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(54) **GAS COOLER FOR HEAT TRANSFER BY CONVECTION.**

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Description

The invention relates to a gas cooler for cooling a flow of gas, mainly by convection, e.g. for cooling gas directly downstream of a radiation cooler receiving gas from a gasification reactor for the gasification of solids, said gas cooler comprising an oblong vertically positioned pressure vessel with an upper gas inlet and a lower gas outlet and, located inside the vessel a heat exchange element with heat exchange surfaces for throughflow of water and steam under high pressure, said heat exchange surfaces forming between them substantially vertically extending gas ducts extending substantially throughout the length of the vessel.

Such a gas cooler is known, for example, from EP-A-0 223 912.

The gas discharging from such a gas reactor may have a pressure of about 30 bar and a temperature in the range of 1400°C or more, and the gas generally entrains liquid ash. In view of a subsequent washing of the gas, this is being cooled to about 200°C in several steps, The initial cooling may e.g. be effected by means of a radiation cooler and in the following step the cooling is effected by means of a convection cooler of the above mentioned type.

In order to obtain the highest possible efficiency of the plant producing the gas and in which the gas is possibly later on utilized, it is necesary to reuse the heat extracted from the gas by the cooling in the convection cooler. This is done by running water and steam through the heat exchange element in the cooler in a two-phase flow under high pressure, following which the steam is separated and utilized in an associated steam turbine plant.

EP-A-0 223 912 describes a cooler of the above mentioned type containing several vertical, parallel membrane walls acting as heat exchange surfaces for cooling the gas by radiation and a tube bundle running across and through the membrane walls and acting as heat exchange surface for cooling the gas by convection.

The gas flowing into the cooler contains solid slag particles which due to the temperature of the material at the inlet behave as "soft" or "humid" particles having a tendency to adhere to the heat exhange walls and accumulate in the gas ducts. Prior coolers are therefore provided with vertically extending gas ducts so that the ash particles under the influence of the gas flow and by gravity may drop directly down towards the bottom of the vessel. The gas temperature is here substantially lower and the ash particles now behave as "hard" and "dry" particles, which by the flow of gas are carried along through the gas outlet. Due to this design of the gas ducts the flow of gas in each duct is a parallel flow. This means that the gas has merely an insignificant velocity component in the direction transversely to the duct, resulting in that the gas flowing down along the heat exchange surfaces, i.e. along the sides of the duct, is being cooled faster than the gas flowing down into the middle of the duct. Thus, a temperature gradient occurs in the gas flow transversely to its direction, thereby offering a smaller effective heat transfer than if the gas flow had the same temperature across the entire cross-sectional area of the gas duct.

It is the object of the invention to provide a gas cooler of the above mentioned type with gas ducts and heat exchange walls designed so as to ensure a uniform distribution of the gas temperature across the cross-section of the duct in the majority of the gas ducts while preventing ash particles from accumulating in the ducts or adhering to the heat exchange walls.

In accordance with a first aspect of the invention this object is solved with the gas cooler of the generic kind in that most of the gas ducts are individually divided into several spaced apart, straight sections, that the transition between two consecutive, straight sections is constituted by at least one short, straight duct section which, when viewed in the direction of the gas flow, is sloping towards the lower end of the vessel, and that the duct at the lower end of the sloping duct section is displaced laterally at a distance corresponding to the width of the duct.

The gas flow is hereby subjected to an abrupt change in direction which forces a mixing of the gas flow, thereby equalizing the gas temperature across the cross-sectional area of the duct.

By dividing each duct into a number of straight sections separated by short sections in which the duct abruptly changes its direction, it is ensured that the gas flow is mixed before it has time to develop into a parallel flow.

As the transition between two straight duct sections is constituted by at least one short straight duct section which, when viewed in the direction of the gas flow, is sloping towards the lower end of the vessel, possibly deposited particles will easily be swept away by the flow of gas due to locally increasing gas velocity in the duct. By displacing the duct sidewise by a distance corresponding to the width of the duct, a supplementary security against accumulation of gas-borne solid particles in the sloping section of the duct is obtained, because the gas flowing along the inner wall of the duct, when viewed in relation to the change in direction, continues straight ahead at the location of the transition and hits the opposite duct wall so that possibly accumulated solid particles are swept away. This design of the gas duct in which the layer of gas flowing down along the first duct wall is passed directly into the layer of gas flowing along the second duct wall, results in a very strong mixing of the gas flow across the total cross-setion of the duct, resulting in the above described equalization of the temperature across the cross-section.

