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## (54) Heat exchanger equipped with deflectors for optimised heat exchange

(57) Finned-tube heat exchanger, particularly for combined cycle power plants and the like, comprising a plurality of finned tubes (1) arranged in rows and flow deflectors (3) positioned between successive rows of said finned tubes (1), adjacent to said tubes, the distinctive feature of which consists in the fact that at least certain of said deflectors (3) comprise a plurality of vortex-generating elements (4) laid out on the surface of said deflectors (3), designed to generate vortexes with axes that are substantially parallel to the direction of flow of a fluid conveyed externally to pass over said finned tubes (1).

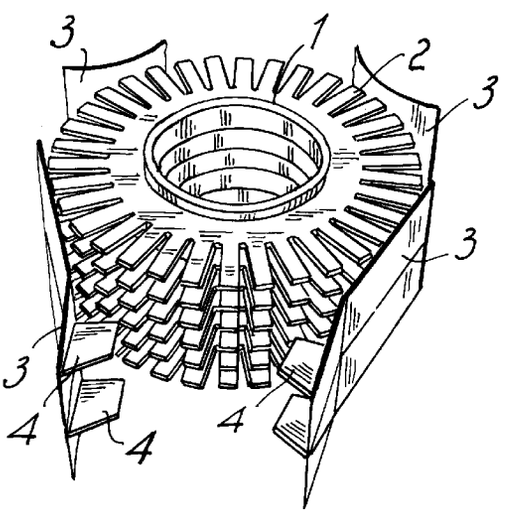


Fig. 1

EP 0 897 095 A2

## Description

**[0001]** The present invention relates to a heat exchanger equipped with deflectors for optimised heat exchange. More specifically, the invention concerns a heat exchanger for use in combined cycle power plants with primary generation using a gas turbine and secondary generation using a steam turbine fed by recovery boilers.

**[0002]** As it is known, the heat exchangers used, for example, in recovery boilers are formed by a plurality of finned tubes, disposed in line or in a staggered arrangement, within which runs a fluid to be heated or cooled, such as water or steam for example. The finned tube units are generally traversed longitudinally (or vertically in the case of vertical recovery boilers) by a hot fluid from which they receive heat by convection, or, in cases where one wants to cool the fluid contained in the finned tubes, the fluid passing over the tubes is it a lower temperature than that of the fluid present in the tubes.

**[0003]** In both cases, the requirements of a heat exchanger consist in the desire to reduce the dimensions and cost of the exchanger for the same heat exchanged and loss of pressure.

**[0004]** In particular, in the case of recovery boilers used in combined cycle power plants, where the fluid in the tubes is water/steam and the external fluid is combustion gas, it is necessary to increase the heat exchange coefficient on the gas side to increase the efficiency of the exchanger.

**[0005]** In order to achieve this object, heat exchangers have been designed featuring tubes equipped with fins that were initially solid and subsequently segmented.

**[0006]** However, it has been found that although achieving a considerable increase in thermal efficiency, the introduction of the fins is not totally satisfactory in that the field of motion generated across the plurality of finned tubes only causes adequate heat exchange in the lateral zones of adjacent tubes and the front portion of the tubes in the first row, while not, however, enabling similar efficiency in the rear portion of the tubes in relation to the direction of movement of the fluid.

**[0007]** Moreover, the situation deteriorates from as early as the second row of finned tubes given that the flow of fluid is partially obstructed by the tubes in the first row. Heat exchangers with fins that are offset from one another (rather than in line) have been designed for this reason to prevent the flow of fluid being obstructed before reaching the finned tubes located behind the first row.

**[0008]** A further solution for improving the heat exchange involves using deflectors that are located between adjacent finned tubes in order to convey the cooling or heating fluid so that it also laps the rear part of each finned tube.

**[0009]** An example of the use of deflectors can be found in United States patent No. 5,163,508. In this case too, although currently the best solution for increasing the thermal coefficient, the use of deflectors located between adjacent finned tubes does not solve the problem of improving the heat exchange in the region behind each finned tube if not by substantially and undesirably increasing the pressure drop.

