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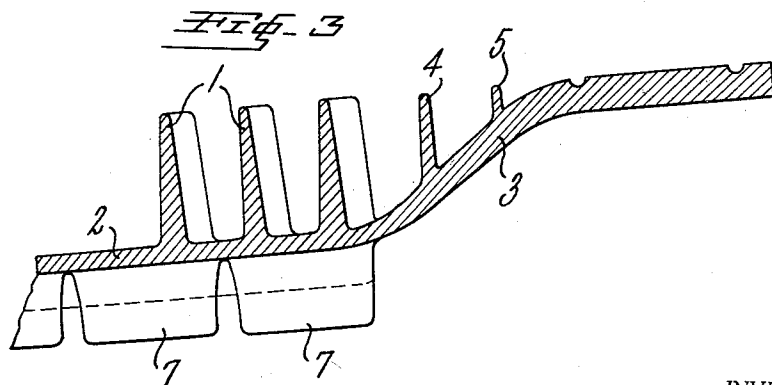
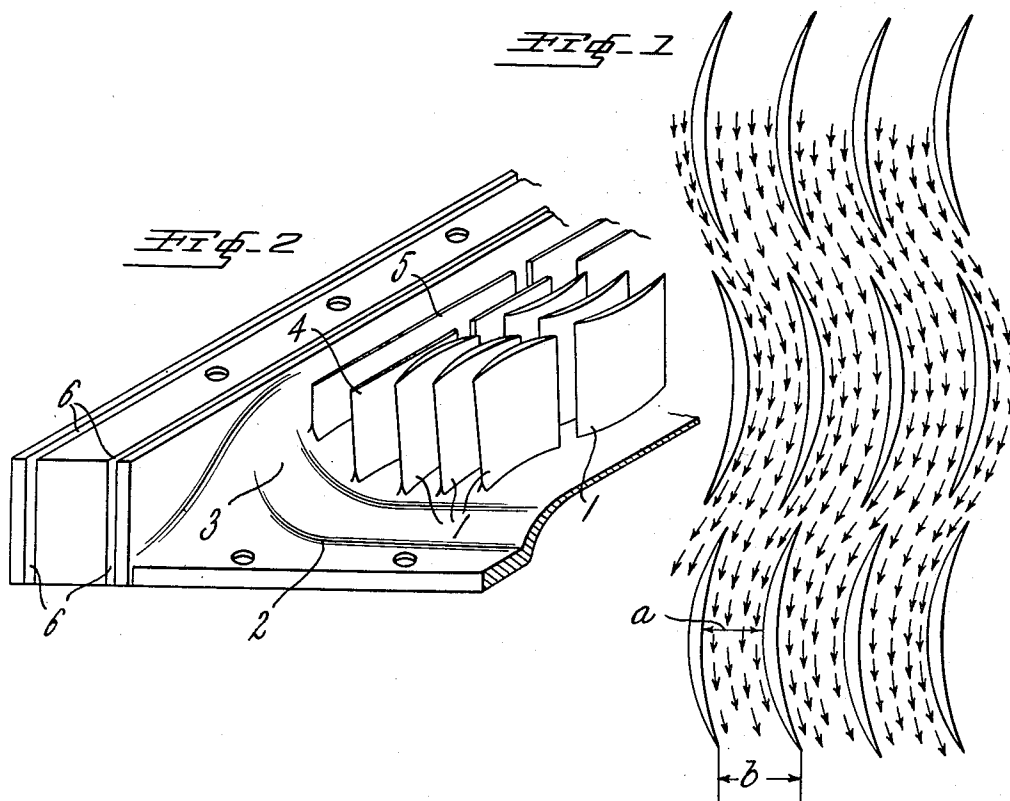
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2,834,582