The gas cooler according to a second aspect of the invention is characterized in that most of the gas ducts are individually divided into several spaced apart, straight sections, that the transition between two consecutive, straight sections is constituted by at least one short, straight duct section which, when viewed in the direction of the gas flow, is sloping towards the lower end of the vessel and a second short, straight duct section which, when viewed in the direction of the gas flow, is sloping towards the lower end of the vessel, and in that the duct at the lower end of the second, inclining duct section is aligned with the vertically extending duct section immediately upstream of the first, sloping duct section.

This design of the gas ducts allows all straight duct sections in each individual duct to be aligned with each other. This brings about a more efficient utilization of the vessel volume by preventing the occurrence of unutilized spaces in the vessel due to repeated displacements of the ducts to one side.

An embodiment of the gas cooler is characterized in that the heat exchange surfaces at one end are connected with a common inlet header for water and steam, and at the other end with a common discharge header and that either the inlet header or the discharge header is suspended in the vessel, thereby also carrying the full load of the heat exchange element, while at the end of the heat exchange element opposite to the end at which it is suspended there are guides limiting the movement of the heat exchange element in the radial direction. The common discharge header may for instance be suspended at the upper end plate or may be supported by seats fastened by welding at the top of the shelf. As the full load of the heat exchange element in the vertical position of the vessel is carried by the common discharge header it is only necessary to guide the heat exchange element at the bottom so as to be movable in the longitudinal direction to cater for the thermal expansion. The frequently complicated and bulky stiffeners used in prior coolers may thus be avoided. This embodiment presents the further advantage that the maintenance of the heat exchange element is facilitated, since it may be removed as a unit from the vertical vessel after the top of the vessel has been dismounted.

A preferred embodiment is characterized in that the heat exchange surfaces are made as welded membrane walls, and that the membrane walls in the transition areas between consecutive, vertically extending duct sections are bent into shape after the welding has been accomplished.

In view of the fact that the lateral displacement of the ducts merely corresponds to a single duct width, it is possible to design the heat exchange surfaces as membrane walls which after the welding has been accomplished are bent into shape, thereby obtaining the advantage of reducing the costs of manufacture and mounting.

A further embodiment is characterized in that an independent heat exchanger with separate inlets and outlets for coolant is installed in one of the vertically extending ducts.

As the heat exchange element in the gas cooler operates as a compact steam boiler it is advantageous to install one or more of the other heat exchangers generally forming part of a steam boiler plant in the pressure vessel, e.g. a superheater or an economiser, with the view of completely utilizing the volume of the vessel and of obtaining simultaneously an improved efficiency of the entire plant of which the gas cooler forms part.

The invention will now be explained in detail by some embodiments and with reference to the drawings, in which

Fig. 1 is a somewhat schematic longitudinal section of a convection cooler according to the invention,

Fig. 2 is a section along line II-II in Fig. 1,

Fig. 3 is a somewhat schematic partial view of a second embodiment of the cooler,

Fig. 4 is a partial view as Fig. 3 of a third embodiment of the cooler,

Fig. 5 is a partial view as Fig. 3 of a fourth embodiment of the cooler, and

Figs 6 to 7 are partial views as Fig. 3 of other embodiments of the cooler, illustrating inserted separate heat exchangers.

The convection cooler illustrated in the drawings consists of an oblong, circular-cylindrical pressure vessel 1 with a shell 2 and provided at the top and at the bottom with end plates 3 and 4, respectively. The upper end plate 3 includes a pipe stub 5 for connection with a conduit, not shown, for the supply of hot gas to the convection cooler. The upper portion of the shell 2 and the end plate 3 have on their inside face a thermal insulation 6 to protect against heat impact from the gas. Closely above the lower end plate 4 the shell accommmodates a pipe stub 8 for the discharge of cooled gas from the convection cooler.

As illustrated in Figs 1 and 2 the vessel includes a heat exchange element 10, divided into a number of vertically extending heat exchange surfaces 11. Substantially vertically extending gas ducts 12 are thus formed between the heat exchange surfaces. In respect of clarity, the heat exchange surfaces are only shown in a single line and parts of the heat exchange surfaces located in Fig. 1 behind the sectional plane and in Fig. 2 below the sectional plane, are not shown.

As it appears from Fig. 1 most of the gas ducts are individually divided into a number of straight, spaced apart sections and the transition between two consecutive straight sections 13 is constituted by at least one short straight duct section 14 which, when viewed in the direction of the gas flow, slopes towards the lower end of the vessel. The duct section

13 at the lower end of the sloping duct section 14 is displaced sidewise in most of the ducts at a distance corresponding to the width of the duct of the straight duct section 13 located immediately above.

In the embodiment illustrated in Fig. 1 all of the heat exchange surfaces, except the central one, are provided with three vertically extending straight sections, while the central heat exchange surface includes four vertically extending straight sections to obtain a more uniform and symmetrical gas flow. The duct width of the majority of the ducts is substantially constant, while in this embodiment there are two duct sections in the middle of the heat exchanger where the duct width is somewhat larger than in the remaining ducts.