**[0010]** The main aim of the present invention is therefore to provide a finned-tube heat exchanger that is equipped with deflectors having a special configuration designed to increase the heat exchange coefficient in the region of the finned tubes that normally receives a low quantity of the flow of fluid that passes over the fins of the tubes themselves.

**[0011]** Within the scope of this aim, an object of the present invention is to provide a finned-tube heat exchanger that is equipped with deflectors having a configuration that makes it possible to convert the flow of external fluid from a mainly laminar flow to a turbulent flow.

**[0012]** Another object of the present invention is to provide a finned-tube heat exchanger equipped with deflectors having a configuration that makes it possible, if desired, to decrease the heat exchange surface for the same heat exchange and loss of pressure.

**[0013]** A further but not last object of the present invention is to provide a heat exchanger that is both highly reliable and relatively easy to manufacture at competitive costs.

**[0014]** This aim, together with these and other objects that shall emerge more clearly hereinafter are achieved by a finned-tube heat heat exchanger, particularly for combined cycle power plants and the like, comprising a plurality of finned tubes arranged in rows and flow deflectors positioned between successive rows of said finned tubes, adjacent to said tubes, characterised by the fact that at least certain of said deflectors comprise a plurality of vortex-generating elements laid out on the surface of said deflectors, designed to generate vortexes with axes that are substantially parallel to the direction of flow of a fluid conveyed externally to pass over said finned tubes.

**[0015]** Further characteristics and advantages of the invention shall emerge more clearly from the description of a preferred but not exclusive embodiment of the heat exchanger as in the invention, illustrated by way of example and without limitation in the attached drawings, in which:

Fig. 1 is a view in perspective of one of the finned tubes with a partial view of deflectors positioned adjacent to the tubes in a heat exchanger according to the invention;

Fig. 2 is a plan view of the heat exchanger according to the invention, with the finned tubes arranged in rows;

Fig. 3 is a plan view of the heat exchanger according to the invention with the finned tubes laid out in a staggered arrangement;

Fig. 4 is a plan view of the heat exchanger accord-

ing to the invention with deflectors in a different embodiment from those in Fig. 1-3;

Fig. 5 is a partial view in perspective illustrating one of the deflectors of the heat exchanger according to the invention;

Fig. 6 is a side elevation of a different embodiment of one of the deflectors used in the heat exchanger according to the invention;

Fig. 7 is a partial view in perspective of one of the finned tubes of the heat exchanger according to the invention with a deflector illustrated in its front portion that has a configuration in accordance with a different embodiment; and

Fig. 8 is a similar view in perspective to that of Fig. 7, but illustrating the rear portion of the deflector as in the embodiment illustrated in Fig. 7, in the heat exchanger according to the invention.

**[0016]** With reference to the aforementioned figures, the heat exchanger as in the invention comprises a plurality of finned tubes 1 laid out adjacent and parallel to one another with the fins indicated by reference number 2. The finned tubes 1 can be arranged either in rows as illustrated in Figures 2 and 4 or in a staggered arrangement as illustrated in Fig. 3.

**[0017]** A plurality of deflectors 3 are located adjacent to the finned tubes 1 to convey the flow of fluid destined to pass over the fins 2 of the tubes and directed mainly longitudinally in relation to the tubes 1, in such a way is to increase the efficiency of heat exchange of the fins themselves.

**[0018]** The deflectors 3 are located between the first row of finned tubes and the second row and between the latter and subsequent rows.

**[0019]** It is also possible to position deflectors 3 in front of the first row and behind the last row of finned tubes.

**[0020]** The deflectors 3 are in their turn equipped with a plurality of vortex-generating elements, indicated by reference number 4, located on the outside surface of the deflectors 3.

**[0021]** The vortex-generating elements 4 are substantially further suitably-sized fins positioned so that they project from the surface of the deflector and are angled in relation to the vertical axis of the deflectors 3.

**[0022]** The vortex-generating elements make it possible to change the flow of fluid from a mainly laminar flow to a turbulent flow in order to increase the coefficient of heat exchange between the fins 3 and the external fluid.

**[0023]** The shape of the deflectors 3 can change as shown purely by way of example in the aforementioned figures.

**[0024]** The deflectors 3 can in this way, for example, have a teardrop configuration as shown in Fig. 2, an angled configuration as shown in Fig. 4, or a profiled configuration with flat sections that are connected at angles as illustrated in Figures 7 and 8.

