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(54) **SHELL-AND-TUBE APPARATUS WITH BAFFLES**

MANTEL-ROHR-VORRICHTUNG MIT ABLENKPLATTEN

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Description

Field of application

[0001] The invention relates to the field of shell-and-tube apparatus, as shown in the preamble of claim 1.

Prior art

[0002] Shell-and-tube apparatus are used normally as heat exchangers between a fluid which flows inside the tubes and a fluid which flows in the shell side.

[0003] Known shell-and-tube apparatus comprise baffles which have essentially two functions: a fluid-dynamic function of deviating and/or accelerating the fluid in the shell side, thus increasing the heat exchange coefficient; and a structural function for preventing vibration of the tubes;

[0004] US 5 058 664 and US 5 642 778 disclose a known method for manufacturing baffles consisting of a rod-baffle supported by a framework.

[0005] EP 2 469 215 discloses baffles formed by thin plates which intersect forming a grille and which are inclined so as to deflect the shell-side flow.

[0006] A drawback of the aforementioned prior art is that each single baffle is composed of several parts which need to be welded and/or fitted together and consequently the construction is relatively costly. Moreover insertion of the tubes through the baffles is a difficult operation.

[0007] Another drawback of these apparatus is that the heat exchange coefficient is greatly affected by the shell-side flow. In order to direct suitably the shell-side flow it is known to provide partitions inside the apparatus which however result in additional head losses.

[0008] The prior art shell-and-tube apparatus generally have a transversal shell-side flow. This term denotes that the gaseous flow outside and around the tubes is mainly directed perpendicular to the axis of tubes. This arrangement typically involves a number of passages crossing various sections of the tube bundle between consecutive baffles.

[0009] A transversal shell-side is generally preferred to provide a good heat exchange between the gaseous flow and the surface of tubes. On the other hand, it involves a considerable pressure drop and requires that baffles provide a proper sealing of the tube bundle sections, to avoid gas bypass from one section to another. The baffle must create a sealing collar around each tube which, however, may increase the cost and/or may render the insertion of tubes more difficult.

[0010] US 4834173 describes for example, heat exchangers with a transversal shell-side flow.

[0011] EP 3 115 734 describes baffles which allow the free insertion of tubes and their subsequent locking.

[0012] BE 1018891 describes a shell-and-tube apparatus according to the preamble of claim 1.

Summary of the invention

[0013] The object of the invention is to provide a shell-and-tube apparatus comprising a plurality of baffles which is advantageous both from the structural point of view and from the point of view of internal fluid dynamics. This object is achieved with an apparatus as described in the claims.

[0014] The baffles comprise a metal plate which has openings for the passage of the tubes through said baffle. At said openings, the baffles comprise tabs protruding from the surface of the baffle. These tabs cooperate to the fluid dynamics and/or the anti-vibrational structural function as will be explained below with the aid of examples.

[0015] Preferably, the baffles are substantially flat elements perpendicular to the axis of the tubes (i.e. to the axis of the tube bundle). The tabs extend from the surface of the respective baffle in a direction parallel to the axis of the tube bundle or in a direction inclined relative to said axis.

[0016] Each tab may extend over an area equal to, or less than, the area of the corresponding opening formed in the metal plate.

[0017] Said tabs may be configured for a fluid-dynamic function, suitable for deviating the shell-side fluid, and/or a structural function of elastically supporting the tubes. Tabs able to cause a significant deviation of the motion of the shell-side fluid are termed fluid-dynamic.

[0018] In preferred embodiments, the shell-side gaseous flow is axial or predominantly axial. Accordingly the gas input(s) and gas output(s) of the shell side of the apparatus are arranged to provide said axial or predominantly axial flow. In some embodiments, at least some of said tabs are fluid-dynamic tabs adapted to deviate (e. g. incline of a given angle) the shell-side gaseous flow from the main axial direction.

[0019] Preferably, the tabs of the baffles are overall arranged to give the shell-side fluid a motion component in the direction transverse to the direction of the longitudinal axis of the tubes or the tube bundle.

[0020] More advantageously, the tabs are arranged to give the shell-side fluid a substantially sinusoidal motion or a substantially helical motion.

[0021] An arrangement of the tabs such as to give the shell-side fluid a substantially sinusoidal flow is preferred when the tubes have a square or triangular pitch. An arrangement of the tabs such as to give the shell-side fluid a substantially helical flow is preferred when the tubes are arranged on circular ranks, even though sinusoidal flows may also be obtained with the latter configuration of tubes.

[0022] In a preferred embodiment, the apparatus comprises baffles with differently configured tabs. The apparatus may comprise two or more sets of baffles in which each set has a specific configuration of tabs. The term "configuration" may comprise one or more features such as for example shape, size and orientation of the tabs.

Baffles with different configurations may be suitably distributed along the tube bundle, for example they can alternate with each other.

[0023] It should be noted that a different configuration of the tabs may change both the fluid-dynamic function and the structural function.

[0024] In some embodiments of the invention, a sequence of baffles with differently configured tabs imparts a target path to the shell-side fluid, creating preferential paths across the shell side, and/or gives a certain degree of turbulence to said fluid. A suitable path and/or increase in turbulence may increase the heat exchange.

[0025] As an alternative to, or in addition to the above, said sequence of baffles may create supports for the tubes according to different planes for effectively dampening the vibrations. For this purpose the tabs of adjacent baffles rest advantageously on a same tube according to different support planes.

[0026] In a preferred embodiment an apparatus according to the invention comprises at least a first set of baffles with a first configuration of tabs, and a second set of baffles with a second configuration of tabs, wherein the second configuration is conjugate to the first configuration and the baffles of the first set and second set alternate along at least part of the tube bundle. In this way, a baffle with the first configuration of tabs faces, and is adjacent to, a baffle with the second configuration of tabs, and so on.

[0027] The shell-side flow therefore encounters alternately tabs of the first configuration and tabs of the second configuration. Said tabs in a conjugate configuration cooperate to give the shell-side fluid a desired fluid dynamic effect. According to preferred embodiments, said fluid-dynamic effect results in essentially sinusoidal or essentially helical flow lines.

[0028] The embodiments with a sinusoidal shell-side flow and the embodiments with a helical shell-side flow may be combined with each other, for example by configuring the baffles for obtaining a sinusoidal flow along at least part of tube bundle and a helical flow along at least another part of the tube bundle.

[0029] In some embodiments a single baffle may comprise tabs with a different configuration. Accordingly, for example, different portions of a single baffle have a different fluid-dynamic effect.

[0030] The tabs may have various forms. In a first embodiment, the tabs have a substantially two-dimensional form wherein one size, for example the thickness, is significantly smaller than the other two sizes. In another embodiment the tabs have a substantially mono-dimensional form in which one size is predominant over the other two. The tabs may have a polygonal form or a more complex form.

[0031] In preferred embodiments, each opening for one or more tubes comprises at least a first region suitable for receiving the tube or tubes with play and a second region suitable for receiving the tube or tubes with less play or with substantially no play. By arranging the baffles in a so-called assembly configuration, the first regions of the openings are aligned allowing free insertion of tubes, each tube being received with play through the openings of the baffles. In said assembly position the baffles are staggered or rotated relative to their operating configuration. By moving the baffles from the assembly position into the operating position, the tubes switch from the first regions into the second regions of the openings, where they are substantially locked in position. The motion which leads the baffles from the assembly position into the operating position may be a displacement (so-called "shift-lock" embodiment) or a rotation (so-called "twist-lock" embodiment).

[0032] These embodiments allowing free insertion of tubes through the baffles and their subsequent locking are described in greater detail in the already mentioned patent application EP 3 115 734.

[0033] In the aforementioned embodiments with locking of the tubes upon assembly, the tabs are advantageously formed so as to provide an elastic support for the tubes when the baffle is in the locking position. In this way the invention provides the further advantage of providing the system with a certain degree of elasticity and flexibility.

[0034] Advantageously the material of the baffles is steel sheet. The baffle may be a single body formed by the cut or punched metal plate or may comprise further elements such as a peripheral reinforcing ring. In some embodiments said metal plate comprises a plurality of superimposed metal sheets. Preferably the metal plate has the shape of a disc or portion of a disc.