As illustrated in Fig. 2, the heat exchange element also includes heat exchange surfaces 15 which seal ducts 13 on the side facing the vessel shell, and the resulting spaces occurring between the heat exchange surfaces and the shell may for instance be filled in with insulating material, on one hand, to minimize the thermal loss to the environment and, on the other hand, to prevent slag particles from accumulating in the sometimes narrow passages.

The heat exchange surfaces 11 and 15 are connected at the bottom with a common inlet header 17 for water and steam and at the top with a common discharge header 18. The common discharge header 18 is suspended in the upper portion of the vessel, e.g. by means of a roughly shown suspension 19 so that the common discharge header 18 carries the full load of the heat exchange element 10. Inlet header 17 may be supported, in a manner not shown, against brackets on the vessel shell 2 or the end plate 4, in such a way that its movement in the radial direction is restricted, while movement in the longitudinal direction of the vessel takes place unimpededly to cater for the thermal expansion of the heat exchange element. In a second embodiment the lower discharge header 17 may be supported on brackets secured to the shell or the end plate, and the discharge header 18 must in this case be guided so that it can only move in the longitudinal direction of the vessel to cater for the necessary thermal expansion. The weight of the heat exchange element 10 is in this case supported by the brackets at the bottom of the vessel.

Figs 3 and 4 schematically show the course of the gas ducts in other embodiments of the convection cooler according to the invention. In Fig. 3 all of the gas ducts are displaced to the same side at the transition between straight sections 13, and it will be seen that in this manner areas occur in the vessel which are not completely utilized as gas passages. The areas give an unsymmetrical distribution of the heat load on the cooler and this has been compensated for by the embodiment according to Fig. 4, in which the heat exchange element as a whole is somewhat inclined in relation to the longitudinal axis of the vessel.

Fig. 5 illustrates a preferred embodiment of the gas cooler in which there is provided, at the downwards facing end of some of the short, straight duct sections 14, another short, straight duct section 20 which, when viewed in the direction of the gas flow, is sloping towards the bottom of the vessel. The sloping duct section 20 has such a length that duct section 13 at the lower end of duct section 20 is in alignment with the vertically extending duct section 13 immediately upstream of the first sloping duct section 14.

Fig. 6 illustrates an embodiment corresponding to the one shown in Fig. 3, but in which separate heat exchangers 21 and 22 are inserted in the unutilized spaces in the vessel. These heat exchangers may for instance be superheaters or preheaters forming part of the steam plant associated with the cooler. Fig. 7 shows a further embodiment in which the heat exchangers 21 and 22 are positioned in the centre of the pressure vessel, the gas ducts being at the sides displaced symmetrically towards the centre, when viewed in the direction of the gas flow.

The heat exchange surfaces are designed as welded membrane walls and the changes in direction of the walls are obtained by bending them to shape after finished welding.

Soot blowers and mechanical vibration members are accommodated within the pressure vessel with the view of cleaning the heat exchange surfaces. If the heat exchange element 10 is suspended at the top of the vessel it is advantageous to arrange the mechanical vibration members at the bottom of inlet header 17 which is guided but still allowed to move somewhat, thereby ensuring that the vibration members have the highest possible effect. The soot blowers are most advantageously arranged at the top of the vessel from where they are directed downwards into the individual gas ducts.

Claims

1. A gas cooler for cooling a flow of gas, mainly by convection, e.g. for cooling gas directly downstream of a radiation cooler receiving gas from a gasification reactor for the gasification of solids, said gas cooler comprising an oblong vertically positioned pressure vessel (1) with an upper gas inlet (5) and a lower gas outlet (8), and located inside the vessel (1) a heat exchange element (10) with heat exchange surfaces (11) for throughflow of water and steam under high pressure, said heat exchange surfaces (11) forming between them substantially vertically extending gas ducts (12) extending substantially throughout the length of the vessel (1), characterized in that most of the gas ducts (12) are individually divided into several spaced apart, straight sections (13),

that the transition between two consecutive, straight sections is constituted by at least one short, straight duct section (14) which, when viewed in the direction of the gas flow, is sloping towards the lower end of the vessel (1) and that the duct (12) at the lower end of the sloping duct section (14) is displaced laterally at a distance corresponding to the width of the duct.