**[0025]** The vortex-generating elements 4 can also have different dimensions and shapes, but as a general rule the size, plan shape, pitch and angle in relation to the vertical axis of the deflectors 3 (angle of incidence) needs to be chosen to suit requirements and in relation to the speed of the fluid available for implementing the heat exchange.

**[0026]** This choice must, furthermore, be made in such a way that the vortexes created by the fins, mainly longitudinally, do not interact with one another so as not to decrease the efficiency of heat exchange that can potentially be obtained.

**[0027]** The vortex flow created by the vortex-generating elements 4 makes its way between the fins up to the finned tubes 1, increasing the efficiency of heat exchange that can be obtained with deflectors of known type for the same loss of pressure.

**[0028]** The vortex-generating elements can be laid out parallel to one another, as illustrated in Fig. 5, in such a way as to create vortexes that all rotate in the same direction of rotation with axes parallel to the direction of flow of the fluid.

**[0029]** Alternatively, the vortex-generating elements 4 can be laid out on the surface of the deflector in pairs with a converging orientation, as illustrated in Fig. 6, so as to create pairs of vortexes in which each vortex has the opposite direction of rotation to the other.

**[0030]** A further example of a possible profile for the deflectors 3 of the heat exchanger as in the invention is shown in Figures 7 and 8, in which the vortex-generating elements 4 are obtained in the rear edge of the deflectors, which is profiled with a square wave shape.

**[0031]** The vortex-generating elements 4 can either be welded on the surface of the deflectors 3 or obtained by shearing the deflectors themselves. In the latter case, an internal lining element (not shown) can be inserted in each deflector 3 to close the opening made by the shearing and by the outward extension of said vortex-generating elements 4 from the surface of the deflector.

**[0032]** In practice, it has been noted that the heat exchanger as in the invention fully achieves the task set in that it increases the coefficient of heat exchange between the fluid that flows externally over the fins of the finned tubes and the fins themselves.

**[0033]** The heat exchanger so conceived is capable of numerous modifications and variants that are all within the inventive concept, moreover all the details can be substituted by other technically equivalent elements.

**[0034]** In practice, the dimensions and materials used can be of any kind to suit requirements and the state of technology providing they are compatible with the specific use.

## Claims

1. Finned-tube heat exchanger, particularly for combined cycle power plants and the like, comprising a plurality of finned tubes arranged in rows and flow

deflectors positioned between successive rows of said finned tubes, adjacent to said tubes, characterised by the fact that at least certain of said deflectors comprise a plurality of vortex-generating elements laid out on the surface of said deflectors, designed to generate vortexes with axes that are substantially parallel to the direction of flow of a fluid conveyed externally to pass over said finned tubes.

2. Finned-tube heat exchanger as in claim 1, characterised by the fact that said vortex-generating elements comprise vortex-generating fins that project from the surface of said flow deflectors.

3. Finned-tube heat exchanger as in claim 2, characterised by the fact that said vortex-generating fins have an inclined leading edge.

4. Finned-tube heat exchanger as in one or more of the previous claims, characterised by the fact that said vortex-generating fins are laid out on the surface of said deflectors with axes that are substantially parallel to one another and inclined in relation to the vertical axe of said deflectors.

5. Finned-tube heat exchanger as in one or more of the previous claims, characterised by the fact that said vortex-generating fins are laid out on the surface of each of said deflectors in pairs with axes that are substantially convergent in such a way as to generate pairs of vortexes in which each vortex has the opposite direction of rotation to the other.

6. Finned-tube heat exchanger as in one or more of the previous claims, characterised by the fact that said vortex-generating fins of said deflectors are welded to the outside surface of said deflectors.

7. Finned-tube heat exchanger as in one or more of the previous claims, characterised by the fact that said vortex-generating fins are obtained by shearing the surface of said deflectors.

8. Finned-tube heat exchanger as in one or more of the previous claims, characterised by the fact that an internal lining element is inserted in said deflectors in which the fins are obtained by shearing.

9. Finned-tube heat exchanger as in one or more of the previous claims, characterised by the fact that each of said deflectors has a teardrop shape.

