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D E C I S I O N
of 27 February 1996

Case Number: T 0095/94 - 3.2.3

Application Number: 87304529.8

Publication Number: 0272766

IPC: F28D 5/02, F28F 1/02

Language of the proceedings: EN

Title of invention:
Elliptical tube coil assembly for evaporative heat exchanger

Patentee:
EVAPCO INTERNATIONAL, INC.

Opponent:
Reinhard Raffel Metallwarenfabrik GmbH

Headword:
-

Relevant legal provisions:
EPC Art. 56

Keyword:
"Inventive step (yes)"

Decisions cited:
-

Catchword:
-

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Case Number: T 0095/94 - 3.2.3

D E C I S I O N
of the Technical Board of Appeal 3.2.3
of 27 February 1996

Appellant: (Proprietor of the patent)
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Decision under appeal: **Decision of the Opposition Division of the European Patent Office dated 10 November 1993, posted on 15 December 1993, revoking European patent No. 0 272 766 pursuant to Article 102(1) EPC.**

Composition of the Board:

Chairman: C. T. Wilson
Members: H. Andrä
L. C. Mancini

Summary of Facts and Submissions

I. European patent No. 0 272 766 was granted on 6 November 1991 on the basis of European patent application No. 87 304 529.8 filed on 21 May 1987.

Granted Claim 1 reads as follows:

"An evaporative heat exchanger (10, 30) comprising a conduit (12, 32) having a longitudinal axis, means (22, 42) for spraying a first external heat exchange fluid in the form of a liquid within the conduit, means (18) for causing a second external heat exchange fluid in the form of a gas to flow through the conduit in a direction parallel to or countercurrent to the direction of the liquid external heat exchange fluid, and a coil assembly (14, 34) having a major plane generally parallel to the planes formed by each level of tube segments (60, 100, 110) in the coil assembly (14, 34) and being mounted within the conduit such that the major plane is generally normal to the longitudinal axis of the conduit and such that the external heat exchange fluids flow externally through the coil assembly in a flow direction generally normal to the major plane of the coil assembly, the coil assembly comprising inlet and outlet manifolds (46, 48) and a plurality of tubes (58, 98, 108) connecting the manifolds, the tubes having a plurality of segments (60, 100, 110) and a plurality of bights (62, 102, 112), the bights being oriented in planes parallel to the flow direction of the external heat exchange fluids, the segments of each tube connecting the bights of each tube and extending between the bights in a direction generally normal to the flow direction of the external heat exchange fluids, the bights (62d, 102b, 112b) of each tube (58d, 98b, 110b) being in contact with the bights (62c, e, 102a, c, 112a, c) of adjacent tubes (58c, e, 98a, c, 108a, c),

characterised by the segments (60, 100, 110) having a generally elliptical cross sectional shape such that the segments (60c) of the same tube (58c) are spaced from each other in the flow direction of the external heat exchange fluids, the segments (60c, d, e, 100a, b, c, 110a, b, c) of adjacent tubes (58c, d, e, 98a, b, c, 108a, b, c) are spaced from each other within planes generally parallel to the major plane, the segments (60c, d, e, 100a, b, c, 110a, b, c) of adjacent tubes (58c, d, e, 98a, b, c, 108a, b, c) in the planes generally parallel to the major plane being staggered and spaced with respect to each other in the flow direction to form a plurality of staggered levels in which every other segment (60c, e, 100a, c, 110a, c) is aligned in the same level generally parallel to the major plane, and each bight (62, 102, 112) having a transverse cross sectional dimension (X, X_3, X_4) in a direction transverse to the flow direction of the external heat exchange fluids and transverse to the longitudinal axis of the segment (60, 100, 110) connected to the bight (62, 102, 112), the distance (D, D_3, D_4) between the centreline of adjacent bights (62c, d, 102a, b, 112a, b) substantially equalling the transverse cross sectional dimension (X, X_3, X_4), the space (S, S_3, S_4) between segments (60c, e, 100a, c, 110a, c) of adjacent tubes (58c, e, 98a, c, 108a, c) at the same level being between about 1.1 and about 1.5 times the transverse cross sectional dimension of the bight (X, X_3, X_4)."

II. With notice of opposition filed on 28 July 1992 the Respondent (Opponent) requested revocation of the patent in accordance with Article 100(a) EPC.

In respect of an alleged lack of inventive step the Opponent cited the following documents:

(D1) US-A-4 196 157,

(D2) FR-A-464 929,

(D3) DE-A-458 528, and

(D4) DE-A-1 551 820.

III. The patent was revoked by a decision taken at the oral proceedings dated 10 November 1993 with written reasons posted on 15 December 1993.

IV. The Appellant (Patentee) filed an appeal against this decision on 4 February 1994 and paid the appeal fee on the same day. The Statement of Grounds of Appeal was filed on 25 April 1994.