2. A gas cooler for cooling a flow of gas, mainly by convection, e.g. for cooling gas directly downstream of a radiation cooler receiving gas from a gasification reactor for the gasification of solids, said gas cooler comprising an oblong vertically positioned pressure vessel (1) with an upper gas inlet (5) and a lower gas outlet (8), and located inside the vessel (1) a heat exchange element (10) with heat exchange surfaces (11) for throughflow of water and steam under high pressure, said heat exchange surfaces (11) forming between them substantially vertically extending gas ducts (12) extending substantially throughout the length of the vessel (1), characterized in that most of the gas ducts (12) are individually divided into several spaced apart, straight sections (13), that the transition between two consecutive, straight sections is constituted by at least one short, straight duct section (14) which, when viewed in the direction of the gas flow, is sloping towards the lower end of the vessel (1) and a second short, straight duct section (20) which, when viewed in the direction of the gas flow, is sloping towards the lower end of the vessel, and in that the duct (12) at the lower end of the second, inclining duct section (20) is aligned with the vertically extending duct section (13) immediately upstream of the first, sloping duct section (14).

3. A gas cooler as claimed in claim 1 or 2, characterized in that the heat exchange surfaces (11) at one end are connected with a common inlet header (17) for water and steam, and at the other end with a common discharge header (18) and that either the inlet header (17) or the discharge header (18) is suspended in the vessel (1), thereby also carrying the full load of the heat exchange element (10), while at the end of the heat exchange element (10) opposite to the end at which it is suspended there are guides limiting the movement of the heat exchange element (10) in the radial direction.

4. A gas cooler as claimed in any of the preceding claims, characterized in that the heat exchange surfaces (11) are made as welded membrane walls, and that the membrane walls in the transition areas (14, 20) between consecutive, vertically extending duct sections (13) are bent into shape after the welding has been accomplished.

5. A gas cooler as claimed in any of the preceding claims, characterized in that an independent heat exchanger (21, 22) with separate inlets and outlets for coolant is installed in one of the vertically extending ducts (12).

6. A gas cooler as claimed in any of the preceding claims, characterized in that it is provided with soot blowers, preferably at the upper end of the heat exchange element (10), and mechanical vibration members, preferably at that end of the heat exchange element (10) that is opposite the end at which it is suspended.

Patentansprüche

1. Gaskühler zur Kühlung eines Stroms von Gas, hauptsächlich durch Konvektion, z.B. zur Kühlung von Gas direkt stromabwärts eines Strahlungskühlers, der Gas aus einem Vergasungsreaktor für die Vergasung fester Stoffe empfängt, umfassend einen länglichen senkrecht plazierten Druckbehälter (1) mit einem oberen Gaseinlaß (5) und einem unteren Gasauslaß (8), ein im Behälter (1) angeordnetes Wärmeaustauschelement (10) mit Wärmeaustauschflächen (11) für den Durchfluß von Wasser und Wasserdampf unter hohem Druck, wobei erwähnte Wärmeaustauschflächen (11) untereinander im wesentlichen senkrecht laufende Gaskanäle (12) bilden, die sich größtenteils über die ganze Länge des Behälters (1) erstrecken, dadurch gekennzeichnet, daß der Großteil der Gaskanäle (12) in mehrere voneinander getrennte geradlinige Abschnitte (13) aufgeteilt ist, und daß der Übergang zwischen zwei nacheinander folgenden geradlinigen Abschnitten aus mindestens einem kurzen, geradlinigen Abschnitt (14) besteht, der, in der Richtung des Gasstroms gesehen, gegen den unteren Teil des Behälters neigt, und daß der Kanal bei dem unteren Teil des abfallenden Kanalabschnittes (14) in der Seitenrichtung in einem Abstand versetzt ist, der der Breite des Kanals entspricht.

2. Gaskühler zur Kühlung eines Stroms von Gas, hauptsächlich durch Konvektion, z.B. zur Kühlung von Gas direkt stromabwärts eines Strahlungskühlers, der Gas aus einem Vergasungsreaktor für die Vergasung fester Stoffe empfängt, umfassend einen länglichen senkrecht plazierten Druckbehälter (1) mit einem oberen Gaseinlaß (5) und einem unteren Gasauslaß (8), ein im Behälter (1) angeordnetes Wärmeaustauschelement (10) mit Wärmeaustauschflächen (11) für

den Durchfluß von Wasser und Wasserdampf unter hohem Druck, wobei erwähnte Wärmeaustauschflächen (11) untereinander im wesentlichen senkrecht laufende Gaskanäle (12) bilden, die sich größtenteils über die ganze Länge des Behälters (1) erstrecken, dadurch gekennzeichnet, daß der Großteil der Gaskanäle (12) in mehrere voneinander getrennte geradlinige Abschnitte (13) aufgeteilt ist, daß der Übergang zwischen zwei nacheinander folgenden geradlinigen Abschnitten aus mindestens einem kurzen geradlinigen Abschnitt (14), der, in der Richtung des Gasstroms gesehen, gegen den unteren Teil des Behälters neigt, und einem zweiten kurzen geradlinigen Kanalabschnitt (20), der, in der Richtung des Gasstroms gesehen, gegen den unteren Teil des Behälters schräg ist, besteht, und daß der Abschnitt (12) bei dem unteren Teil des zweiten abfallenden Kanalabschnitts (20) mit dem senkrecht laufenden Kanalabschnitt (13) unmittelbar stromaufwärts des ersten abfallenden Kanalabschnitts (14) fluchtet.