[0035] Each baffle may extend over the whole of or substantially the whole cross-sectional area of the shell side, or it may extend only over a portion of said area. Baffles which cover only a part of the cross-sectional area of the shell side may be alternated with a different arrangement, for example to cover different portions of the area.

[0036] The advantage of the invention is given by the constructional simplicity combined with the fact that baffles actively cooperate with the fluid dynamics and/or the structural feature. For example the invention allows to realize an apparatus in which the baffles cooperate to the internal fluid dynamics by directing the shell-side flow and further provide a yielding elastic support for the tubes.

[0037] In some embodiments the tabs projecting from the surface of the baffle act essentially like bracket elements which are able to bend and therefore provide an elastic support for the tubes. This is an important advantage because the prior art system for assembling the tubes and the baffles is problematic: a relatively free coupling is not able to counteract the vibrations in an effective manner, while a precise fit makes the mounting difficult and makes the ensemble of tubes and baffles too rigid. The invention solves the problem by allowing a precise mounting which, at the same time, gives the system a certain elasticity owing to the ability of the tabs to flex.

[0038] The fluid-dynamic effect has the advantage of increasing the heat exchange coefficient and optimising the shell-side flow, exploiting the passages through the baffles for this purpose without introducing substantive additional head losses. The suitably directed shell-side flow, for example with sinusoidal or helical lines, runs over all tubes and allows full exploitation of the tube bundle.

[0039] In first embodiments of the invention, the openings for the tubes are formed in the metal plate of the baffle, advantageously with a punching or cutting process, and said tabs are formed by strips of material of the metal plate, generated by the cutting or punching of the openings, and bent in appropriate manner. Preferred cutting techniques comprise laser cutting and water-jet cutting.

[0040] In second embodiments of the invention, the tabs are formed by elements firmly applied on the metal plate at the openings. Advantageously the tabs are sheet-metal elements applied by means of welding, preferably spot-welding (resistance welding).

[0041] In the first embodiments of the invention, the baffles comprise advantageously a plate with a small thickness, such that the tabs are elastic and easy to bend. In order to increase the stability of the baffles, a reinforcing ring welded to the outer edge of the plate can be provided.

[0042] The second embodiments (applied tabs) have the advantage that the thickness of the tabs may differ from the thickness of the metal plate forming the baffle. For example, the tabs may be thinner to ensure they are elastic and easy to bend.

[0043] In a particularly preferred variant a baffle comprises a metal plate of the desired thickness, with openings for the tubes obtained by means of laser cutting or water-jet cutting; the fluid-dynamic tabs are made from thin sheet metal and are applied on the baffle in the region of the openings by means of spot welds.

[0044] In some variants, in order to facilitate the operation of positioning and welding the tabs, the metal plate comprises two superimposed metal sheets of different thickness. A first metal sheet with a relatively large thickness has a structural function and comprises the through-openings for the passage of the tubes. A second metal sheet with a smaller thickness (less than that of the first sheet) is mounted onto the first sheet and comprises the fluid-dynamic tabs. Said tabs, in this case, may be formed by bending the strips or part of the strips extending beyond the openings. The tabs may be bent before the insertion of tubes or during the insertion of tubes.

[0045] In addition to ensuring a greater heat exchange efficiency, both the construction methods described above are faster and cheaper than the conventional methods which envisage forming the baffles by assembling a large number of linear elements of the bar type.

[0046] It should be noted that the invention is advantageous both for exchangers with or without the said system for locking the tubes during assembly.

[0047] Preferably an apparatus according to the invention is a chemical reactor for use in a chemical plant. The chemical reactor may contain a catalyst in some embodiments.

[0048] Another advantage of the invention consists in the possibility of providing differently configured tabs on the same baffle. In this way it is possible to achieve better control of the internal fluid dynamics.

[0049] The invention is applicable to apparatus with straight tubes and apparatus with U-shaped tubes. In this latter case the baffles are applied along the straight portion of the U-shaped tubes.

[0050] Still another advantage of the invention is that the apparatus can have an axial or predominantly axial shell-side flow, which has a smaller pressure drop compared to transversal shell-side flow. In such a case the baffles do not need to create a gas-tight seal around tubes, which facilitates their insertion. Thanks to the fluid-dynamic effect of the tabs, the invention provides a good heat exchange combined with the low pressure drop of the axial-flow design.

[0051] The advantages of the invention will emerge even more clearly with the aid of the detailed description below relating to a number of preferred embodiments.

Description of the figures

[0052]

Fig. 1 shows a simplified diagram of a shell-and-tube apparatus comprising a set of anti-vibration baffles.

Fig. 2 shows a tube passing through a baffle in an embodiment of the invention.

Fig. 3 shows in schematic form a set of baffles of the apparatus shown in Fig. 1, according to a first example of a variant of the invention.

Fig. 4 is a schematic cross-section through the baffles and the tubes according to Fig. 3 and shows the shell-side flow lines.

Fig. 5 shows a detail of Fig. 4.

Fig. 6 shows a set of baffles in a second variant of the invention.

Fig. 7 shows a set of baffles in a third variant of the invention.

Fig. 8 is a schematic cross-section through the baffles and the tubes according to Fig. 7.

Fig. 9 shows a set of baffles in a fourth variant of the invention.

Figs. 10 to 13 show a number of variations of em-

bodiment of the tabs of the baffles.

Figs. 14 and 15 show further embodiments of the tabs of the baffles.

Detailed description

[0053] Fig. 1 shows in schematic form a shell-and-tube apparatus 1 comprising: a shell 2; a straight-tube bundle 3; a plurality of baffles 5 separated by an interval p; two tube plates 6. In Fig. 1, for simpler illustration, only the axes of the tubes are indicated. Moreover the central axis 20 of the tube bundle 3 which is parallel to the axes of the tubes is indicated.

[0054] Each of the baffles 5 (Fig. 2) comprises essentially a metal disc 10 in which openings 11 for allowing the tubes 4 to pass through are formed. In the region of said openings 11, or at least some of them, the baffle 5 comprises appendix tabs 12 formed by strips of material of the disc 10 which protrude from one side 13 of the disc 10.

[0055] The openings 11 and the tabs 12 may be formed using various methods. For example: the openings 11 are obtained by means of partial punching and the tabs 12 are formed by strips of the material of the disc 10, which instead of being removed, remain attached to the disc; the openings 11 may be obtained using a suitable cutting method, preferably laser or water-jet cutting, and subsequent bending of strips to form the tabs 12; the tabs 12 are thin sheet-metal elements which are mounted on the disc 10. These examples are provided by way of a non-limiting example and other manufacturing methods are possible.

[0056] Each opening 11 is passed through by a tube 4 or several tubes 4 depending on the specific embodiment.

[0057] Figs. 3 to 5 show an embodiment (shift lock type) in which the tubes 4 can be freely inserted into the openings 11, with a certain amount of play, when the baffles 5 are in an axially offset assembly position. Once insertion of the tubes has been completed, the baffles can be locked on the tubes with conjugate linear displacements ***+f*** or ***-f*** which bring the said baffles into alignment. The direction of said displacements ***+f*** , ***-f*** is also called locking direction. Preferably, adjacent baffles are locked by displacements in opposite directions.

[0058] For this purpose, for example, the openings 11 have an essentially trapezoidal form comprising a base portion suitable to receive a tube with play, and flanks converging towards a tapered head portion for locking the tube. Such an embodiment is also shown in Figs. 10-15.

[0059] The set of baffles 5 comprises first baffles 5a having a first configuration of tabs 112a and second baffles 6b having a second configuration of tabs 112b in which the first baffles 5a and the second baffles 5b alternate with each other in the longitudinal direction of the tube bundle. The figure also shows a tube plate 6. In the example the baffles 5a and 5b can be locked on the tube bundle by means of the linear displacements ***+f***, ***-f,*** respectively.

[0060] The tabs 112a with said first configuration protrude from the respective baffles 5a in a direction forming, in a reference plane, a first angle ***a1*** with the direction of the direction of the axis 14 of the tubes and the axis 20 of the tube bundle 3.

[0061] The tabs 112b with said second configuration protrude from the respective baffles 5b in a second direction forming with said direction of the axes 14 and 20, in the same reference plane, a second angle ***a2*** with a sign opposite to that of the first angle ***a1*** (Fig. 5).