PLATE HEAT EXCHANGER

Filed June 11, 1954

2 Sheets-Sheet 1



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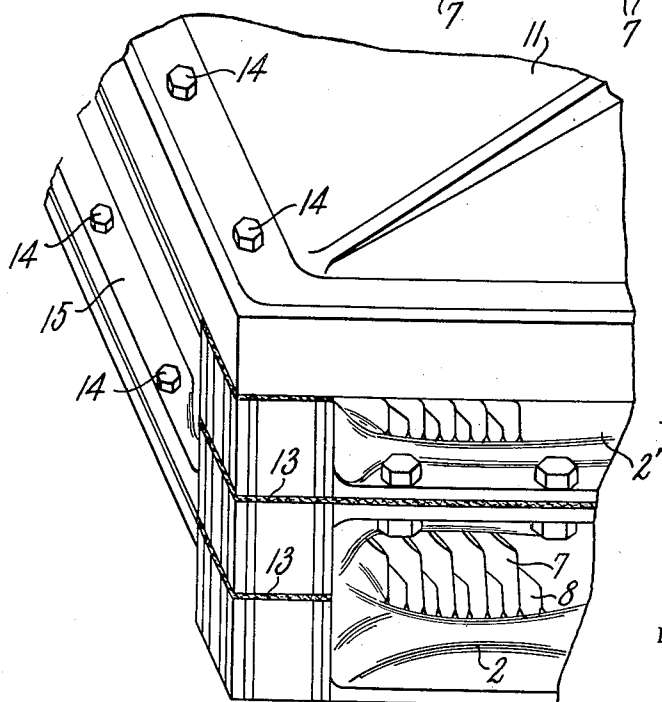
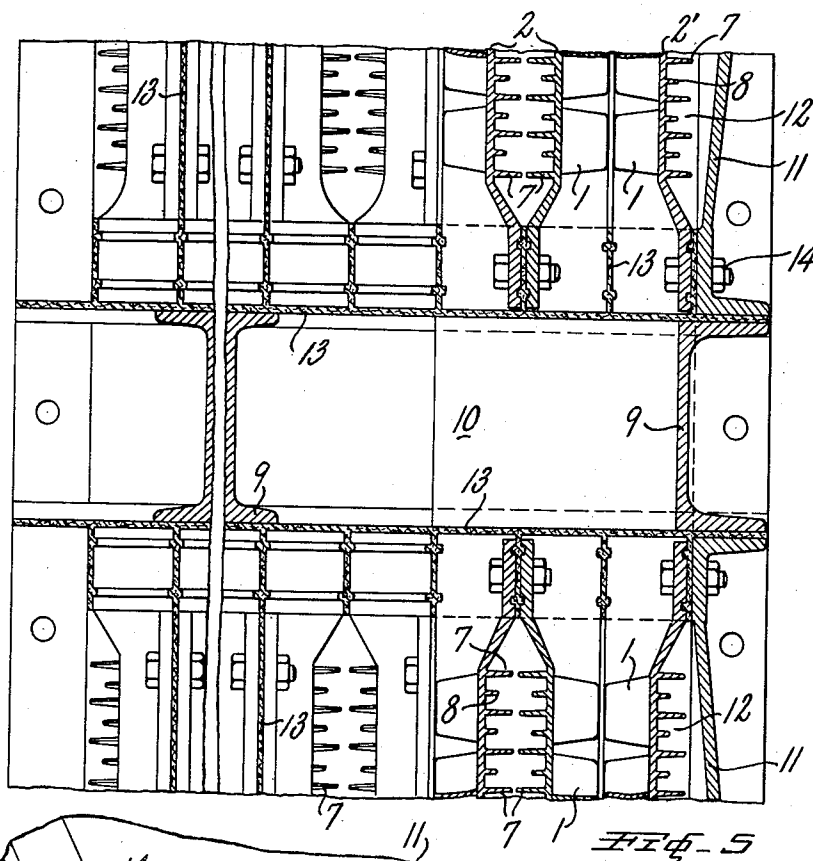
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PLATE HEAT EXCHANGER

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2 Sheets-Sheet 2



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1

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PLATE HEAT EXCHANGER

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6 Claims. (Cl. 257-245)

The present invention refers to a plate heat exchanger, in particular, a cross-stream heat exchanger with ribs subdivided in longitudinal direction thereof to thereby form individual ribs of which each two successive ribs in the direction of flow alternate with their forward and rearward end edges which are bent toward one side and toward the opposite side, respectively.