3. Gaskühler nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß die Wärmeaustauschflächen (11) an einem Ende mit einem gemeinsamen Einlaßkasten (17) für Wasser und Wasserdampf und am anderen Ende mit einem gemeinsamen Auslaßkasten (18) verbunden sind, und daß entweder der Einlaßkasten (17) oder der Auslaßkasten (18) im Behälter (1) aufgehängt ist und damit auch das volle Gewicht des Wärmeaustauschelementes (10) trägt, während beim im Verhältnis zum das Element tragenden Ende entgegengesetzten Ende Leitstangen vorgesehen sind, die die Bewegung des Wärmeaustauschelementes (10) in der Radialrichtung begrenzen.

4. Gaskühler nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Wärmeaustauschflächen (11) aus zusammengeschweißten Membranwänden bestehen, und daß die Membranwände in den Übergangsbereichen (14, 20) zwischen nacheinander folgenden, senkrecht verlaufenden Kanalabschnitten (13) nach dem Schweißen in Form gebogen sind.

5. Gaskühler nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß ein unabhängiger Wärmeaustauscher (21, 22) mit getrennten Ein- und Ausläßen für Kältemittel in einem der senkrecht verlaufenden Kanäle (12) eingebaut ist.

6. Gaskühler nach einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß Rußgebläse, vorzugsweise beim oberen Teil des Wärmeaustauschelementes (10), und mechanische Vibrationsorgane, vorzugsweise beim im Verhältnis zum das Element tragenden Ende entgegengesetzten Ende vorgesehen sind.

Revendications

1. Refroidisseur de gaz pour refroidissement d'un courant gazeux, essentiellement par convection, par exemple refroidissement de gaz directement en aval d'un refroidisseur par rayonnement, recevant les gaz d'un réacteur de gazéification de solides, ledit refroidisseur de gaz comprenant un récipient oblong (1), résistant à la pression, placé verticalement avec une entrée (5) de gaz dans le haut et une sortie (8) de gaz dans le bas, un élément échangeur de chaleur (10) étant logé dans le récipient et comportant des surfaces (11) d'échange de chaleur au passage d'un écoulement d'eau et de vapeur sous haute pression, lesdites surfaces (11) d'échange de chaleur formant entre elles des conduits essentiellement verticaux de gaz (12) qui s'étendent essentiellement sur toute la longueur du récipient (1), **caractérisé** en ce que la plupart des conduits de gaz (12) sont individuellement divisés en plusieurs sections rectilignes (13) mutuellement espacées et que la transition entre deux sections rectilignes consécutives est constituée par au moins une courte section rectiligne de conduit (14) qui considérée dans le sens de l'écoulement gazeux, va en s'inclinant vers l'extrémité inférieure du récipient (1), le conduit (12) à l'extrémité inférieure de la section de conduit inclinée (14) étant décalé latéralement d'une distance correspondant à la largeur du conduit.

2. Refroidisseur de gaz pour refroidissement d'un courant gazeux, essentiellement par convection, par exemple refroidissement de gaz directement en aval d'un refroidisseur par rayonnement, recevant les gaz d'un réacteur de gazéification de solides, ledit refroidisseur de gaz comprenant un récipient oblong (1), résistant à la pression, placé verticalement avec une entrée (5) de gaz dans le haut et une sortie (8) de gaz dans le bas, un élément échangeur de chaleur (10) étant logé dans le récipient et comportant des surfaces (11) d'échange de chaleur au passage d'un écoulement d'eau et de vapeur sous haute pression, lesdites surfaces (11) d'échange de chaleur formant entre elles des conduits essentiellement verticaux de gaz (12) qui s'étendent essentiellement sur toute la longueur du récipient (1), **caractérisé** en ce que la plupart des conduits de gaz (12) sont individuellement divisés en plusieurs sections rectilignes (13) mutuellement espacées et que la transition entre deux sections rectilignes consé-

cutives est constituée par au moins une courte section rectilignes de conduit (14) qui, considérée dans le sens de l'écoulement gazeux, va en s'inclinant vers l'extrémité inférieure du récipient (1), et une seconde courte section rectiligne de conduit (20) qui, considérée dans le sens de l'écoulement gazeux, va en s'inclinant vers le bas du récipient, le conduit (12) à l'extrémité inférieure de la seconde section inclinée de conduit (20) étant aligné avec la section verticale de conduit (13) située immédiatement en amont de la première section inclinée de conduit (14).

