

June 14, 1960

T. A. ÖDMAN

2,940,736

ELEMENT SET FOR HEAT EXCHANGERS

Filed May 11, 1950

2 Sheets-Sheet 1

Fig. 1.

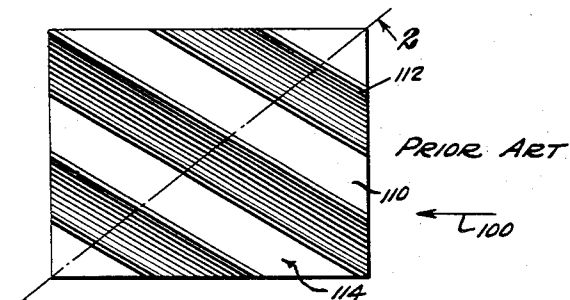


Fig. 2.



Fig. 3.

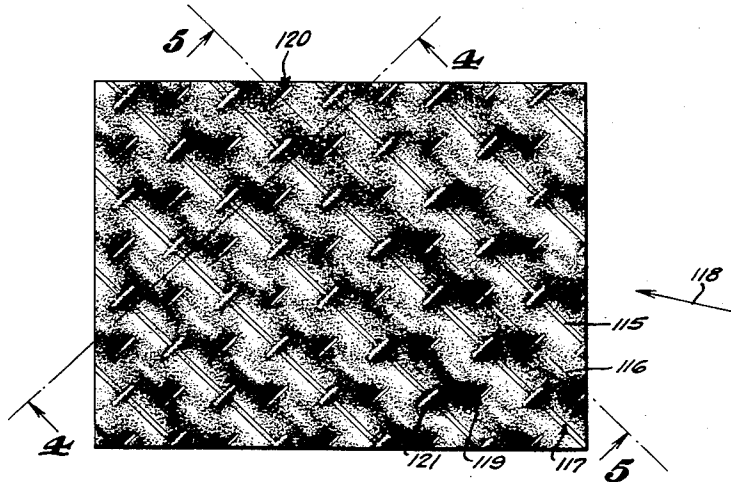


Fig. 4.



Fig. 5.



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Fig. 6.

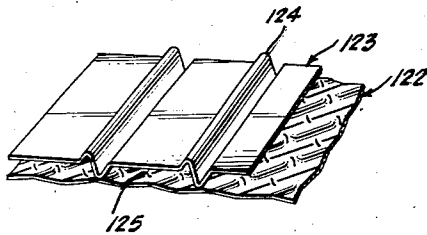


Fig. 10.

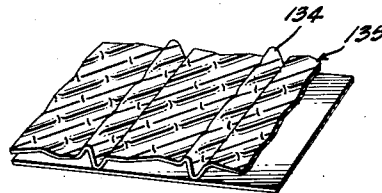


Fig. 7.

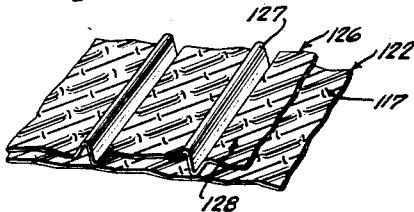


Fig. 11.

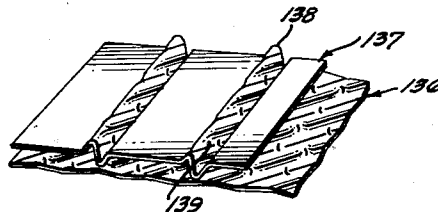


Fig. 8.

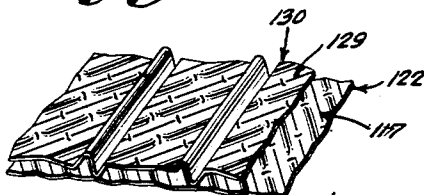


Fig. 12.

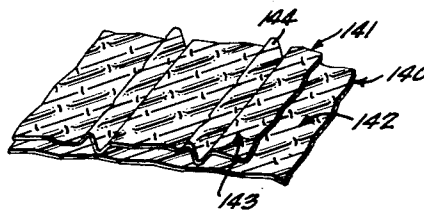
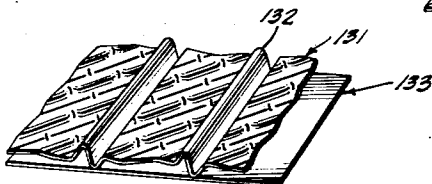


Fig. 9.



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ELEMENT SET FOR HEAT EXCHANGERS

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9 Claims. (Cl. 257—245)

The present invention relates to heat exchangers for preheating air and other gaseous media. More specifically, the invention relates to the heat exchanging surfaces exposed to such media.

