 435 and for the general information about that construction, reference is made to that publication.
In the drawing there is shown part of one fin 10 containing perpendicular to its surface a so-called oval tube 12, i.e. a tube having an oblong cross section without any flat walls.

As shown in the drawing the tube has in cross section a maximum dimension b and a minimum dimension a. According to the invention the wall thickness of the tube may vary according to the location. In this way four locations are important with respect to the tension when the tube is under internal pressure. These locations are the places with largest radius indicated by their thickness S_1 and S_2 and the places with the smaller radius indicated by their thickness S_3 and S_4. By providing the wall thickness S_1 and S_2, S_3 and S_4 in such a way that they fulfil the claimed equation and when at the same time the first ratio b/a lies between 2,80 and 5,20 and second ratio b/s lies between 15 and 38, S being the average wall thickness
[e.g. = $S = (S_1 + S_2 + S_3 + S_4)/4$] the tube is optimised with respect to its strength against internal pressure and lowest material consumption.

The following explanation shows that the stress in the area with the smallest radius is higher than in the one with the largest radius, and that

In Fig. 2 there is shown the tube 12 and in the left hand part of the drawing there is shown the stress T_0 in the wall of the tube 12 when no pressurised fluid is present within the tube. In this situation the fins exert from the outer side a pressure on the wall of the tube 12, which pressure is the highest in the small diameter portions. In the right hand side of figure 2 there is shown the stress T_p in the tube wall when a pressurised fluid is present within the tube, in which case the fluid exerts a pressure on the tube wall as shown in that part of fig. 2, the stress being the smallest in the small radius portion of the tube. It should however be noted that the tension T_0 in the left hand side and the stress T_p in the right hand side of fig. 2 are differently oriented, in the left hand side being from the outside to the inside and in the right hand side being from the inside to the outside.

The schematic representation of fig. 2 is based upon calculations made with respect to a simplified model of a so called flat oval tube. The simplification has primarily to do with the fact that it was accepted that the tube has an ellipse shape with a major axis of 12 mm and a minor axis of 3.2 mm and an average wall thickness of 0.5 mm.
In the normal use of a heat exchanger this is quit often switched on and off, which means that with the same frequency a pressurised fluid is supplied to the interior of the tube 12 and the pressure relieved after switching off.
In Fig. 3 there is shown the shape of the tube 12 either in the non operative condition of the heat exchanger, in which situation the tube has the shape 12A and most of the stress is concentrated in the small radius portion of the wall. Upon applying a pressurised fluid in the tube 12 it takes the shape 12B. As can clearly be seen in fig. 3 the wall is moving as if it is articulating around the small diameter portion of the wall. This adds to the tensions which apply to these portions, and requires fatigue properties for these portions. By using the wall thickness ratio's according to the invention these improved fatigue properties have been obtained.

To further elucidate this phenomena, the stress T occurring in a small radius portion of the tube wall is represented in fig. 4 in function of the time t. Every time the heat exchanger is switched on the stress increases nearly stepwise, and after switching off it decreases more or less in the same way.

Claims

1. Heat exchanger, comprising a group of tubes secured to a pack of fins by means of mechanical expansion of the tubes following their insertion in holes aligned in the fins, the tubes having an oblong cross-section without any flat walls,
   characterised in that
   a first ratio between the maximum dimension (b) and the minimum dimension (a) of the cross-section, is of between 2.80 and 5.20 and a second ratio between the maximum dimension (b) of the cross-section and the thickness (s) of the tube is between 15 and 38; and in that the wall thickness of the tube fulfils the equation

   $$\{[S3 + S4) / (S1 + S2)] - 1\}^{*} 100 > 5$$

   wherein S3 and S4 are the wall thickness in the area of the tube with the smallest radius, and S1 and S2 are the wall thickness in the area of the tube with the largest radius.