3. Refroidisseur de gaz selon les revendications 1 ou 2, **caractérisé** en ce que les surfaces d'échange de chaleur (11) sont, à une extrémité, reliées à une tête commune d'entrée (17) d'eau et de vapeur et, à l'autre extrémité, reliées à une tête commune de sortie (18), la tête d'entrée (17) ou la tête de sortie (18) étant suspendue dans le récipient et supportant donc ainsi tout le poids de l'élément échangeur de chaleur (10), des guides de limitation du mouvement de l'élément échangeur de chaleur (10) dans le sens radial étant présents à l'extrémité opposée de l'élément échangeur de chaleur par rapport à celle où celui-ci est suspendu.

4. Refroidisseur de gaz selon une quelconque des revendications précédentes, **caractérisé** en ce que les surfaces d'échange de chaleur (11) sont constituées par des parois composées de tubes soudés et que ces parois, dans les zones de transition (14, 20) entre sections verticales consécutives de conduit (13) sont pliées en forme après que le soudage a été effectué.

5. Refroidisseur de gaz selon une quelconque des revendications précédentes, **caractérisé** par le fait qu'un échangeur de chaleur (21, 22) indépendant, avec entrées et sorties séparées pour agent de refroidissement, est installé dans un des conduits verticaux (12).

6. Refroidisseur de gaz selon une quelconque des revendications précédentes, **caractérisé** en ce qu'il est pourvu de dispositifs de soufflage de suie, de préférence à l'extrémité supérieure de l'élément échangeur de chaleur (10), et d'éléments de vibrage mécanique, de préférence à l'extrémité de l'élément échangeur de chaleur (10) opposée à celle où celui-ci est suspendu.