10. Finned-tube heat exchanger as in one or more of the previous claims, characterised by the fact that each of said deflectors has a V shape.

11. Finned-tube heat exchanger as in one or more of the previous claims, characterised by the fact that each of said flow deflectors is shaped with flat sections that are connected to one another at angles, the vortex-generating fins of said deflector being formed in the rear edge of said deflector with a square wave profile.

12. Finned-tube heat exchanger as in one or more of the previous claims, characterised by the fact that said finned tubes are arranged in aligned rows.

13. Finned-tube heat exchanger as in one or more of the previous claims, characterised by the fact that said finned tubes are arranged in a staggered configuration.

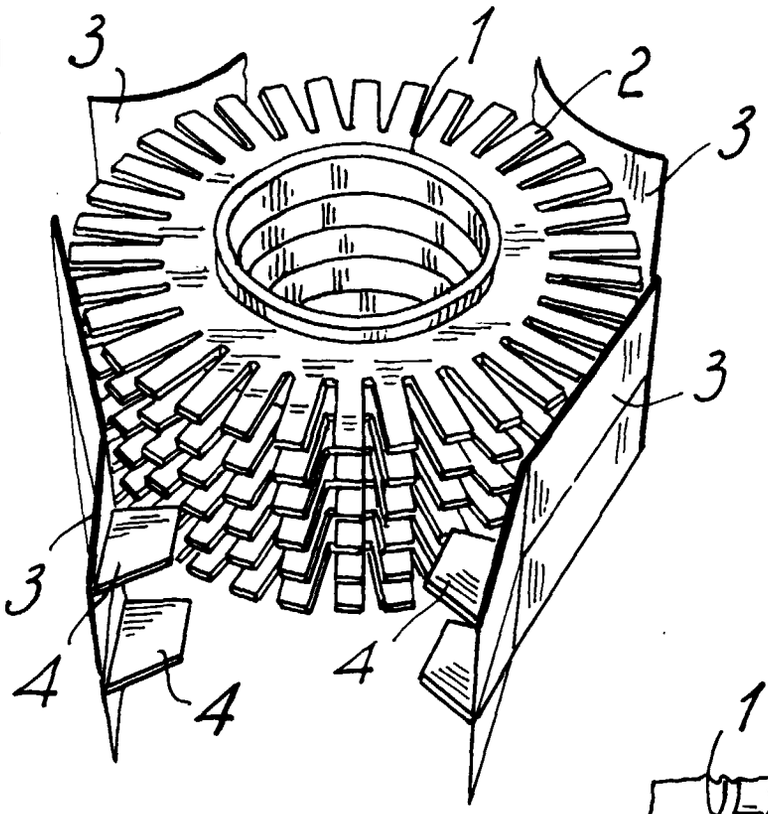


Fig. 1

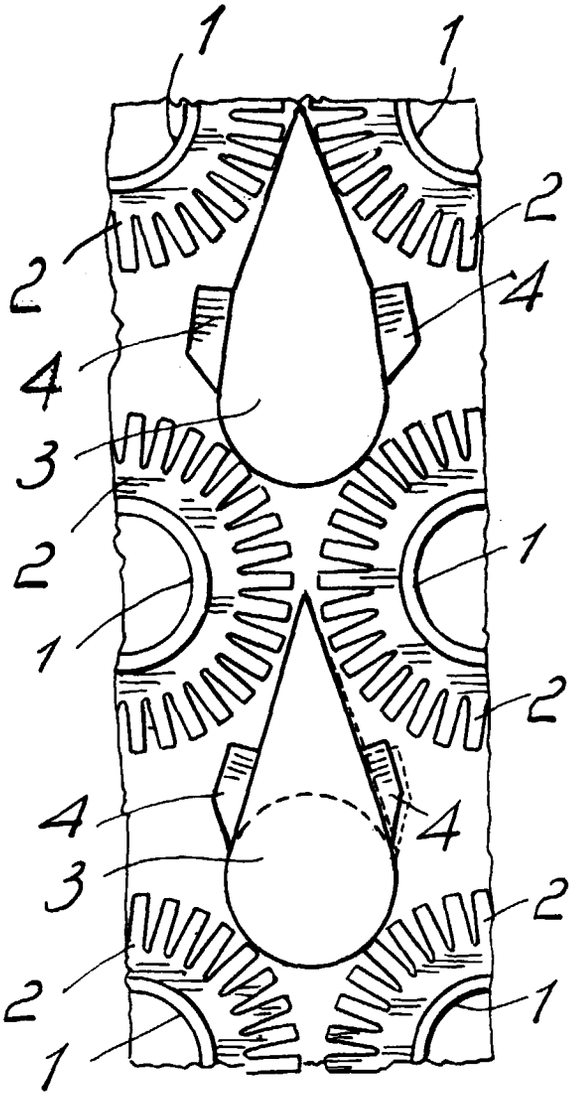


Fig. 2

