(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 117 820**
B1

(12) # EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: **11.11.87**

(51) Int. Cl.⁴: **F 28 F 9/22**

(21) Application number: **84400377.2**

(22) Date of filing: **24.02.84**

(54) **Segmental baffle high performance shell and tube heat exchanger.**

(30) Priority: **28.02.83 US 470805**

(43) Date of publication of application:
05.09.84 Bulletin 84/36

(45) Publication of the grant of the patent:
11.11.87 Bulletin 87/46

(84) Designated contracting states:
AT BE CH DE FR GB IT LI LU NL SE

(56) References cited:
CH-A- 442 380
DE-A- 2 410 292
FR-A- 2 036 806
FR-E- 65 106
US-A- 3 630 276
US-A- 3 696 863
US-A- 4 183 401

(73) Proprietor: **BALTIMORE AIRCOIL COMPANY, INC.**
Montevideo Road
Jessup, Maryland 20 794 (US)

(72) Inventor: **Geary, David R.**
323 Tunstall Court
Severna Park Maryland 21146 (US)
Inventor: **Flamm, Katherine K.**
1504 Ivanhoe Avenue
Baltimore Maryland 21228 (US)
Inventor: **Morrison, Frank T.**
1228 Driftwood Court
Arnold Maryland 21012 (US)

(74) Representative: **Ahner, Francis et al**
CABINET REGIMBEAU 26, avenue Kléber
F-75116 Paris (FR)

EP 0 117 820 B1

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid (Art. 99(1) European patent convention).

Description

Background of the invention

In the past, several methods were used to obtain better heat transfer coefficients in shell and tube heat exchangers. Briefly, these methods were 1) increasing the flow rate and increasing the pressure drop in typical shell and tube heat exchangers, 2) by increasing the heat transfer surface area in shell and tube heat exchangers, such as by using a fluted tube, or 3) by using a different type of heat exchanger than the shell and tube heat exchanger altogether, such as a plate and frame heat exchanger, which utilizes extremely narrow flow passages to enhance heat transfer. Thus, those skilled in the art continue to look for designs of shell and tube heat exchangers of more compact size which occupy less space and/or which lead to high overall heat transfer coefficients combined with low pressure drops over a broad range of fluid flow rates in the shell and tube heat exchangers.

Summary of the invention

The invention relates to a high performance shell and tube heat exchanger for obtaining high overall heat transfer coefficients at low pressure drops and low flow rates in said shell and tube heat exchangers.

The invention relates to a shell and tube heat exchanger comprising :

a) an outer shell ;

b) a plurality of tubes within said shell ;

c) a series of circular segmental baffles forming a partial barrier to liquid flow each having holes therethrough for blocking the fluid flow around the tubes passing through said holes, said baffles being spaced axially along said tubes within said outer shell and being oriented such that a twist angle is formed by the diameter or chord line of one baffle and the diameter or chord line of an adjacent baffle in said series of baffles, said twist angle appearing between adjacent baffles arranged with the same torsion of angle, according to the preamble of claim 1.

Such shell and tube heat exchangers are already known, as disclosed in DE-A-2 410 292. In particular, the segmental baffles of the exchanger described in DE-A-2 410 292 have a segmented baffle angle of 60° or 120°, and are oriented so as to form a twist angle of 60° or 120° respectively ; furthermore, smooth tubes are used.

The state of the art is also illustrated by US-A-3 630 276. In particular, smooth tubes are used, as well as segmented baffles oriented so as to form a twist angle of 120°; the segmented baffle angle of these baffles is not precisely defined in the description and claims of this patent, but the Figure 4 thereof shows an obtuse angle which is substantially greater than 180°.

Furthermore, fluted or corrugated tubes in a shell and tube heat exchanger are generally known for increasing the heat transfer area, as described in US-A-3 696 863. The heat exchanger illustrated at figure 8 of this patent also comprises segmented baffles oriented so as to form a twist angle of 180° creating an undulating flow path (reference 42).

It is an object of this invention to obtain high overall heat transfer coefficients at low pressure drops and low fluid flows in shell and tube heat exchangers, with a higher performance than by using exchangers of the above type.

It is a further object of this invention to provide a heat exchanger which eliminates or reduces the amount of tube vibration that may exist due to tube support baffle peripheral clearance tolerances.