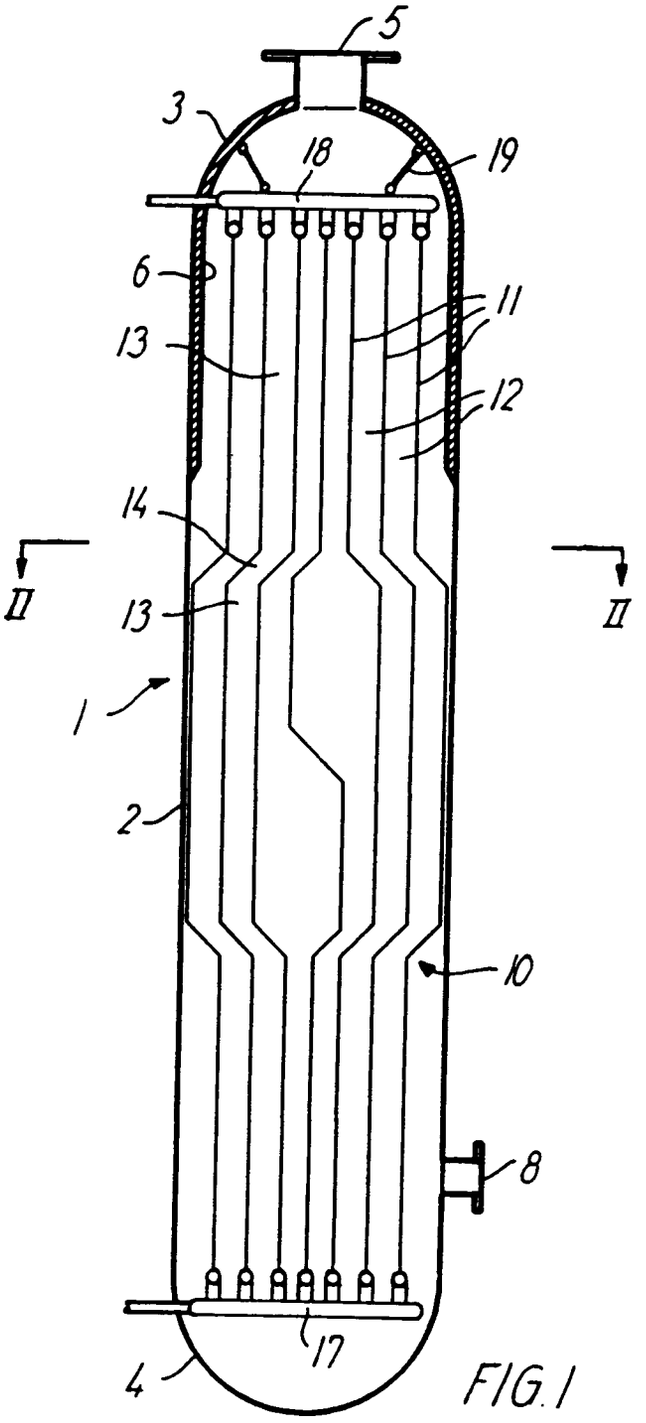


FIG.1

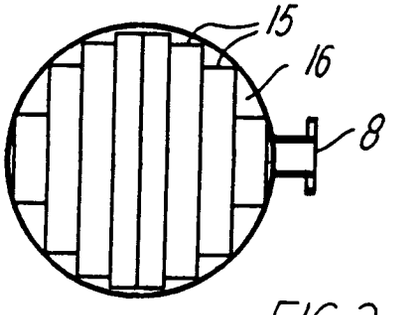


FIG.2

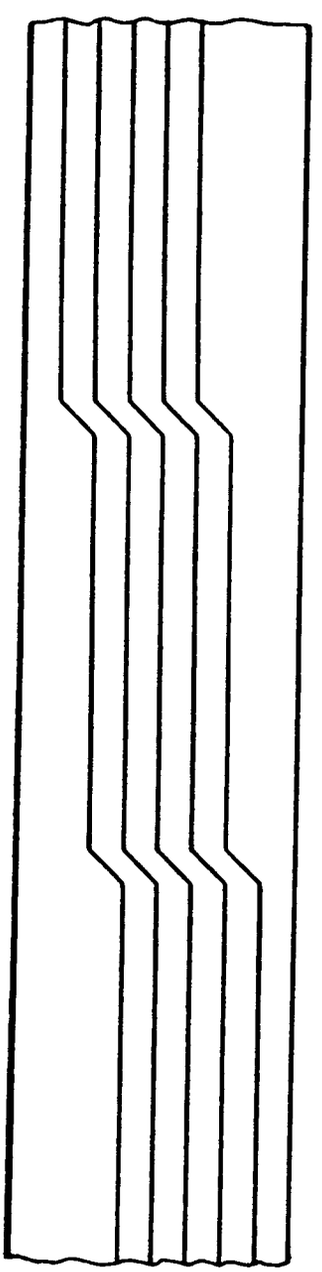


FIG. 3

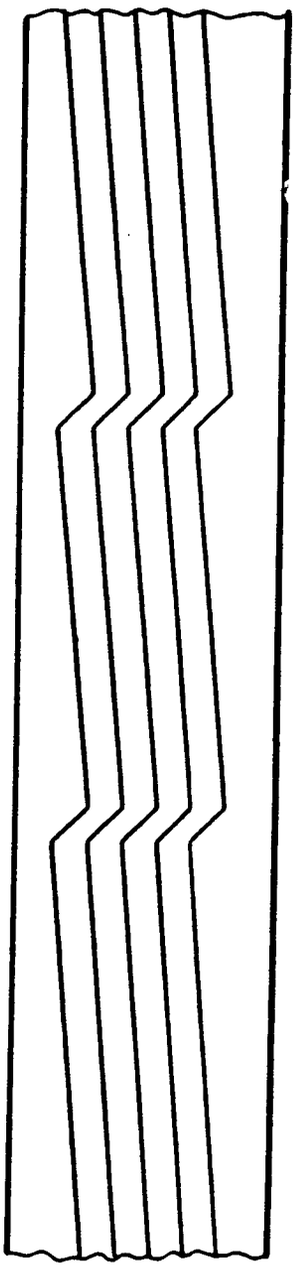