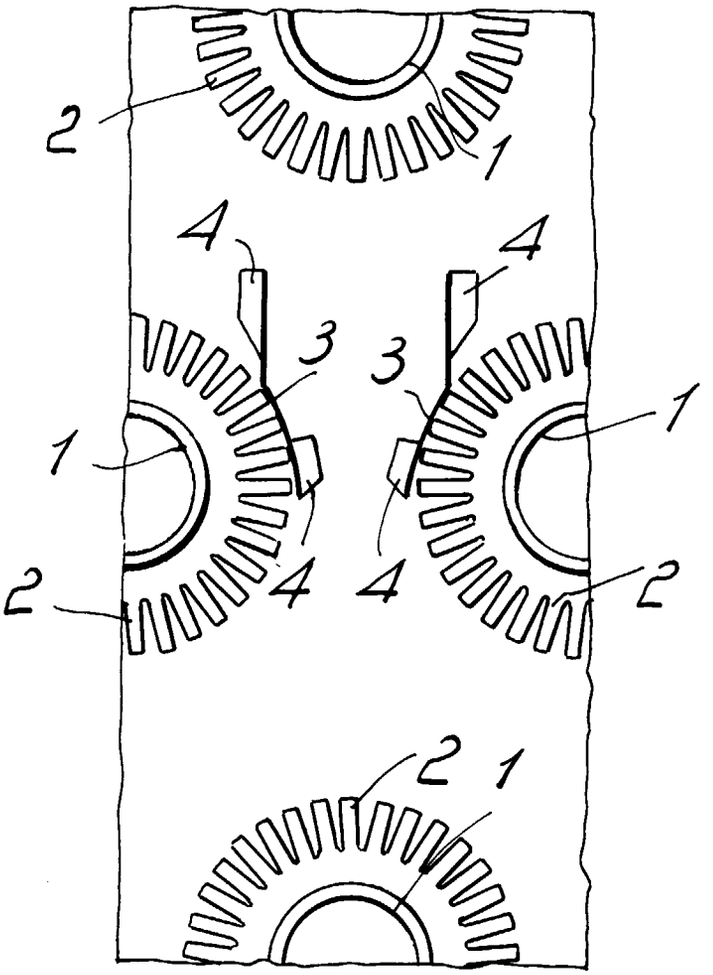


Fig.3

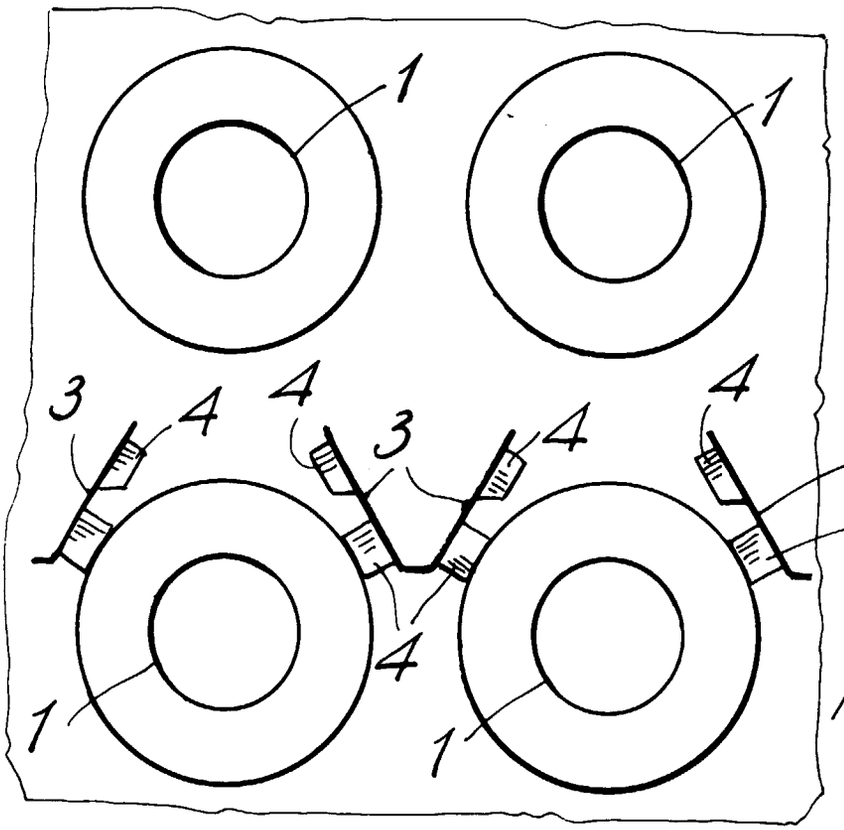


Fig.4

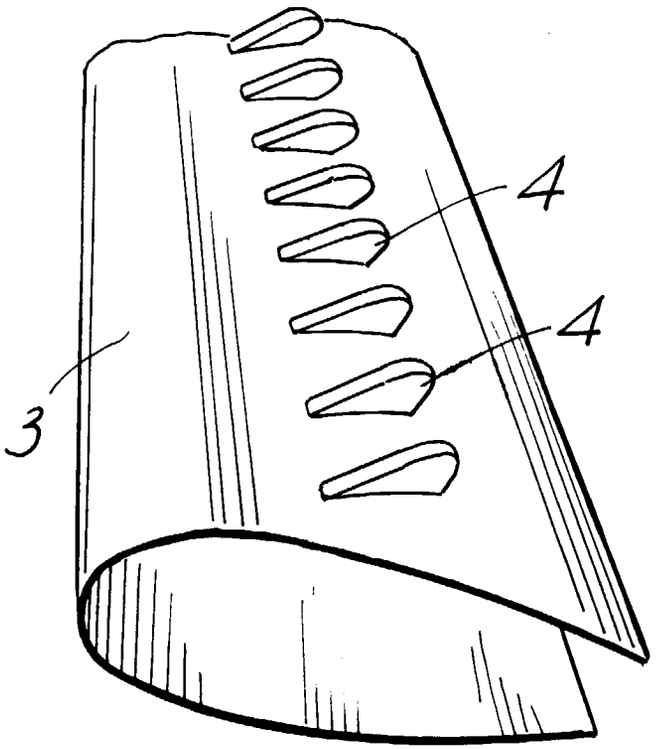


Fig.5

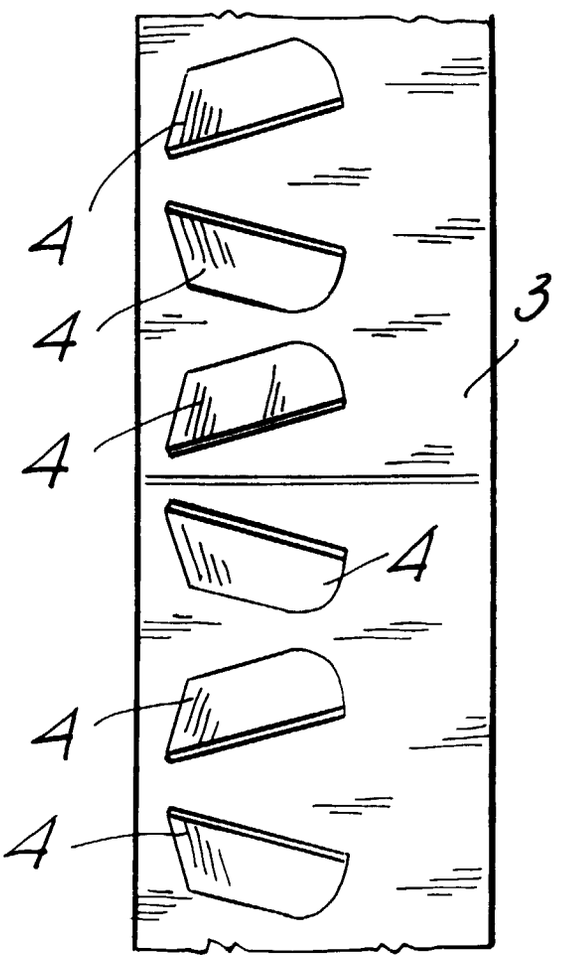


Fig.6

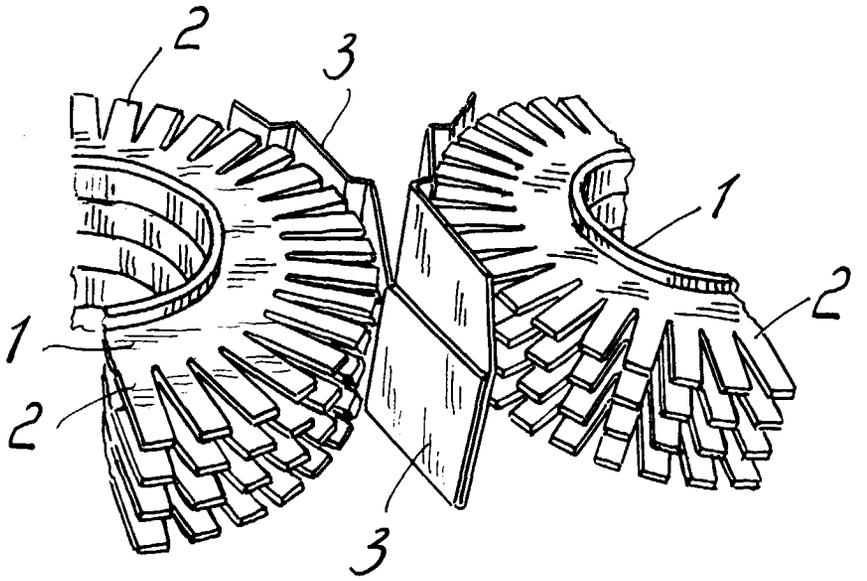


Fig. 7

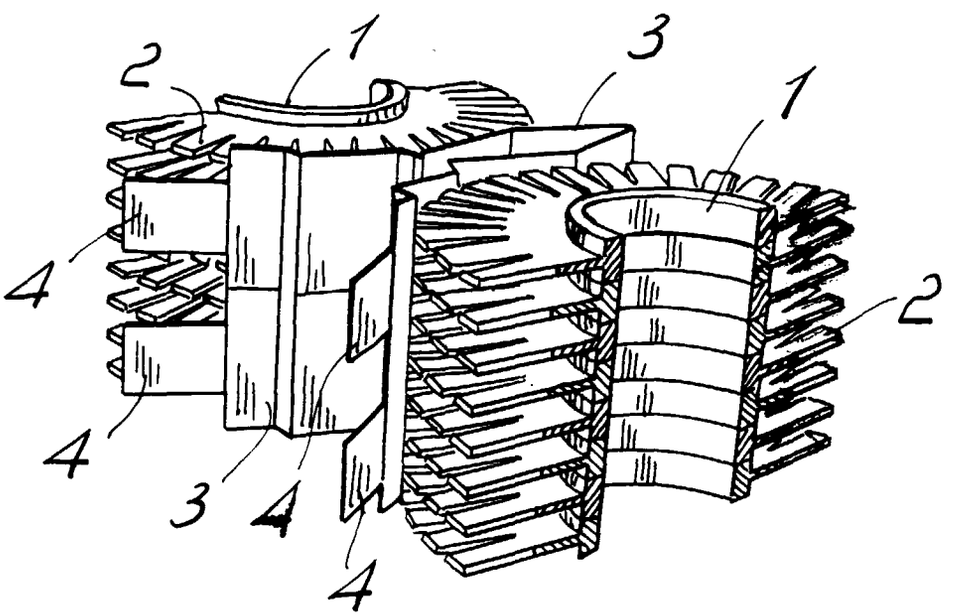


Fig. 8