An Affidavit illustrating the development of the invention and including test results obtained from evaporative heat exchangers comprising coils with circular and elliptical tube cross-section was received on 13 August 1994.

V. In a communication pursuant to Rule 110(2) EPC dated 9 November 1995 the Board pointed out that according to their provisional opinion the subject-matter of Claim 1 as granted involves an inventive step and that it would appear that the patent could be maintained in the version as granted.

VI. The Appellant requested that the contested decision to revoke the patent be set aside and, according to the main request, that the patent be upheld in unamended form.

According to an auxiliary request, Claims 1 and 6 as granted should be combined to provide a new independent Claim 1.

The Appellant's arguments can be summarised as follows:

The decisive question to be answered in the assessment of inventive step in the present case is whether the skilled person at the priority date of the application in suit having read (D1) would think that what was shown in (D2) would help him to make a better product. In the Patentee's opinion the skilled person would not have looked into (D2), but if he had, he would still not have achieved the construction of Claim 1.

(D1) abandoned the traditional idea of packing the tubes tightly and spaced out the tubes in the coil assembly by putting spacer rods between the tubes. The object of (D1) was the lowering of construction costs of a counter-flow evaporative heat transfer device without any corresponding reduction in heat transfer capability and without any increase in operating costs. The results were a reduction of the amount of tubing with consequential reduced costs, an increased air velocity and water flow and a greater flow velocity of fluid in the tubes.

Starting out from (D1), the problem solved by the invention is to achieve at least as good a heat transfer capacity as (D1), a reduced pressure drop of the internal fluid and an improved flow of the external fluids, e.g. water and air.

Having achieved the benefits according to (D1) by "opening up" the tube bundle, it would not have been logical if the skilled person had decided that it would produce greater benefits by putting more surface area of tube into a given volume, as according to the invention.

Although in (D2) one can find tubing having a dual cross-section, partly circular, partly oval, there was no reason for the skilled person to take that particular illustration from some 70 years earlier, then to rearrange the tubes so that they are staggered, then to go back along the path proposed by (D1), and then to build that sort of coil into an evaporative heat exchanger. This is far more than what could possibly be said to be obvious and it is only with hindsight that one can combine (D1) and (D2), make the necessary "adjustments" and arrive at the claimed invention.

VII. From the Respondent no observations or requests have been filed.

Reasons for the Decision

1. The appeal is admissible.

Main request:

2. *Novelty*

2.1 The closest prior art to the subject-matter of Claim 1 is described in (D1).

(D1) discloses an evaporative heat exchanger comprising

- a conduit having a longitudinal axis, means for spraying a first external heat exchange fluid in

the form of a liquid within the conduit, means for causing a second external heat exchange fluid in the form of a gas to flow through the conduit in a direction parallel or countercurrent to the direction of the liquid external heat exchange fluid, and

- a coil assembly having a major plane generally parallel to the planes formed by each level of tube segments in the coil assembly and being mounted within the conduit such that the major plane is generally normal to the longitudinal axis of the conduit and such that the external heat exchange fluids flow externally through the coil assembly in a flow direction generally normal to the major plane of the coil assembly,

- the coil assembly comprising inlet and outlet manifolds and a plurality of tubes connecting the manifolds, the tubes having a plurality of segments and a plurality of bights, the bights being oriented in planes parallel to the flow direction of the external heat exchange fluids, the segments of each tube connecting the bights of each tube and extending between the bights in a direction generally normal to the flow direction of the external heat exchange fluids, whereby the segments of adjacent tubes are spaced from each other within planes generally parallel to the major plane, the segments of adjacent tubes in the planes generally parallel to the major planes being staggered and spaced with respect to each other in the flow direction to form a plurality of staggered levels in which every other segment is aligned in the same level generally parallel to the major plane, and each bight having a transverse cross sectional dimension (D) in a direction transverse to the flow

direction of the external heat exchange fluids and transverse to the longitudinal axis of the segment connected to the bight, the distance between the centreline of adjacent bights substantially equalling the transverse cross sectional dimension (D) (cf. Figure 6 and the description, column 5, lines 11 to 42).

2.2 The subject-matter of Claim 1 differs from the disclosure of (D1) by the following features:

- the segments have a generally elliptical cross-sectional shape such that the segments of the same tube are spaced from each other in the flow direction of the external heat exchange fluids,

- the bights of each tube are in contact with the bights of adjacent tubes, and

- the space between segments of adjacent tubes at the same level is between about 1.1 and about 1.5 times the transverse cross-sectional dimension of the bight.

2.3 It follows from the fact that this is the nearest prior art, that none of the citations discussed in the opposition and appeal proceedings discloses all the features of Claim 1 of the patent in suit, so that the subject-matter of this claim is novel in the sense of Article 54(1) EPC.