[0062] Preferably said second angle is equal and opposite to said first angle, i.e. ***a2 = -a1.***

[0063] More advantageously, the absolute value (modulus) of said first angle ***a1*** and second angle ***a2*** is comprised between 30 and 60 degrees, and is preferably 45 degrees.

[0064] Said reference plane is for example the plane shown in Fig. 4.

[0065] With reference to Fig. 5 the upper surface 120 of a tab 112a faces the opening 11 and comprises a flat surface inclined at said angle ***a1*** relative to the direction of the axis 20 of the tube bundle. Similarly the upper surface 121 of a tab 112b has a flat surface with an inclination ***a2*** relative to the said axis 20.

[0066] As a result of this arrangement, as shown in particular in Fig. 4, the tabs 112a and 112b deviate the shell-side flow inside the apparatus 1 alternately in two different directions, for example upwards and downwards, resulting in substantially sinusoidal flow lines Fs bending upwards or downwards while traversing the first baffles 5a or the second baffles 5b, respectively.

[0067] In Figs. 3 to 5 the tabs 112a, 112b are arranged on one side of the opening 11 which moves towards the tube 4 as a result of the locking displacement ***+f*** or ***-f,*** for example on the smaller side of trapezoidal openings 11. In this way the aforementioned tabs 112a, 112b provide an elastic support for the tubes 4 when the baffles 5a, 5b switch from the assembly position to the locked position.

[0068] In Fig. 5 in particular it can be seen that a tube 4 makes a bearing contact alternately according to one direction and according to an opposite direction, for example upwards and downwards. In the locking phase, the tubes 4 are wedged between the inclined flanks of the openings 11; the tabs 112a, 112b provide an elastic element to recover any play due to the constructional tolerances.

[0069] It can be understood that the tabs 112a, 112b have both a fluid dynamic function, determining sinusoidal flow lines, and a structural function of elastically supporting the tubes 4, compensating for play due to the constructional tolerances, and preventing vibrations.

[0070] Fig. 6 shows a variant of the embodiment of Figs. 3-5, in which the tabs 112a, 112b are arranged laterally with respect to the locking direction of baffles 5, for example along the converging flanks of the trapezoidal

openings 11.

[0071] Figs. 7 and 8 shows a variant of the twist-lock type in which the baffles 5 pass from an assembly position (where the tubes can be freely inserted with play into the openings 11) into a locking position with conjugate rotations $+\varphi$ or $-\varphi$ about the axis 20. Preferably adjacent baffles allow locking of the tubes with rotations in opposite directions.

[0072] In said twist-lock embodiment, the set of baffles 5 advantageously comprises first baffles 5a and second baffles 5b with tabs 212a, 212b configured to impart a helical motion to the shell-side fluid.

[0073] In greater detail, according to the shown embodiment, the tabs 212a, 212b extend from opposite sides of the baffles, for example the tabs 212a extend from front sides 13a of the baffles 5a and the tabs 212b extend from rear sides 13b of the baffles 5b. The tabs 212a, 212b are also angularly offset. As a result of this arrangement, as shown in Figs. 7 and 8, the tabs 212a, 212b deviate the shell-side flow helically around the direction of the axes 14 and 20, thus generating essentially helical flow lines Fe.

[0074] In Figs. 7 and 8, the tabs 212a, 212b are positioned, relative to the openings 11, so that the tubes 4 move towards said tabs 212a, 212b when the baffle passes from the assembly position into the operating position. In this way, the tabs also act as elastic supports for the tubes and for recovery of the play (in a similar manner to that shown in Figs. 3-5).

[0075] Fig. 9 shows a variant of Figs. 7 and 8 in which the tabs 212a, 212b are positioned laterally with respect to the locking movement (in a similar manner to that shown in Fig. 6). With the configuration of the tabs shown in Fig. 9 a sinusoidal flow associated with the twist-lock configuration is obtained.

[0076] Figs. 10-13 show examples of embodiment of the tabs, indicated generally by the reference number 12. Figs. 14 and 15 shows further examples of embodiment. Said examples of embodiments in Figs. 10 to 15 are likewise applicable to the various embodiments shown in Figs. 1-9.

[0077] Fig. 10 shows an example of embodiment in which the tabs 12 have an essentially polygonal trapezium-like form and are connected to the sheet-metal disc along one side 15.

[0078] Fig. 11 shows a variant in which only a part of the material removed from the disc 10 forms the tab 12 and, consequently, the area of the tabs 12 is smaller than the area of the openings 11.

[0079] Fig. 12 shows a variant in which the tabs 12 are joined to a base 16 of the opening 11 having an essentially trapezoidal form.

[0080] Fig. 13 shows a variant in which the openings 11 each comprise two tabs 12 which extend on opposite sides relative to the plane of the baffle.

[0081] Openings with an essentially trapezoidal form as shown in Figs. 10-12 are generally suitable for receiving only one tube 4; consequently the baffle requires a number of openings 11 equal to the number of tubes 4. Fig. 13 shows an example of an embodiment of opening 11 of the shift-lock type suitable for receiving four tubes.

[0082] Figs. 14 and 15 show an embodiment in which the tabs 12 are formed by thin sheet-metal elements which are mounted on the disc 10 for example by means of spot welds 25.

[0083] It should be noted that the constructional form shown in Figs. 14 and 15 may be applied to all the variants of the invention.

[0084] It should be finally noted that embodiments of the invention, for example similar to embodiments of Figs. 1-9 are also possible without the above described shift-lock or twist-lock baffle locking system.

Claims

1. Shell-and-tube apparatus comprising a plurality of baffles (5) which are arranged along the tube bundle, perpendicular to an axis (20) of the tube bundle (3) and passed through by said tubes, wherein:

   each baffle is an essentially flat body and comprises a metal plate (10) with openings (11) for the passage of the tubes through said baffle;
   at said openings (11) the baffle comprises tabs which protrude away from the metal plate,
   said tabs are configured to operate as elastic supports for the tubes and/or to operate as fluid-dynamic tabs adapted to deviate a fluid traversing the shell side of the apparatus, **characterized in that** the shell-side gaseous flow is axial or predominantly axial and **in that** at least some of said tabs are fluid-dynamic tabs adapted to deviate the shell-side gaseous flow from the main axial direction.

2. Apparatus according to claim 1, wherein all tabs of each baffle extend from the same side (13) of the respective baffle.

3. Apparatus according to any of claims 1 to 2 comprising first baffles (5a) having a first configuration of tabs and second baffles (5b) having a second configuration of tabs, wherein the first baffles and the second baffles alternate along at least a part of the tube bundle and wherein said first configuration and second configuration of tabs are conjugate to impart to the shell-side flow a movement component transverse to the axis (20) of the tube bundle (3).

4. Apparatus according to claim 3, wherein:

   the first baffles (5a) have tabs (112a) configured to direct the shell-side flow in a first direction forming, in a reference plane, a first angle (a1) with the axis of the tubes,

the second baffles (5b) have tabs (112b) configured to direct the shell-side flow in a second direction (2a) forming, in said reference plane, a second angle with the axis of the tubes, said second angle having a sign opposite to the first angle,
thus obtaining shell-side flow lines which, passing through the baffles, are alternately deviated in different directions.

5. Apparatus according to claim 4, wherein the shell-side flow lines are substantially sinusoidal.

6. Apparatus according to claim 3, wherein the first baffles (5a) and the second baffles (5b) comprise tabs (212a, 212b) directed so as to impart to the shell-side fluid a substantially helical flow about the axis of the tube bundle.

7. Apparatus according to claim 6, wherein the tabs (212a, 212b) protrude from opposite sides (13a, 13b) of the respective first baffles and second baffles (5a, 5b) and the baffle tabs facing each other are angularly offset.

8. Apparatus according to any one of the preceding claims, wherein at least one baffle comprises tabs of varying configuration.

9. Apparatus according to any one of the preceding claims, wherein each baffle occupies all or substantially all of the cross-sectional area of the shell side, or only a portion of said area.

10. Apparatus according to any one of the preceding claims, wherein tabs of adjacent baffles rest on opposite sides on each tube.