This is achieved with a shell and tube exchanger wherein :

the tubes are continuously fluted along substantially the complete tube length,

each baffle has a segmented baffle angle of about 180°,

the twist angle between adjacent baffles is about 90°, according to the characterizing portion of claim 1.

This combination improves considerably the heat transfer coefficients, due to a highly effective combination of wave-like undulating flow and rotating helical flow.

According to a preferred embodiment of present invention, the baffles are located a distance apart of at least 0.7 times the diameter of the baffle but not greater than 6 times the diameter of the baffle. With such a space between adjacent baffles, a natural spiral and wave-like pattern of fluid flowing through the shell and tube heat exchanger is easy to form.

To better describe the invention there are included herein Figures 1 and 2.

Figure 1 shows a cutaway view of a typical shell and tube heat exchanger with the segmented baffles therein, and Figure 2 shows the same cutaway view of the baffles and shell without the individual tubes of the shell and tube heat exchanger.

Referring now to Figures 1 and 2, a central portion 1 of a typical shell and tube heat exchanger is shown. Typical flanges for enclosing the shell ends, inlet and outlet piping portions and tube sheets or tube end walls are not shown in the diagram but would be well known to those skilled in the art. This heat exchanger consists of a housing or shell portion 2 shown in cutaway views having therein a plurality of fluted tubes 3. These tubes can be arranged within the heat exchanger in a typical spaced pattern, and the number and size of the tubes Will vary depending on the type of heat exchanger one is using. The fluid or material to be cooled is typically, though

not necessarily always, within the shell 2 of the heat exchanger 1 flowing in one direction whereas the heat exchange fluid inside of the tubes 3 flows in the opposite direction. Also, the tubes 3 are continuously fluted 9, along substantially the complete tube length, except for each tube end 8, where the tube surface is smooth to permit a proper seal or tube end attachment to a separating tube end wall at the ends of tubes which encloses and seals the outside of all tube ends from the outer shell region 10.

Located within the shell and tube heat exchanger 1 are a plurality of segmented-circular baffles 4, 5, 6, and 7. These baffles are in the form of a circular segment having an arc of 180° (segmented baffle angle). These baffles are provided in the heat exchanger 1 such that adjacent baffles are oriented at an angle of 90° (twist angle) as illustrated in the figures. The baffles are constructed with holes such that they fit snugly over the plurality of tubes 3 provided within the heat exchanger and would prevent the flow of fluid outside tbe tubes where the baffle is located since the baffle forms a wall against fluid flowing in the direction of the baffle, thereby causing a rotating flow direction or a combination rotating flow with undulating flow pattern.

As can be seem in Figure 2, the plurality of baffles 4 through 7 are oriented at an angle of 90° from each other in such a way so that fluid flowing within the shell 2 forms a helical spiral configuration (shown as β 15) as it flows along. In addition to forming a helical spiral fluid flow (15) a portion of the fluid also flows in a wavelike undulating pattern (shown as 16), and it is the combination of the wavelike undulating pattern along with the spiral helical flow pattern that brings about the higher heat transfer efficiency of this type of shell and tube heat exchanger.

The baffles can be constructed of any material such as for example metal or other material which preferably is noncorrosive to the fluid flowing therethrough.

Although the segmented baffle angle of the baffles is shown in figure 2 as 180°, one skilled in the art would realize that any segmented baffle angle slightly more or less than 180° would be satisfactory, with a variation of some degrees from the precise value of 180°.

Furthermore, although the angles at which the baffles are oriented one from the otherare shown in figure 2 as 90°, one skilled in the art would realize that any twist angle slightly more or less than 90° would be satisfactory, with a variation of some degrees from the precise value of 90°.

The particular 90° twist angle is shown in figure 2 such that if one takes baffle 4 with one side of the angle as the diameter line 60 which is an extension of the diameter line of the baffle (9), and one takes the diameter or chord line of the next adjacent baffle 5 (shown as line 61), it can be seen that the twist angle of difference thereto is 90°. This follows similarly with baffles 5 and 6 where the twist angle is also 90° taken as an extension of the diameters of the adjacent baffles.

The baffles are spaced apart in the shell and tube heat exchanger at such a distance as to provide a natural spiral helical and wave-like flow path of any fluid therethrough. The baffles must be located a distance apart at least 0.7 times the diameter of the baffle or shell but not greater than 6.0 times the diameter of the shell and cannot be at such a close or extremely far distance so that any spiral and wave-like pattern of fluid flowing therethrough would be difficult to form.