3. *Inventive step*

3.1 As already illustrated in the Board's communication dated 9 November 1995, in the heat exchanger known from (D1) spacers in the coil assembly are used so that laterally adjacent tubes are spaced apart from each

other along the entire length of tubes of both the bights and the segments. This arrangement results in a lower pressure drop of air blown externally through the coil assembly as compared to a tight-packed coil assembly, due to the open spaces between the laterally adjacent tubes. It has, however, the disadvantage that less heat transfer surface area can be installed in a given unit width. This requires a higher flow rate in the tubes and correspondingly leads to a higher pressure drop of the fluid flowing internally within the coil assembly.

The problem to be solved by Claim 1 with regard to the disclosure of (D1) is therefore seen in improving the heat transfer between the internal and the external heat exchange fluids whilst reducing the pressure drop of the internal fluid and at least maintaining the pressure drop of the external heat exchange fluids with regard to the level according to (D1).

3.2 The first instance considered the subject-matter of Claim 1 to be obvious from a combination of (D1) with (D2).

(D2) describes a superheater comprising a number of serpentine-shaped tubes containing vapour and being arranged side-by-side in a restricted space of a boiler. The citation aims at increasing the number of tubes to be arranged in a given space and to improve thereby the utilization of the hot combustion gases. This problem is solved by positioning of the tube serpentines side-by-side at one level, that is in a non-staggered arrangement, the bights of adjacent tubes being in contact with each other and the segments having a laterally flat cross-sectional shape.

Due to the arrangement of the tube serpentines at only one level, the open space between the laterally adjacent tubes is very restricted as compared to the subject-matter of Claim 1 of the patent in suit. The space between segments of adjacent tubes at the same level is not between about 1.1 and about 1.5 times the transverse cross-sectional dimension of the bight, as required by Claim 1, but has a corresponding value of approximately 0.5 (see the configuration of Figures 2 and 3 of (D2)).

It follows therefrom that the arrangement shown in (D2) does not teach the above-cited feature of Claim 1. It cannot, therefore, arrive at a low pressure drop of the external heat exchange fluids as achieved by Claim 1 and does not solve the inherent problem.

3.3 The first instance argued in the contested decision (see page 7, paragraph 3) that the optimum space between segments of adjacent tubes is already suggested by Figure 8 of (D1).

Figure 8 of (D1) clearly refers to an arrangement of tubes having a circular cross-section. As the skilled person is aware that the amount of heat transfer between a body immersed in a fluid and the fluid depends to a great extent on the particular shape of the body, he would not consider transferring heat exchange characteristics obtained from bodies having circular cross-section to bodies having elliptical cross-section. In this context, reference is made to the test results in the Appellant's Affidavit of 11 August 1994, in particular graphs III and IV concerning the air-side pressure drop of a round-tube, spaced-apart coil according to (D1) in comparison with graphs V and VI concerning the air-side pressure drop of an elliptical-tube, tight-packed coil in accordance with the

invention, the latter arrangement exhibiting a substantially different, i.e. reduced, pressure drop and hence different heat transfer characteristics.

Furthermore, according to the teaching of (D2), it is indispensable that the tube serpentines are arranged such that the bights of neighboured serpentines are in contact with each other (see page 1, lines 12 to 18 and 34 to 45 of (D2)), since otherwise an increased number of tubes as required in accordance with the inherent problem could not be provided in the known heat exchanger. The spacing of adjacent tubes at the same level as indicated in Claim 1 of the patent in suit would therefore be contrary to the teaching of (D2).

3.4 As indicated above, (D2) tackles the problem of increasing the number of tubes to be arranged in a given space of superheater.

(D1), on the other hand, aims at an evaporative heat exchanger in which the amount of tubing used is significantly reduced in comparison with prior art tightly-packed coil assemblies.

Notwithstanding the constructional differences between a (dry) superheater and an evaporative heat exchanger, the above-cited aspects of the problems underlying (D1) and (D2), respectively, are clearly opposed to one another. Since the skilled person would expect that the solutions to contradictory problems are incompatible, he would also for this reason not envisage a combination of the teachings of (D1) and (D2) in the manner presumed in the contested decision.

3.5 The Board has also examined the further prior art documents discussed in the proceedings before the first instance and has found them non-prejudicial to the subject-matter of Claim 1.

3.6 For the reasons given above, the subject-matter of Claim 1 according to the main request involves an inventive step (Article 56 EPC) and is patentable under Article 52(1) EPC.

4. The fact that (D1) comes closer to the subject-matter of Claim 1 than the prior art corresponding to the first portion of Claim 1 does not give rise to an amendment of the wording of Claim 1 with regard to Rule 29(1) EPC since neither this provision nor Article 84 EPC constitutes a ground for opposition.

5. Claims 2 to 11 are dependent upon Claim 1 and relate to preferred embodiments thereof, and are therefore also patentable. The patent can thus be maintained in the version as granted.

Auxiliary request

Since the claims according to the main request are found to comply with the requirements of the EPC, consideration of the auxiliary request is not necessary.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The patent is maintained unamended.

The Registrar:

N. Maslin

The Chairman:

C. T. Wilson