The present invention has as one of its purposes the production of a heat exchanger composed of plates equipped with ribs and assemblable to a square-shaped unit, whereby several of such square units form a complete air heater so that within the individual pockets or compartments thereof no local cooling down areas are caused whereby simultaneously consideration is given to the fact that the heat receiving and heat discharging surfaces afford a highly reduced resistance at a relatively high heat transmission coefficient.

According to the invention, this will be accomplished by presenting ribs which assume a crescent shape in cross-section, whereby these ribs are disposed in groups next to each other as seen perpendicular to the direction of flow, while the cross-section of the path of flow varies continuously. As far as this is technically possible, the crescent-shaped cross-section of the ribs are at both their ends pointed. Furthermore, the radius of curvature of both side faces defining the crescent-formation is chosen to be sufficiently large so that the gases or air stream perform or describe under relatively small lateral deviations a serpentine movement through the pockets or compartments of the heat exchanger. It is of importance that, in contradistinction to known apparatus, the serpentine-like movement of the gases or of the air is carried out while the cross-sections are insignificantly changed which serve for the individual air paths. This is achieved according to the invention through individual ribs of crescent-shaped cross section, which, as seen perpendicular to the direction of flow, are disposed in groups next to each other, the ribs of one bank being slightly offset with respect to the ribs of the adjacent bank in the direction of flow.

Thus, insignificant disturbances during continuous passage of the gases or of the air through the pocket occur, whereby while any possible turbulence is avoided a most favorable transition of the streaming media from one group of ribs to the next group is attained. Despite the avoidance of turbulences the gaseous media adapt themselves or conform to predetermined bordering surfaces while shade formation of the passing streams is avoided. These streams are split when flowing from one group of ribs to the next following one, while eddies are avoided so that always other gas or air strata come in direct and intimate contact with the surfaces of walls defining the paths for such streams. Thus, an increased heat exchange or transfer is produced, while the resistance is simultaneously reduced. Thus, for a predetermined output for achieving transfer of heat it will be sufficient to employ an exhaust fan or an air compressor fan, while quantitative reduction of cast iron ma-

2

terial at the most reduced consumption of energy is maintained.

According to the invention the heating areas for the ribs of the air treatment are smaller than the heating areas for the ribs of gas treatment. This is accomplished by providing ribs of reduced height in the air section as compared to the ribs placed in the gas section. In this manner a super-cooling below the dew point in the gas section is avoided, thus preventing water vapor contained in the flue gases from condensing at the foot of the ribs and forming thereat a continuously increasing deposit of cementitious material. In view of such deposits, accumulation of heat on the ribs in the gas section would be markedly reduced.

According to the invention there are arranged and preferably within the range of the air entrance in the gas section on the curved flange one or several continuous ribs. Instead of completely continuous ribs, other ribs may be provided which are subdivided in more or less larger spaces which ribs, however, are not laterally bent at their forward and rearward edges. Such structure serves also the purpose of avoiding local super-cooling in order to prevent any deficiencies resulting from condensation, sweating, and deposit of ashes which would form passage obstructions. The effect of continuous ribs which extend on the curved flange will be enhanced due to the fact that the plates in the air sections and positioned opposite these continuous gas ribs are devoid of any ribs. These ribs are disposed preferably in the direction of flow of the air or gases parallel rows of successive ribs. Thus between two adjacent rows of ribs, channels are formed for the use of steam brushes, the nozzles of which are accommodated preferably in U-shaped irons and are thus spaced from each other in superposed cubicles defining spaces therebetween.

In cases in which the danger of super-cooling of the plates in the gas section is particularly great, the rows of ribs in the air section may preferably alternate with continuous and intermediate ribs of relatively reduced height.

As the screw bolts made from wrought iron which connect the plates at their edges with each other afford a greater heat expansion coefficient than the rib-equipped plates made from cast iron the latter will show slight curvature and are so assembled that the median parts thereof are firmly superimposed upon each other, while the edges of the plates will normally be somewhat spaced apart.

In this manner the screw bolts receive a certain pre-tension which prevent loosening up of the screw bolts due to non-uniform heat expansion of the wrought iron and cast iron, respectively, whereby simultaneously the safety of the sealing means is enhanced.