11. Apparatus according to any one of the preceding claims, wherein the baffles are formed in such a way that:

each opening for one or more tubes comprises at least a first region suitable to receive the tube or tubes with play and a second region suitable to receive the tube or tubes with less play or with substantially zero play;
each tube of the bundle is received in a first region of a respective seat when the baffle is in a so-called assembly position and is received in a second region of the seat when the baffle is in an operating position.

12. Apparatus according to claim 11, wherein the tabs are positioned relative to the openings (11) so that the tubes move towards said tabs when the baffles are arranged in the operating position, such that the tabs define elastic supports for the tubes when the baffles are in the operating position.

13. Apparatus according to any one of the preceding claims, wherein the tabs are formed by sheet-metal elements mounted on the metal plate in correspondence of the openings.

14. Apparatus according to any one of claims 1 to 12, wherein the openings are punched or cut in the metal plate, and said tabs are formed by strips of material of the metal plate generated by the cutting or punching of the openings, and suitably bent.

15. Apparatus according to any one of the preceding claims, wherein the baffles comprise an outer reinforcing ring having a thickness greater than the thickness of the metal plate.

Patentansprüche

1. Rohrbündelvorrichtung mit einer Vielzahl von Leitblechen (5), die entlang des Rohrbündels senkrecht zu einer Achse (20) des Rohrbündels (3) angeordnet sind und von den Rohren durchlaufen werden, wobei:

jedes Leitblech ein im wesentlichen flacher Körper ist und eine Metallplatte (10) mit Öffnungen (11) für den Durchgang der Rohre durch das Leitblech aufweist;
das Leitblech an den Öffnungen (11) Laschen aufweist, die von der Metallplatte weg vorstehen,
die Laschen so konfiguriert sind, dass sie als elastische Stützen für die Rohre wirken und/oder als fluiddynamische Laschen wirken, die angepasst sind, ein die Gehäuseseite der Vorrichtung durchströmendes Fluid abzulenken, **dadurch gekennzeichnet, dass** die gehäuseseitige Gasströmung axial oder überwiegend axial ist und dass mindestens einige der Laschen fluiddynamische Laschen sind, die angepasst sind, die gehäuseseitige Gasströmung von der Hauptaxialrichtung abzulenken.

2. Vorrichtung nach Anspruch 1, wobei sich alle Laschen jedes Leitblechs von derselben Seite (13) des jeweiligen Leitblechs aus erstrecken.

3. Vorrichtung nach einem der Ansprüche 1 bis 2, umfassend erste Leitbleche (5a) mit einer ersten Konfiguration von Laschen und zweite Leitbleche (5b) mit einer zweiten Konfiguration von Laschen, wobei sich die ersten Leitbleche und die zweiten Leitbleche entlang mindestens eines Teils des Rohrbündels abwechseln und wobei die erste Konfiguration und die zweite Konfiguration von Vorsprüngen konjugiert

sind, um der gehäuseseitigen Strömung eine Bewegungskomponente quer zur Achse (20) des Rohrbündels (3) zu verleihen.

4. Vorrichtung nach Anspruch 3, wobei:

die ersten Leitbleche (5a) Laschen (112a) aufweisen, die so konfiguriert sind, dass sie die gehäuseseitige Strömung in eine erste Richtung lenken, die in einer Bezugsebene einen ersten Winkel (a1) mit der Achse der Rohre bildet,
die zweiten Leitbleche (5b) Laschen (112b) aufweisen, die so konfiguriert sind, dass sie die gehäuseseitige Strömung in eine zweite Richtung (2a) lenken, die in der Bezugsebene einen zweiten Winkel mit der Achse der Rohre bildet, wobei der zweite Winkel ein dem ersten Winkel entgegengesetztes Vorzeichen hat, um gehäuseseitige Strömungslinien zu erhalten, die beim Durchlaufen der Leitbleche wechselseitig in verschiedene Richtungen abgelenkt werden.

5. Vorrichtung nach Anspruch 4, wobei die gehäuseseitigen Strömungslinien im wesentlichen sinusförmig sind.

6. Vorrichtung nach Anspruch 3, wobei die ersten Leitbleche (5a) und die zweiten Leitbleche (5b) Laschen (212a, 212b) umfassen, die so ausgerichtet sind, dass sie dem gehäuseseitigen Fluid eine im wesentlichen spiralförmige Strömung um die Achse des Rohrbündels verleihen.

7. Vorrichtung nach Anspruch 6, wobei die Laschen (212a, 212b) von gegenüberliegenden Seiten (13a, 13b) der jeweiligen ersten und zweiten Leitbleche (5a, 5b) vorstehen und die einander zugewandten Leitblechlaschen winkelversetzt sind.

8. Vorrichtung nach einem der vorstehenden Ansprüche, wobei mindestens ein Leitblech Laschen unterschiedlicher Konfiguration aufweist.

9. Vorrichtung nach einem der vorstehenden Ansprüche, wobei jedes Leitblech die gesamte oder im wesentlichen die gesamte Querschnittsfläche der Gehäuseseite oder nur einen Teil dieser Fläche einnimmt.

10. Vorrichtung nach einem der vorstehenden Ansprüche, wobei Laschen benachbarter Leitbleche auf gegenüberliegenden Seiten auf jedem Rohr aufliegen.

11. Vorrichtung nach einem der vorstehenden Ansprüche, wobei die Leitbleche in so einer Art gebildet sind, dass:

jede Öffnung für ein oder mehrere Rohre mindestens einen ersten Bereich aufweist, der geeignet ist, das Rohr bzw. die Rohre mit Spiel aufzunehmen, und einen zweiten Bereich, der geeignet ist, das Rohr bzw. die Rohre mit weniger Spiel oder mit im wesentlichen keinem Spiel aufzunehmen;
jedes Rohr des Bündels in einem ersten Bereich eines entsprechenden Sitzes aufgenommen wird, wenn sich das Leitblech in einer sogenannten Montageposition befindet, und in einem zweiten Bereich des Sitzes aufgenommen wird, wenn sich das Leitblech in einer Betriebsposition befindet.

12. Vorrichtung nach Anspruch 11, wobei die Laschen relativ zu den Öffnungen (11) so positioniert sind, dass sich die Rohre in Richtung der Laschen bewegen, wenn die Leitbleche in der Betriebsposition angeordnet werden, so dass die Laschen elastische Stützen für die Rohre definieren, wenn die Leitbleche in der Betriebsposition sind.

13. Vorrichtung nach einem der vorstehenden Ansprüche, wobei die Laschen durch Blechelemente gebildet werden, die an der Metallplatte entsprechend den Öffnungen angebracht sind.

14. Vorrichtung nach einem der Ansprüche 1 bis 12, wobei die Öffnungen in die Metallplatte gestanzt oder geschnitten sind und die Laschen durch Materialstreifen der Metallplatte, die durch das Schneiden oder Stanzen der Öffnungen erzeugt sind, gebildet und in geeigneter Weise gebogen sind.

15. Vorrichtung nach einem der vorstehenden Ansprüche, wobei die Leitbleche einen äußeren Verstärkungsring mit einer Dicke aufweisen, die größer ist als die Dicke der Metallplatte.

Revendications

1. Appareil à calandre comprenant une pluralité de déflecteurs (5) qui sont disposés le long du faisceau de tubes, perpendiculairement à un axe (20) du faisceau de tubes (3) et traversées par lesdits tubes, dans lequel :

chaque déflecteur est un corps essentiellement plat et comprend une plaque métallique (10) avec des ouvertures (11) pour le passage des tubes à travers ledit déflecteur;
au niveau desdites ouvertures (11), le déflecteur comprend des languettes qui font saillie de la plaque métallique,
lesdites languettes étant configurées pour fonctionner comme supports élastiques pour les tubes et/ou pour fonctionner comme des languet-

tes fluidodynamiques adaptées pour dévier un fluide traversant le côté enveloppe de l'appareil, caractérisé en ce l'écoulement gazeux côté enveloppe est axial ou principalement axial et en au moins certaines desdites languettes sont des languettes fluidodynamiques adaptées pour dévier l'écoulement gazeux côté enveloppe de la direction axiale principale.

2. Appareil selon la revendication 1, dans lequel toutes les languettes de chaque déflecteur s'étendent du même côté (13) du déflecteur respectif.