These baffles have an outside diametric clearance to fit within the shell with ease. However, it should be noted that the baffles are not physically attached to the inside wall of the shell, but rather held in position axially by rods (not shown) which parallel the tubes. Therefore, it is conceivable that the baffles can vibrate within the shell due to the clearance tolerances. It is further important to note that segmental baffles at 180° twist positions, as shown at figure 8 of US-A-3 696 863 hereabove cited, could vibrate over a greater distance in the direction perpendicular to the straight cut segment side, than in any other direction.

Therefore, orienting each second baffle at about 90° will also prevent vibration in the assembly by means of alternate supporting baffle orientation of the straight edge.

The above description refers to an illustration of the invention and is not intended to be limitative thereof. For example, the invention includes consideration for any generic type of segmental baffle, such as single, double, triple, or any multiple-segmental baffle component.

Claims

1. A shell and tube heat exchanger comprising :
   a) an outer shell (2) ;
   b) a plurality of tubes (3) within said shell ;
   c) a series of circular segmental baffles (4, 5, 6, 7) forming a partial barrier to liquid flow each having holes therethrough for blocking the fluid flow around the tubes passing through said holes, said baffles being spaced axially along said tubes within said outer shell and being oriented such that a twist angle is formed by the diameter or chord line of one baffle and the diameter or chord line of an adjacent baffle in said series of baffles, said twist angle appearing between adjacent baffles arranged with the same torsion of angle, characterized in that the tubes (3) are continuously fluted along substantially the complete tube length, in that each baffle (4, 5, 6, 7) has a segmented baffle angle of about 180°, and in that said twist angle between adjacent baffles is about 90°.

2. A shell and tube heat exchanger according to claim 1, characterized in that the baffles (4, 5, 6, 7) are located a distance apart of at least 0.7 times the diameter of the baffle but not greater than 6 times the diameter of the baffle.

Patentansprüche

1. Mantel- und Rohrwärmeaustauscher, der aufweist :

a) einen äußeren Mantel (2),

b) eine Mehrzahl von Rohren (3) in dem Mantel, und

c) eine Reihe von kreisförmigen Segmentlenkblechen (4, 5, 6, 7), die eine Teilsperre für den Flüssigkeitsstrom bilden und die jeweils sie durchsetzende Öffnungen zum Blockieren des Fluidstromes um die Rohre haben, die durch die Öffnungen gehen, bei dem die Lenkbleche axial längs der Rohre in dem äußeren Mantel im Abstand angeordnet und derart ausgerichtet sind, daß sich ein Drallwinkel zwischen dem Durchmesser oder der Profilsehne eines Lenkbleches und dem Durchmesser oder der Profillinie eines benachbarten Lenkbleches der Gruppe von Lenkblechen bildet, und bei dem der zwischen benachbarten Lenkblechen auftretende Drallwinkel in dieselbe Winkeldrehung weist, dadurch gekennzeichnet, daß die Rohre (3) durchgehend im wesentlichen über die gesamte Rohrlänge hinweg geriffelt sind, daß jedes Lenkblech (4, 5, 6, 7) einen Segmentlenkblechwinkel von etwa 180° hat und daß der Drallwinkel zwischen benachbarten Lenkblechen etwa 90° ist.

2. Mantel- und Rohrwärmeaustauscher nach Anspruch 1, dadurch gekennzeichnet, daß die Lenkbleche (4, 5, 6, 7) in einem Abstand von wenigstens dem 0,7-fachen des Durchmessers des Lenkblechs angeordnet sind, der aber nicht größer als das 6-fache des Durchmessers des Lenkblechs ist.

Revendications

1. Echangeur tubulaire de chaleur comportant

a) une enveloppe extérieure (2) ;

b) une pluralité de tubes (3) à l'intérieur de ladite enveloppe ;

c) une série de déflecteurs en forme de segment circulaire (4, 5, 6, 7) formant une barrière partielle à l'écoulement du liquide et comportant chacun des trous traversants, de façon à interdire l'écoulement du fluide autour des tubes qui passent dans lesdits trous, lesdits déflecteurs étant espacés axialement le long desdits tubes à l'intérieur de ladite enveloppe extérieure et étant orientés de façon qu'un angle de torsade soit formé par la ligne diamétrale ou ligne de corde de l'un des déflecteurs et la ligne diamétrale ou ligne de corde d'un déflecteur voisin dans ladite série des déflecteurs, ledit angle de torsade apparaissant, entre des déflecteurs voisins, avec le même angle de torsion, caractérisé en ce que les tubes (3) sont cannelés en continu sensiblement sur toute la longueur du tube ; en ce que chaque déflecteur (4, 5, 6, 7) présente un angle de segment d'environ 180°; et en ce que ledit angle de torsade entre les déflecteurs voisins est d'environ 90°.