2. Heat exchanger according to claim 1,
   characterised in that
   the first ratio is between 3.75 and 5.20.

3. Heat exchanger according to claim 1,
   characterised in that
   the first ratio is between 3.75 and 5.00.

4. Heat exchanger according to any of the claims 1 to 3,
   characterised in that
   the second ratio is between 17 and 26.

5. Heat exchanger according to any of the claims 1 to 4,
   characterised in that
   the equation is larger or equal to 6.

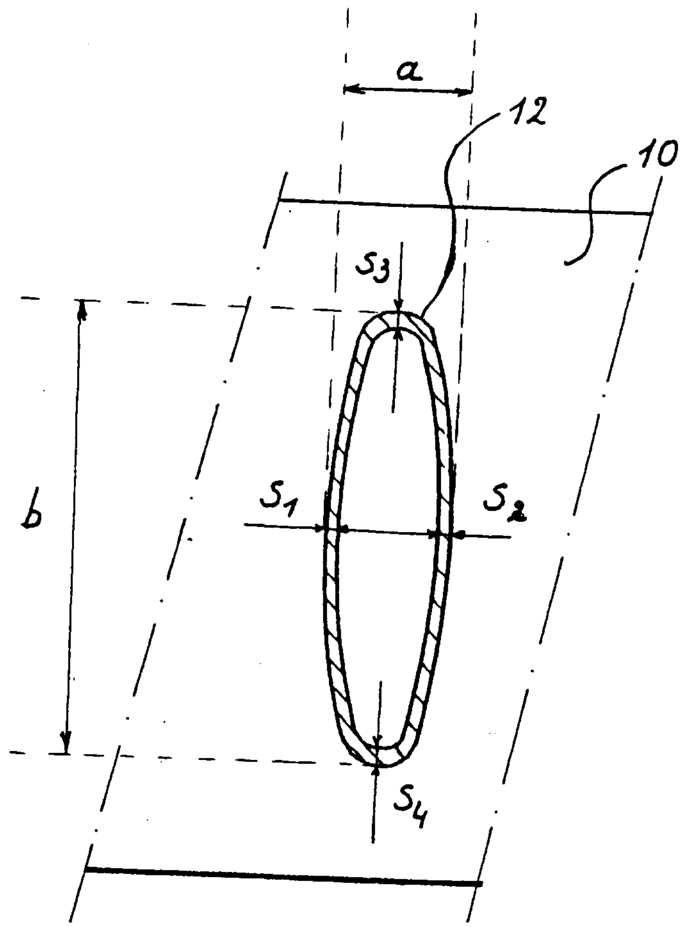

FIG. 1

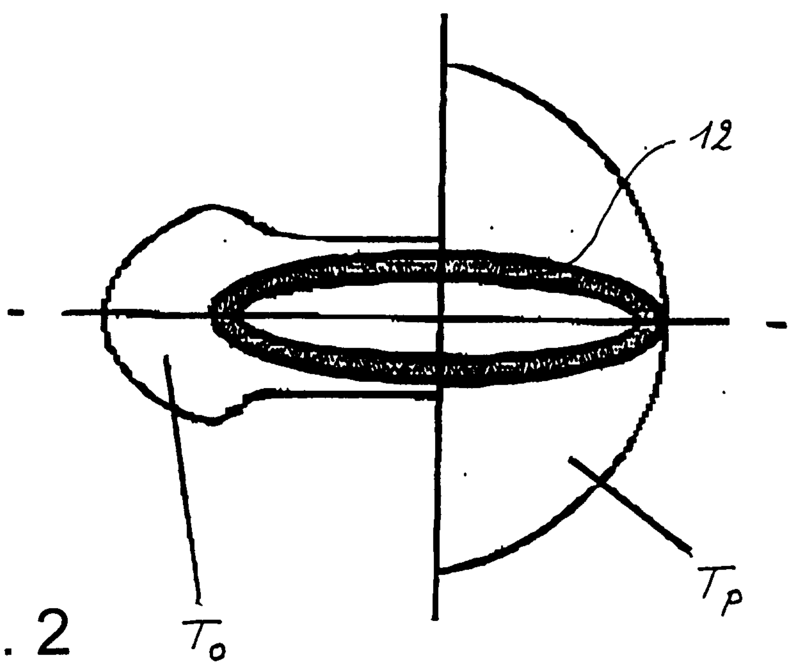

FIG. 2

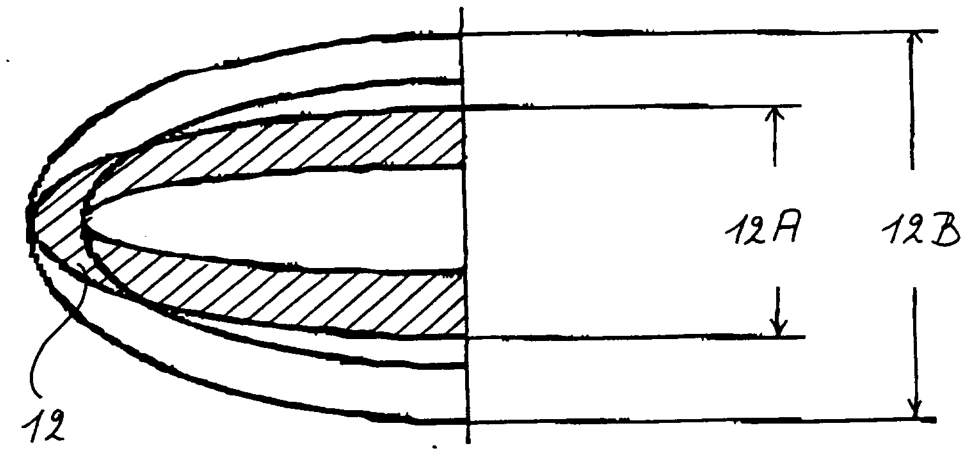

FIG. 3

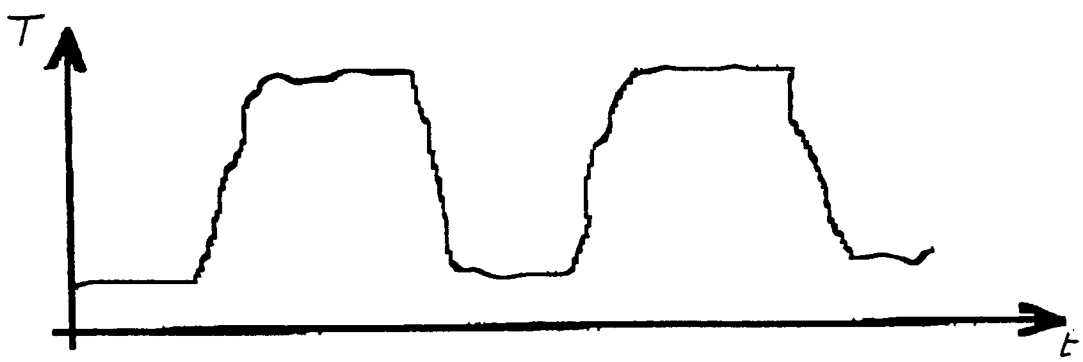

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 96 20 2233

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.6)
A	US 3 239 002 A (YOUNG RADIATOR) * the whole document * ---	1	F28F1/32 F28F1/02
D,A	EP 0 633 435 A (BORLETTI CLIMATIZZAZIONE) 11 January 1995 * abstract; figure 3 * ---	1	
A	FR 2 269 053 A (CHAUSSON USINES SA) 21 November 1975 * the whole document * ---	1	
A	FR 2 406 794 A (VOLKSWAGENWERK AG) 18 May 1979 * the whole document * -----	1	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			F28F

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	16 December 1996	Zaegel, B

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
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