The rib-equipped plates contain four flanges at the edges thereof to form a tight seal between the air section and the gas section, as well as for the cover in such a manner that gas and air cannot be in direct contact and cannot mix with each other. The inner sealing surfaces of the composed pockets or compartments receive a double-groove sealing arrangement which extend at right angles toward the corners at their respective sealing portions. Horizontal sealing means between individual superimposed cubicles are effectuated by means of the pressure of the weight exerted on asbestos rope material placed in the sealing grooves.

The above and other objects of the invention will become further apparent from the following detailed description, reference being had to the accompanying drawings showing preferred embodiments of the invention.

In the drawings:

Fig. 1 is a top plan view of a plurality of ribs crescent-shaped in cross section;

3

Fig. 2 is a perspective view of a corner piece of a heat exchange plate according to the invention;

Fig. 3 is a cross section of a plate of Fig. 2 extending perpendicular to the ribs placed in the gas section;

Fig. 4 is a corner piece of the air-heat exchanger; and

Fig. 5 is a vertical section through a portion of the air-heat exchanger illustrated on a reduced scale.

Fig. 1 shows the crescent-shaped formation of a plurality of ribs which are juxta-positioned, as well as successively arranged on the heat exchange plates. The crescent-shaped sections of the ribs present only relatively small curvature and are at their respective opposite ends substantially pointed. In this representation the arrows indicated therein illustrate the transformation of the gas flow from one group of ribs to the next group of ribs. The narrowest cross section of a path gas flow is designated by "a," while "b" indicates the largest cross section of such path. Consequently there always takes place at locations of transition from one group of ribs to an adjacent one an insignificant expansion and within the median portions of the path between the ribs an insignificant compression of gaseous media. It ensues therefrom an improved uniformity of the air passage or of the gas passing through the heat exchanger which entails a considerably increased and intimate contact of the heat surfaces or areas with the heat carrier or medium.

A section of the ribs carrying plate 2 according to Fig. 2 illustrates ribs 1 disposed successively in rows, as well as in groups next to each other. On the curved flange 3 of the gas section of the plate 2 there are arranged spaced ribs 4 and 5 reduced in height, but with increased distances from each other. In accordance with the required case in question, a greater or smaller number of ribs similar to those as indicated at 4 and 5 may be disposed on the curve flange 3. On the opposite air side of the plate 2 ribs of the type of ribs 4 and 5 are not provided as can be seen in Fig. 3 in which the sealing grooves 6 of the plate edges are also shown.

In the cross-section according to Fig. 3 numeral 2 designates rib carrying plate having ribs 1 on the gas section, whereas ribs 4 and 5 present extended ribs of reduced height on curved flange 3.

On the air section there are also shown ribs perpendicular to the ribs 1 forming special ribs 7 whose cross sections correspond to those ribs shown in Fig. 1. In order to avoid any cooling down ribs 7 according to Fig. 3 are of shorter or reduced height than ribs 1 in the gas section.

Figs. 4 and 5 illustrate ribs carrying plate 2 whose ribs 7 are positioned in the air section, whereas the higher ribs 1 are placed in the gas section. Ribs 7 alternate with ribs 8 of considerably reduced height. Numeral 9 designates the flanges which are U-shaped in cross-section and provide for the spaces 10 therebetween used to receive the nozzle tubes not shown which serve to receive steam brushes.

The cover walls or plates 11 form with the last plate 2' an air pocket 12 which due to the inner smooth wall surface 11 affords considerably reduced heat transfer to the air flowing through this pocket so that the heat losses to the outside will be at a minimum. As can be visualized from the cross-section of the cover plates 11 according to Fig. 5 these plates 11 are outwardly directed or curved. The sealing means 13 are formed under the influence of the weight of the square-shaped heat exchange bodies. Screw bolts 14 by which the plate edges 15 are connected together, receive, as hereinabove stated, a pre-tension corresponding to the respective heat expansion coefficient. To this end the rib plates are cast with a slight curvature whereby the median parts during assembly operation are firmly superimposed on each other, while the edges of the plates are spaced a predetermined small distance from each other. When the plate edges are contracted to one another sufficient pre-tension is imparted to the screw bolts

4

which prevents loosening of said screw bolts during temperature changes.

Details of the invention may deviate from the drawings which show some embodiments of the invention. In particular, in accordance with the respective velocity conditions of the media passing through the heat exchanger the ribs of crescent-shaped cross section may be given a more or less extended formation with respect to that shown in Fig. 1.