3. Appareil selon l'une quelconque des revendications 1 à 2 comprenant des premiers déflecteurs (5a) ayant une première configuration de languettes et des seconds déflecteurs (5b) ayant une seconde configuration de languettes, dans lequel les premiers déflecteurs et les seconds déflecteurs alternent le long d'au moins une partie du faisceau de tubes et dans lequel lesdites première configuration et seconde configuration de languettes sont conjuguées pour conférer au flux côté enveloppe une composante de mouvement transversale à l'axe (20) du faisceau de tubes (3).

4. Appareil selon la revendication 3, dans lequel :

les premiers déflecteurs (5a) ont des languettes (112a) configurées pour diriger l'écoulement côté enveloppe dans une première direction formant, dans un plan de référence, un premier angle (a1) avec l'axe des tubes,
les seconds déflecteurs (5b) ont des languettes (112b) configurées pour diriger le flux côté enveloppe dans une seconde direction (2a) formant, dans ledit plan de référence, un deuxième angle avec l'axe des tubes, ledit deuxième angle ayant un signe opposé au premier angle,
obtenant ainsi des lignes d'écoulement côté enveloppe qui, traversant les déflecteurs, sont alternativement déviées dans des directions différentes.

5. Appareil selon la revendication 4, dans lequel les lignes d'écoulement côté enveloppe sont sensiblement sinusoïdales.

6. Appareil selon la revendication 3, dans lequel les premiers déflecteurs (5a) et les seconds déflecteurs (5b) comprennent des languettes (212a, 212b) dirigées de manière à communiquer au fluide côté enveloppe un écoulement sensiblement hélicoïdal autour de l'axe du faisceau de tubes.

7. Appareil selon la revendication 6, dans lequel les languettes (212a, 212b) font saillie des côtés opposés (13a, 13b) des premiers et seconds déflecteurs respectifs (5a, 5b) et les languettes de déflecteur se faisant face sont décalées angulairement.

8. Appareil selon l'une des revendications précédentes, dans lequel au moins un déflecteur comprend des languettes de configuration variables.

9. Appareil selon l'une quelconque des revendications précédentes, dans lequel chaque déflecteur occupe la totalité ou sensiblement la totalité de la surface en coupe transversale du côté de l'enveloppe, ou seulement une partie de ladite zone.

10. Appareil selon l'une des revendications précédentes, dans lequel les languettes des déflecteurs adjacentes reposent sur les côtés opposés de chaque tube.

11. Appareil selon l'une des revendications précédentes, dans lequel les déflecteurs sont formés de telle manière que :

chaque ouverture pour un ou plusieurs tubes comprend au moins une première région apte à recevoir le ou les tubes avec un jeu et une deuxième région apte à recevoir le ou les tubes avec un jeu moindre ou avec un jeu sensiblement nul ;
chaque tube du faisceau est reçu dans une première région d'un siège respectif lorsque la déflecteur est dans une position dite d'assemblage et est reçu dans une deuxième région du siège lorsque la déflecteur est dans une position de fonctionnement.

12. Appareil selon la revendication 11, dans lequel les languettes sont positionnées par rapport aux ouvertures (11) de sorte que les tubes se déplacent vers lesdites languettes lorsque les déflecteurs sont disposés en position de fonctionnement, de sorte que les languettes définissent des supports élastiques pour les tubes lorsque les déflecteurs sont en position de fonctionnement.

13. Appareil selon l'une des revendications précédentes, dans lequel les languettes sont formées par des éléments en tôle montés sur la plaque métallique en correspondance des ouvertures.

14. Appareil selon l'une quelconque des revendications 1 à 12, dans lequel les ouvertures sont poinçonnées ou découpées dans la plaque métallique, et lesdites languettes sont formées par des bandes de matériau de la plaque métallique générées par la découpe ou le poinçonnage des ouvertures, et pliées de manière appropriée.

15. Appareil selon l'une des revendications précéden-

tes, dans lequel les déflecteurs comprennent une bague de renforcement externe ayant une épaisseur supérieure à l'épaisseur de la plaque métallique.