2. Echangeur tubulaire de chaleur selon la revendication 1, caractérisé en ce que les déflecteurs (4, 5, 6, 7) sont placés à une distance l'un de l'autre d'au moins 0,7 fois le diamètre du déflecteur, mais non supérieure à 6 fois le diamètre du déflecteur.

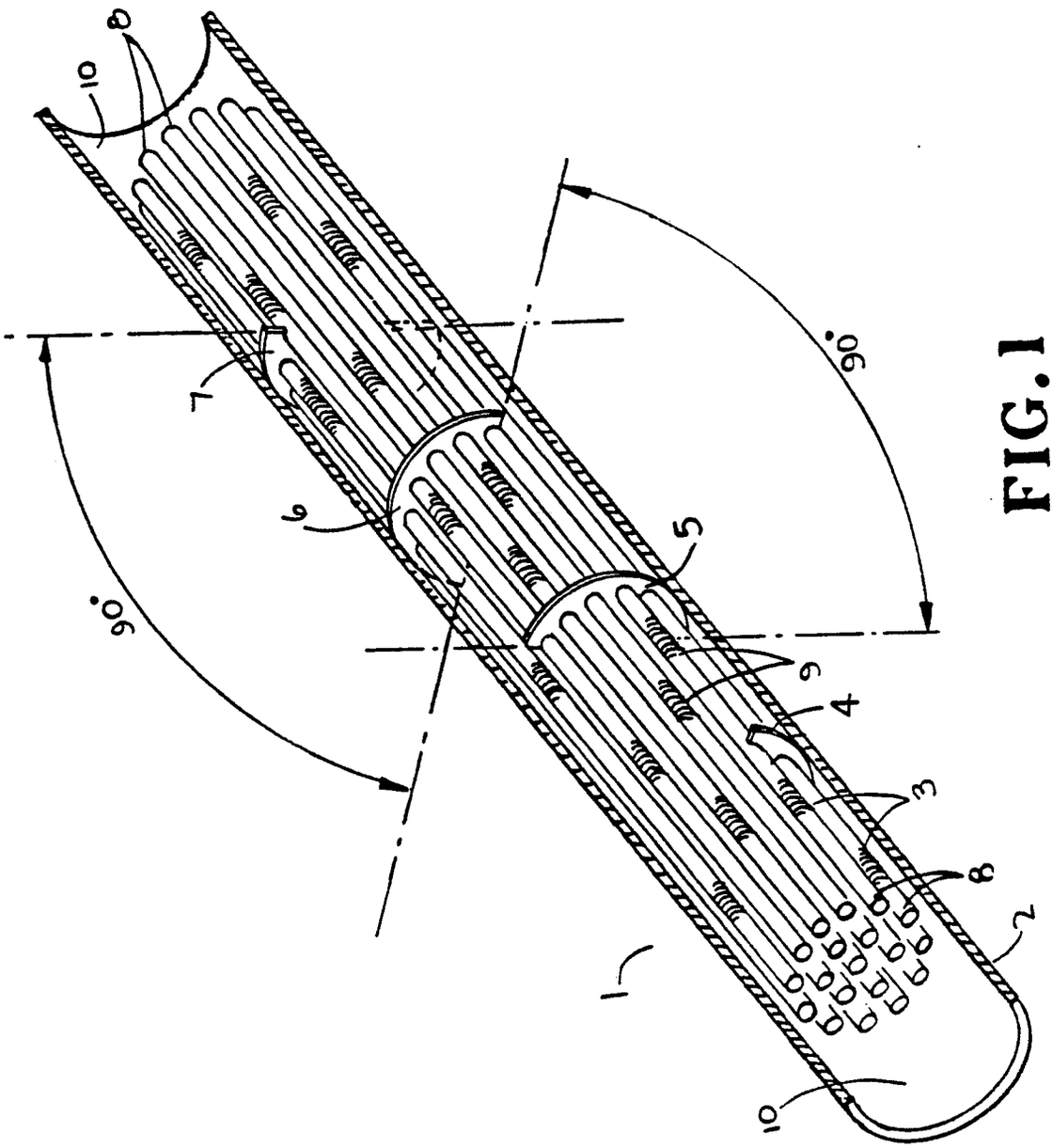

FIG. 1

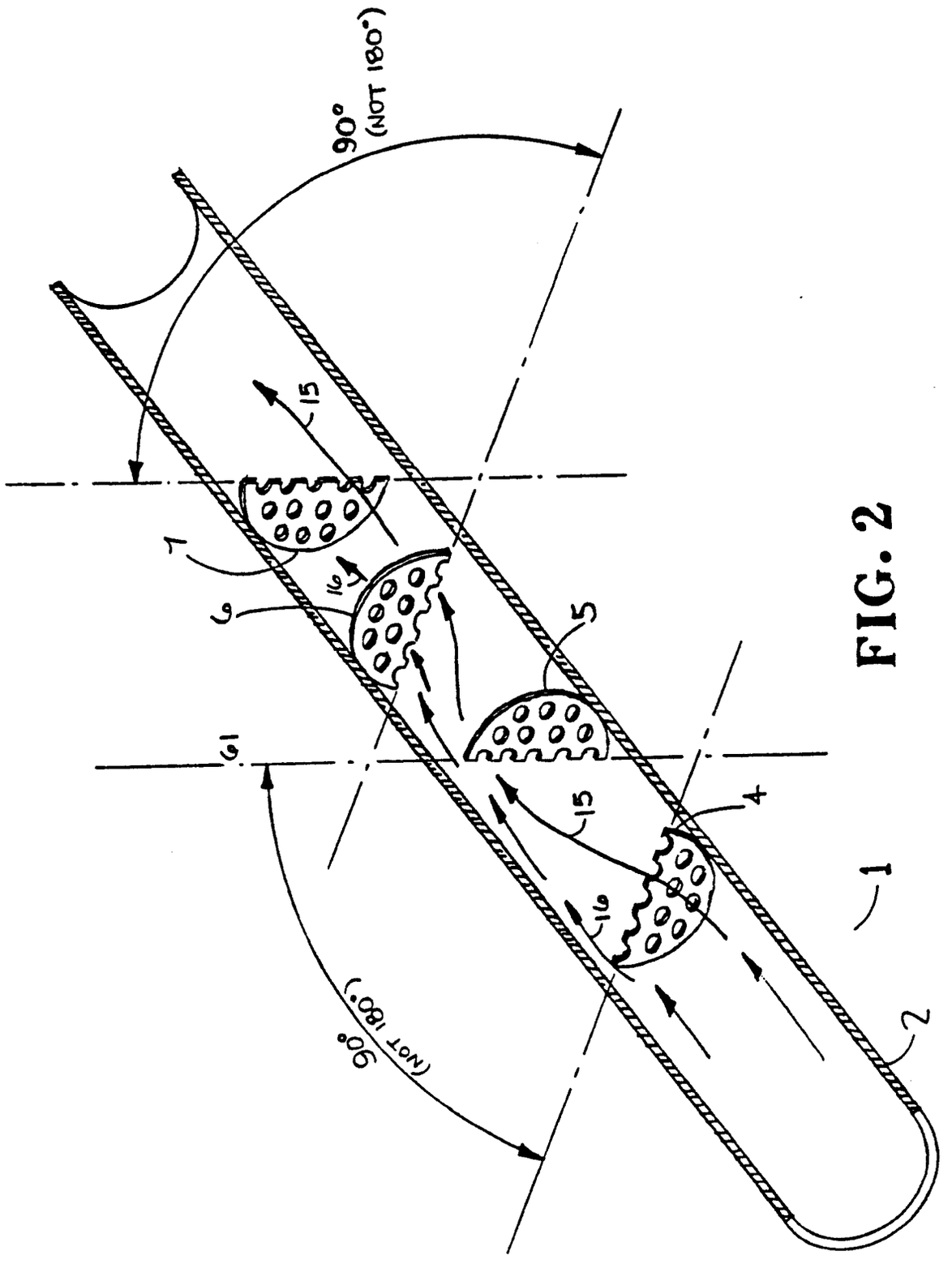

FIG. 2