Due to the fact that eddies or turbulences are avoided during the flow of the media through the air and gas pockets all the above mentioned advantages are attained over the heretofore known cross-heat exchangers as an eddy-free transformation of the air and gas flows ensues when passing the groups of ribs in the direction of flow thus contributing to a most favorable heat transfer at a given output while savings in cast iron material, space and energy are achieved.

It can thus be seen that there has been provided in accordance with the invention a heat exchanger comprising a plurality of superposed plate elements, each plate element having a plurality of spaced, substantially parallel, serpentine-shaped ribs disposed on each of said opposed surfaces, said ribs being subdivided in longitudinal direction thereof to form successive groups of rib portions, each of said rib portions being crescent-shaped in cross-section and having a median part gradually converging to the respective ends, the ends of the rib portions of adjacent groups facing in opposite directions, said ribs of one of said surfaces extending in transverse direction to said ribs of the other of said surfaces and being greater in height than said ribs of said other surface.

Various changes and modifications may be made without departing from the spirit and scope of the present invention and it is intended that such obvious changes and modifications be embraced by the annexed claims.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent, is:

1. In a heat-exchanger plate element having a pair of opposed surfaces; a plurality of spaced, substantially parallel, serpentine-shaped ribs disposed on each of said opposed surfaces, said ribs being subdivided in longitudinal direction thereof to form successive groups of rib portions, each of said rib portions being crescent-shaped in cross-section and having a median part gradually converging to the respective ends, the ends of the rib portions of adjacent groups facing in opposite directions, adjacent groups of rib portions being slightly offset in transverse direction with respect to each other, said ribs of one of said surfaces extending in transverse direction to said ribs of the other of said surfaces and being greater in height than said ribs of said other surface.

2. In a plate element according to claim 1, wherein between said ribs disposed on said other surface additional ribs of lesser height are positioned extending in the same direction as said first-mentioned ribs on said other surface.

3. A heat exchanger comprising a plurality of superposed plate elements, each having a pair of opposed substantially planar surfaces and a flange curved out of the plane of said surfaces, the flange of one plate element being connected fluid-tightly to and being substantially coextensive with the flange of an adjacent plate element, a plurality of spaced substantially parallel serpentine-shaped ribs disposed on each of said opposed surfaces, said ribs being subdivided in longitudinal direction thereof to form successive groups of rib portions, each of said rib portions being crescent-shaped in cross-section and having a median part gradually converging to the respective ends, the ends of the rib portions of adjacent groups facing in opposite directions, adjacent groups of rib portions being slidably offset in transverse direction with respect to each other, said ribs of one of said surfaces extending in transverse direction to said ribs of the other

51

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of said surfaces and being greater in height than said ribs of said other surface, each of said plate elements being further provided with at least one substantially straight rib disposed on said one surface along said flange and extending in longitudinal direction of the latter, outwardly curved cover means positioned on said superposed plate elements, and means connecting said cover means and said plate elements.

4. A heat exchanger according to claim 3, each of said plate elements being provided with groove means disposed longitudinally along said flange, said connecting means including gasket means seated between adjacent flanges, whereby said gasket means are compressed into said groove means of said flanges to thereby seal off adjacent plate elements from each other.

5. A heat exchanger according to claim 4, each of said flanges being provided with a curved portion extending longitudinally thereof, said connecting means acting along the median of said curved portions, respectively, whereby in spite of differences in heat expansion of the component parts of said exchanger during heat exchange, the seal between adjacent plate elements will not be affected.

6. In a heat-exchanger plate element having a pair of opposed surfaces; a plurality of spaced, substantially

parallel, serpentine-shaped ribs disposed on each of said opposed surfaces, said ribs being subdivided in longitudinal direction thereof to form successive groups of rib portions, each of said rib portions being crescent-shaped in cross-section and having a median part gradually converging to the respective ends, the ends of the rib portions of adjacent groups facing in opposite directions, adjacent groups of rib portions being slightly offset in transverse direction with respect to each other, said ribs of one of said surfaces extending in transverse direction to said ribs of the other of said surfaces.

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