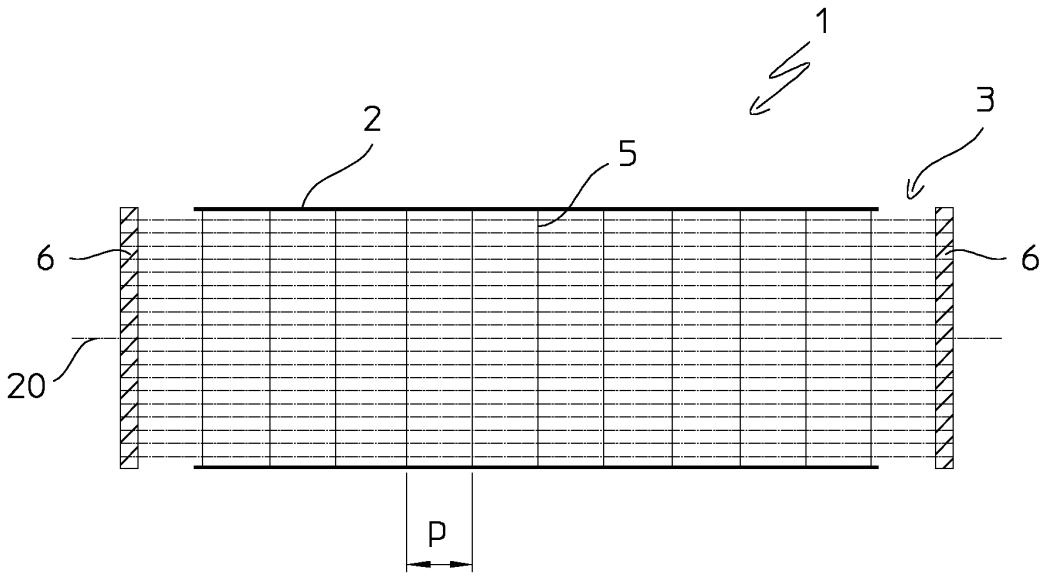


Fig.1

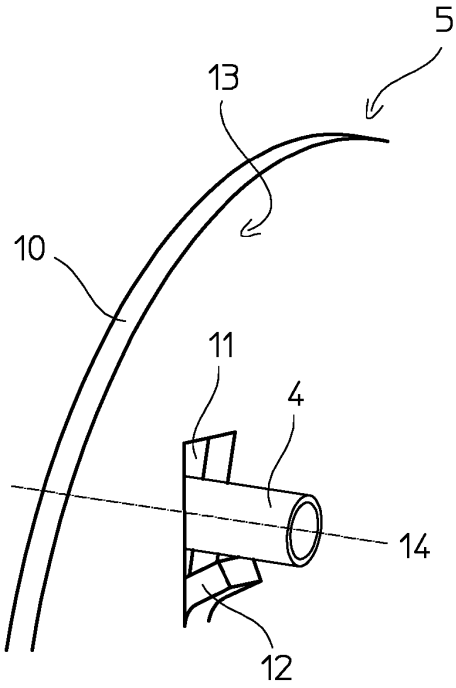


Fig.2

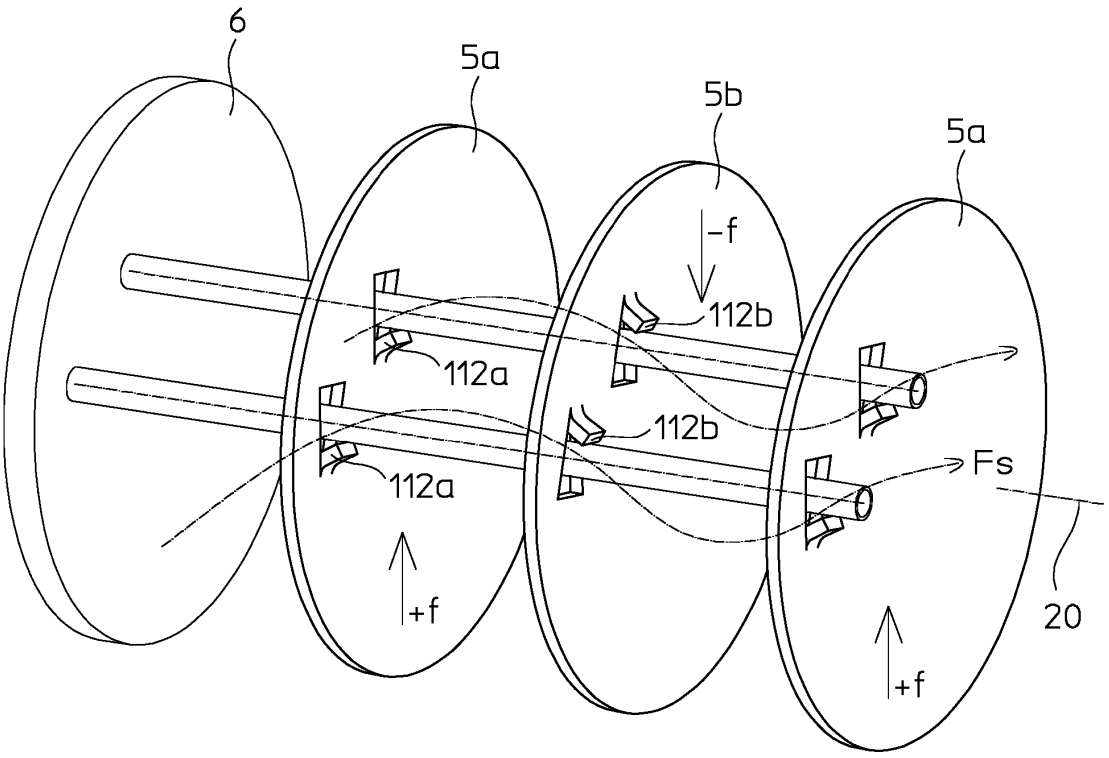

6
5a
5b
5a
-f
112b
112a
112b
112a
Fs
+f
20
+f

Fig.3

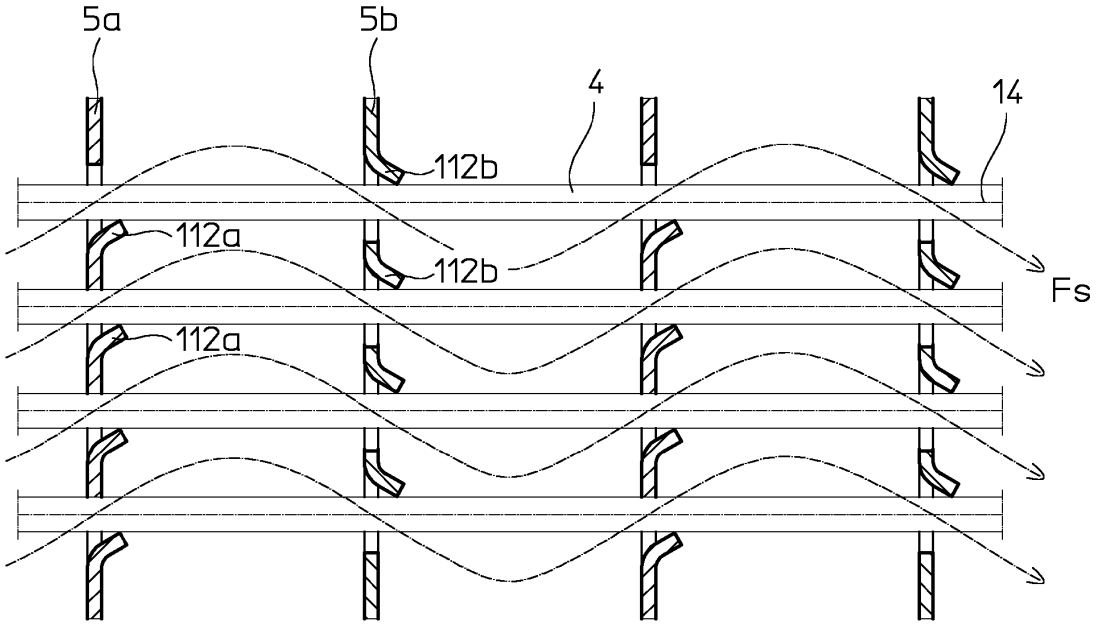

5a
5b
4
14
112b
112a
112b
Fs
112a

Fig.4

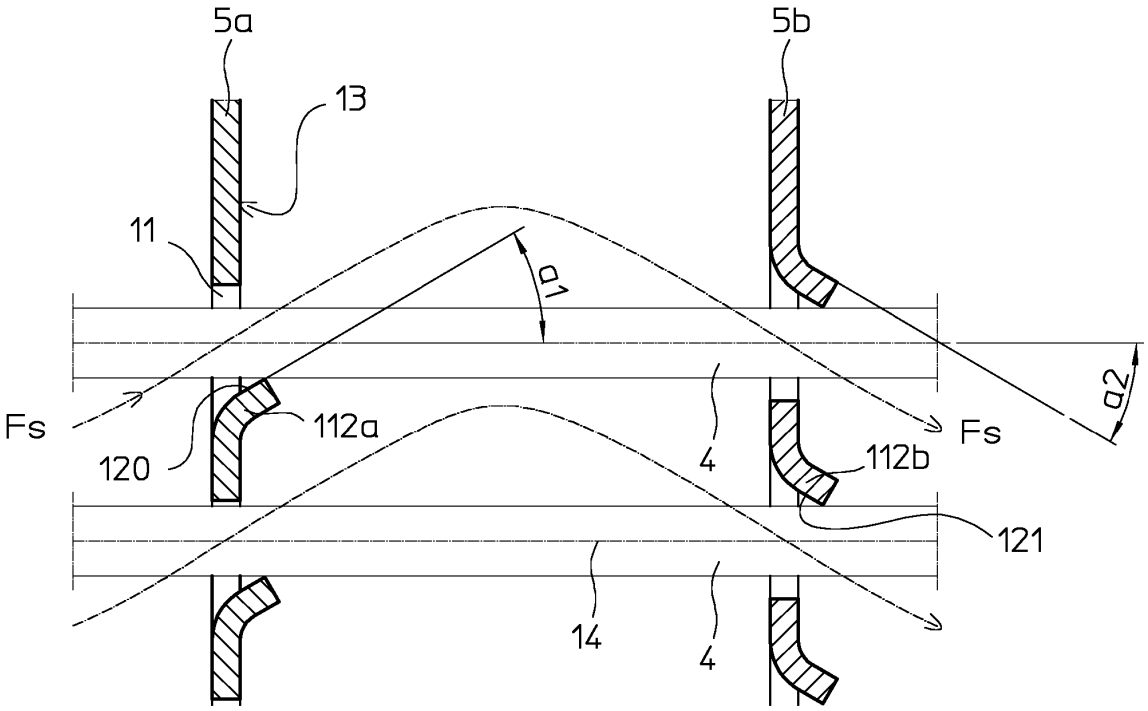
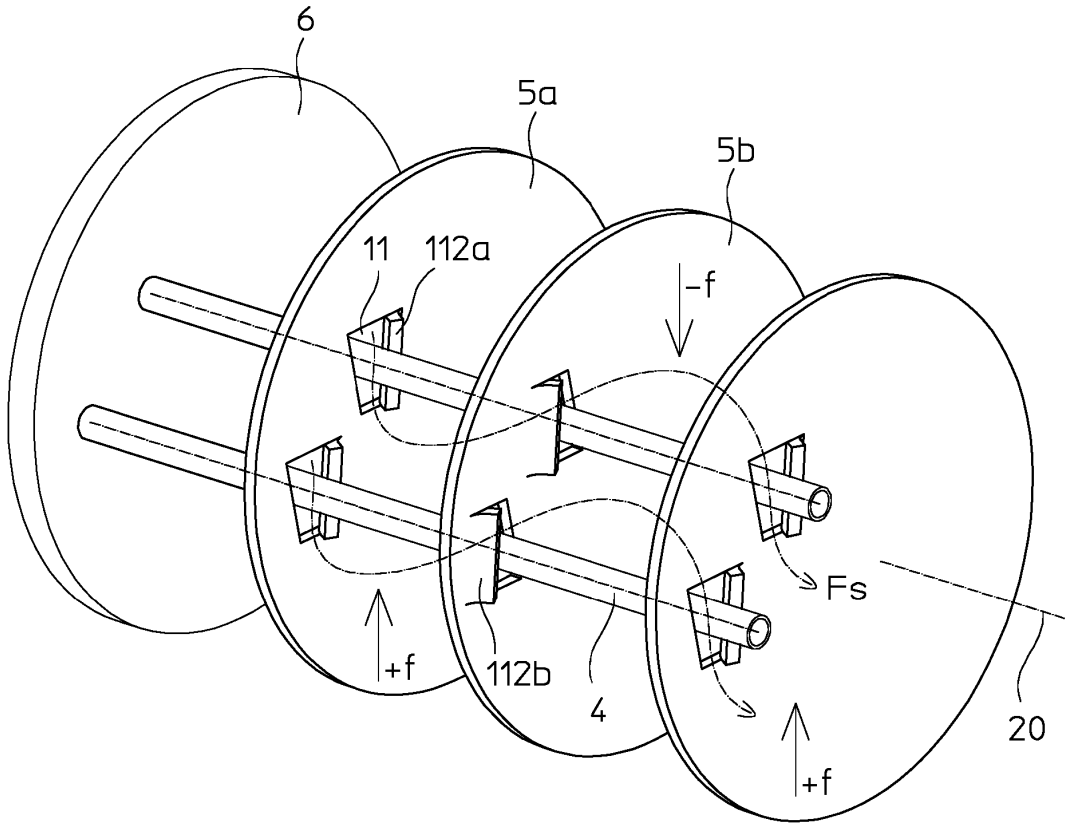