FIG. 4

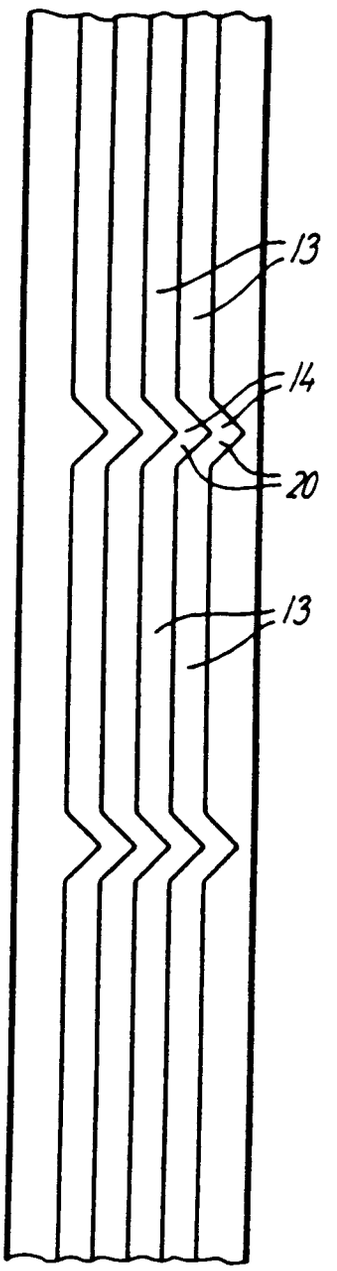


FIG. 5

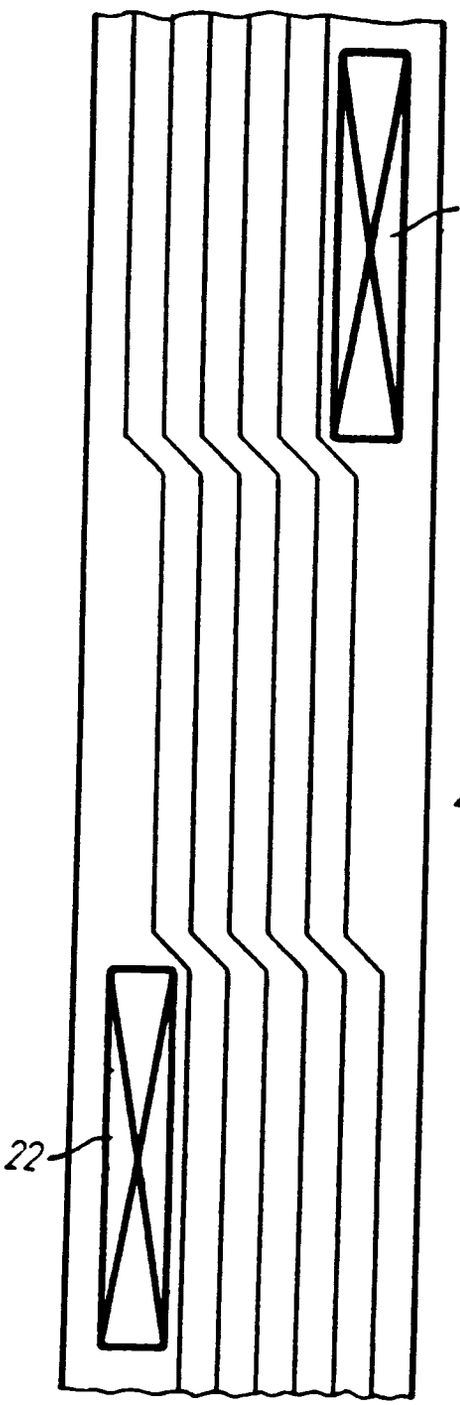


FIG.6

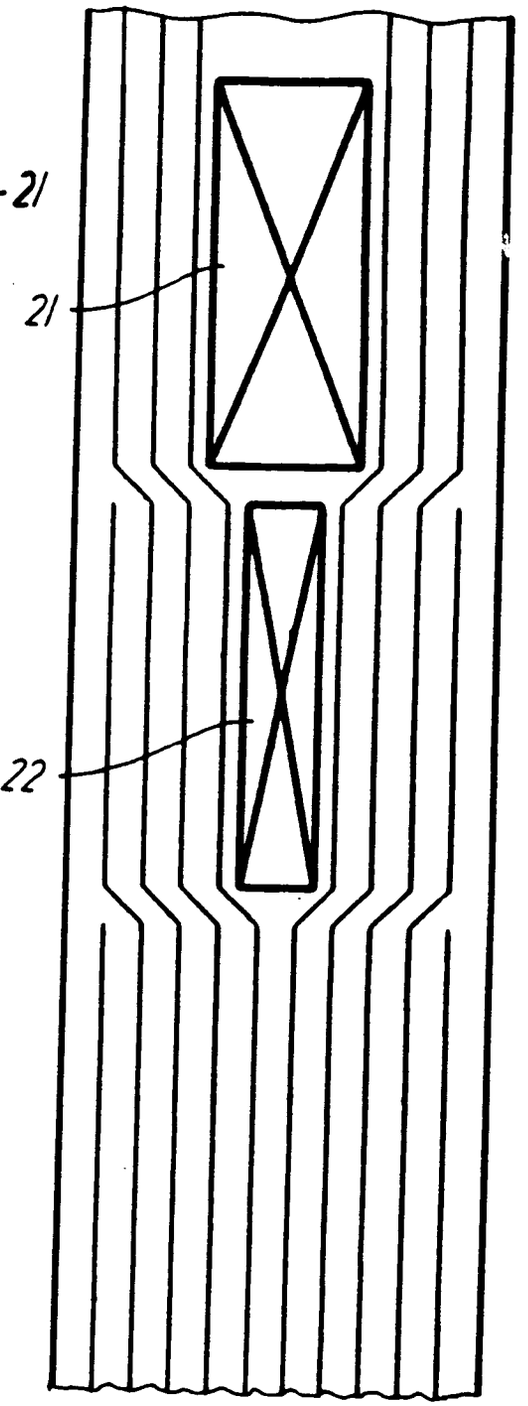


FIG.7