5a
5b
13
11
a1
a2
Fs
120
112a
4
112b
Fs
121
14
4

Fig.5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5a
5b
11
112a
-f
Fs
+f
112b
4
20
+f

Fig.6

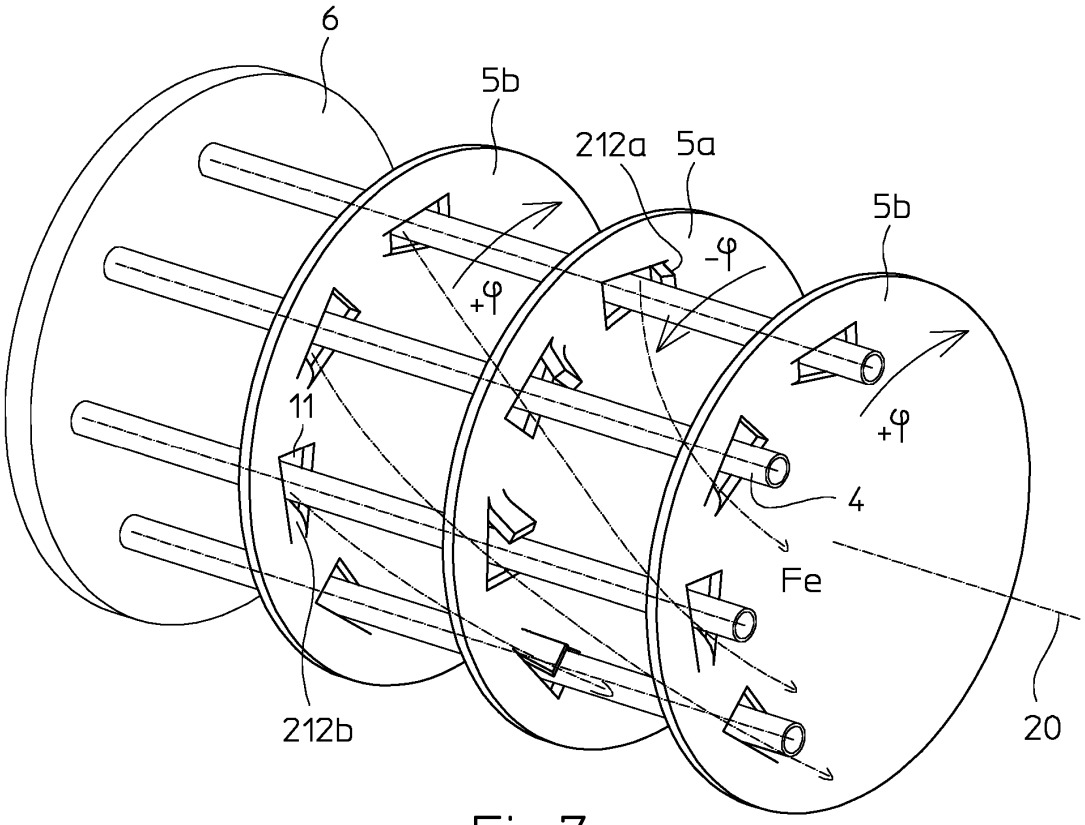
6
5b
212a
5a
5b
-φ
+φ
11
+φ
4
Fe
212b
20

Fig.7

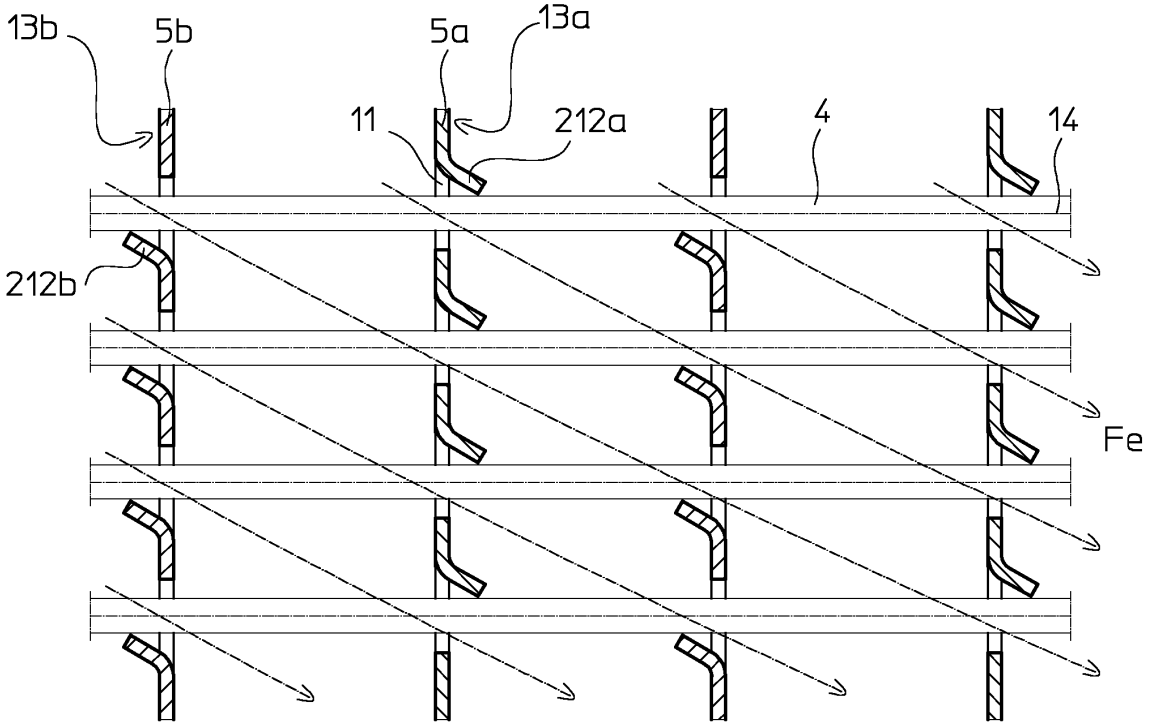
13b
5b
5a
13a
11
212a
4
14
212b
Fe

Fig.8

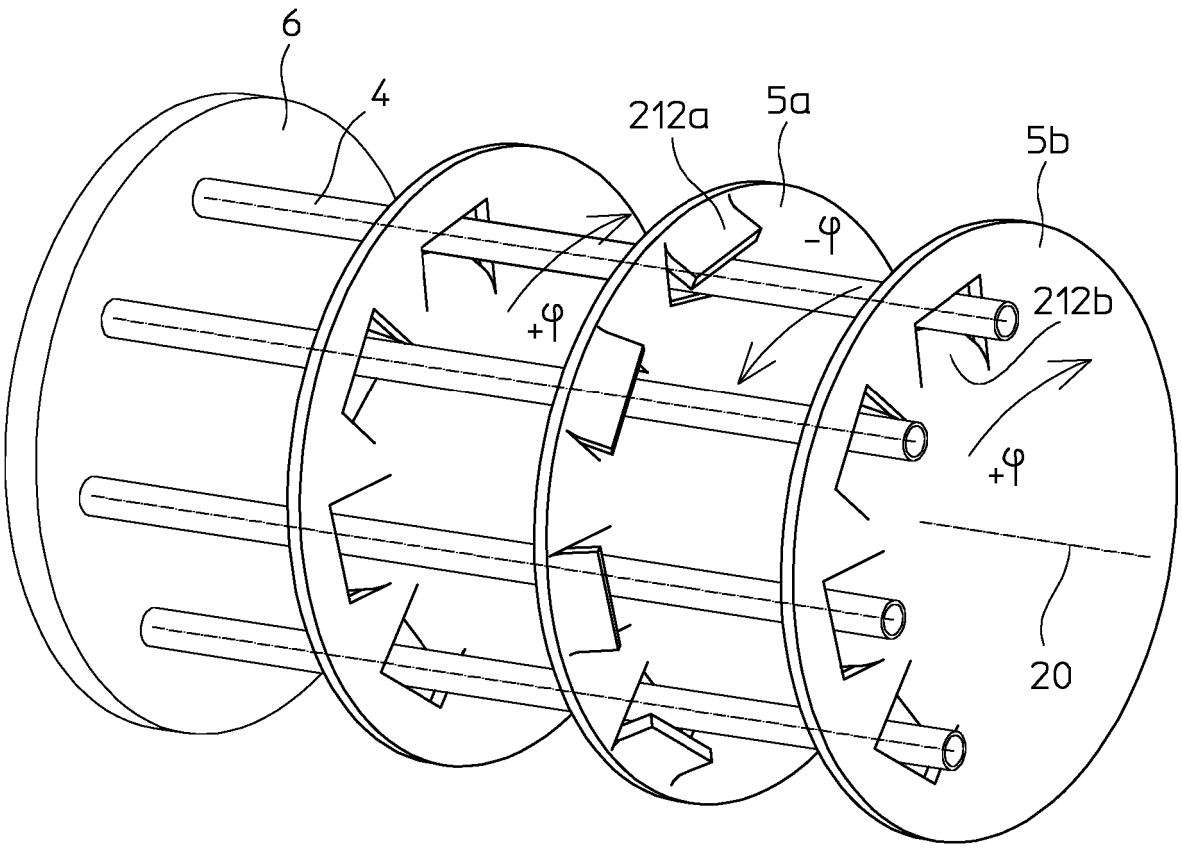

Fig.9

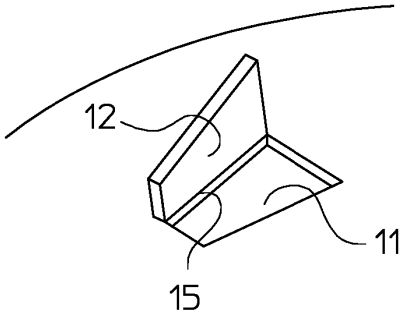

Fig.10

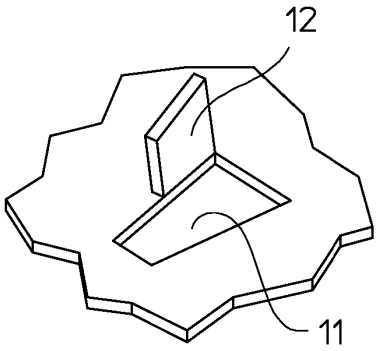

Fig.11

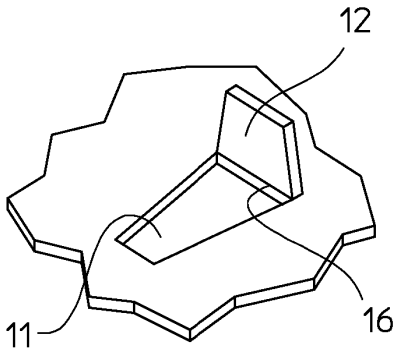

Fig.12

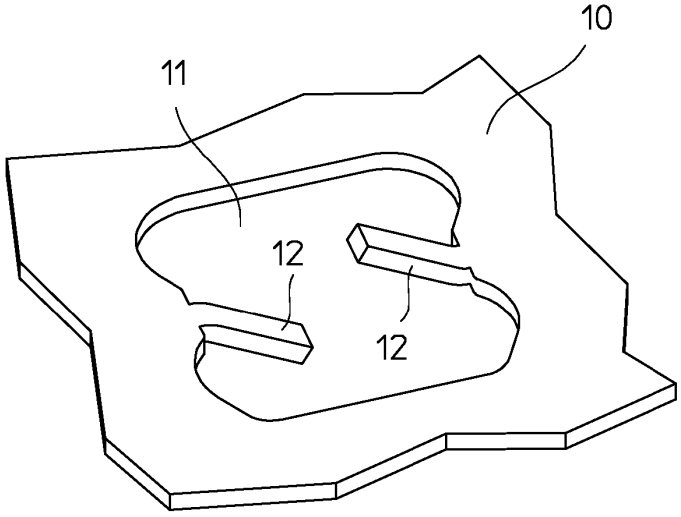

Fig.13

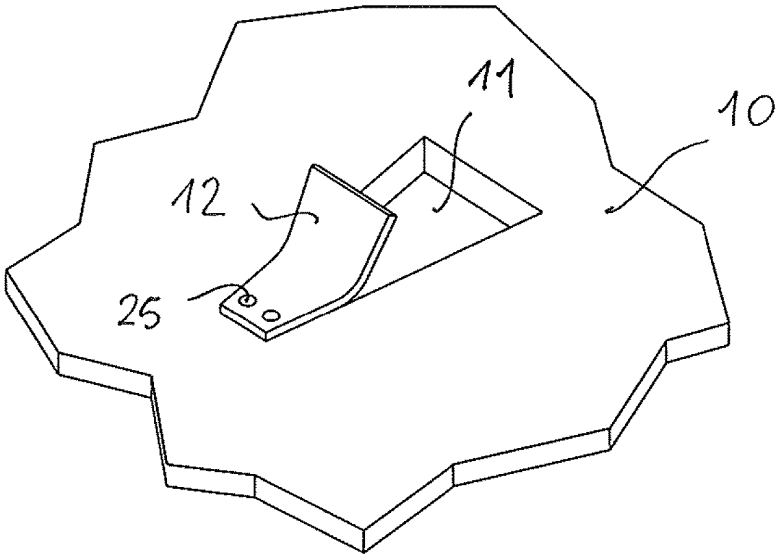

Fig.14

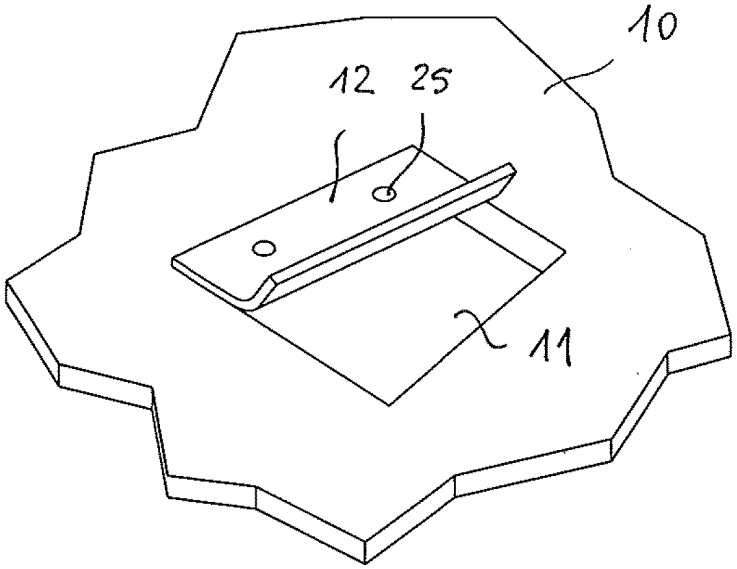

Fig.15

REFERENCES CITED IN THE DESCRIPTION

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