In heat exchangers of the kind under consideration where the heat exchange takes place between gaseous media not in contact with each other and where the media pass through a number of channels, the walls of which absorb heat from one medium and reject it to the other medium, it is most important that the average value of the heat transfer coefficient is as high as possible and at the same time the pressure drop of the media flowing through the channels does not become too high.

Since the heating surfaces embodying the present invention are best adapted for use in exchangers of the regenerative type, the present invention will hereinafter for the sake of simplicity be described with reference to this type of exchanger, although certain embodiments of the invention are also applicable to heat exchangers of the recuperative type.

The heat transfer coefficient is dependent on the structure of the walls of the channels as well as upon the dimensions of the channels, their shape, and other design factors. The pressure drop, is of course to a great extent dependent on the details of the form of the channels. In air preheaters of the regenerative type, in the Ljungstroms air preheater, for example, the channels have hitherto been built up of packs of plates, that is, plates placed beside but at a certain distance from each other, whereby channels for the fluid media have been formed between the plates. At least one side of each channel formed in this manner has been undulated to give the media a certain turbulence, so as to minimize a boundary layer and increase the heat transfer coefficient without the pressure drop becoming too high.

It is most important for efficient heat transfer that the boundary layer be reduced to a minimum. As is known, a result of this is that surfaces provided with spikes, sharp projections and similar elements always show a high heat transfer coefficient. The difficulties lie in the problem of how to obtain such a high heat transfer coefficient without too high a corresponding pressure drop.

The element type above described in regenerative preheaters suffers from the deficiency that the heat transfer coefficient is rather low. However, at the same time it has the advantage of a relatively low pressure drop.

The surfaces required in an air preheater for a certain heat exchanger at a certain efficiency, is, naturally, directly proportioned to the heat transfer coefficient. Therefore it is most desirable to design channels for a considerably higher heat transfer rate without causing the pressure drop to become too great.

This invention has for its object the provision of a new type of heating surface possessing very advantageous properties to the heat transfer efficiency and the pressure drop as compared with the channel constructions hitherto used, and through which great advantage is

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obtained that the dimensions of the heat exchanger can be considerably reduced, or that an air preheater of given dimensions can handle greater quantities of heat exchanging media than earlier types, without the efficiency thereof being impaired.

This result has been accomplished by the present invention by interrupting the boundary layer in each channel in an effective manner, so that the heat transfer coefficient increases to a value never before attained in earlier heat exchangers of this type without the pressure drop at the same time rising to unacceptable values, which otherwise is usually a result of the efforts of increasing the heat transfer coefficient.

To this end the invention contemplates the provision of heat exchange plates, at least every other one of which in a pack of such plates, has a surface configuration providing a multiplicity of shallow depressions and projections on the surface of the plate.

Further, and more specifically, in carrying out the concept of the present invention, each of at least every second one of the heat exchange plates is provided with a surface configuration comprising a multiplicity of parallel furrows extending obliquely with respect to the longitudinal axes of the channels, which define the general direction of the flow of the gaseous media, the crest portions of said furrows being depressed at a plurality of spaced intervals thereon to interrupt the continuity of the walls of the furrows.

Referring now to the drawings:

Fig. 1 is a plan view of a heat exchange element representative of the prior art;

Fig. 2 is a sectional view taken substantially on the line 2—2 of Fig. 1;

Fig. 3 is a plan view of a form of element embodying the present invention;

Fig. 4 is a sectional view taken substantially on the line 4—4 of Fig. 3;

Fig. 5 is a sectional view taken substantially on the line 5—5 of Fig. 3;

Figs. 6 to 12 inclusive are more or less diagrammatic views of plate combinations embodying the principles of the present invention.

Referring now more particularly to the drawings Fig. 1 shows a heat exchange plate of previously known character having a surface configuration providing a multiplicity of shallow depressions 110 and projections 112 which between them generate a series of parallel shallow furrows indicated generally at 114. This represents a typical example of prior art structure through which gaseous media flow with laminar flow, the general direction of gas flow being indicated by the arrow 100 which is at approximately a 30° angle to the furrows 114.

In Fig. 3, a furrowed plate structure of improved design in accordance with the present invention is shown having depressions 115 separated by intervening projections or ridges 116 and providing furrows 117 which are at an angle of approximately 30° to the general line of flow of the fluid media as indicated by the arrow 118.

In this structure, however, the crests forming the ridges 116 between the adjacent furrows 117, are interrupted at intervals by being depressed, as indicated at 119, by transversely extending furrows 120, preferably of less depth than the main furrows 117, the purpose of these transverse depressions being to break up the laminar flow of fluid media along the walls of the major furrows.

The net effect is to provide a surface having what may be termed a waffle pattern. The opposite surfaces of the plate are symmetrical and the depressions in the underside of the ridges formed by the furrows 117 are indicated at 121.

In Figs. 6 through 12 inclusive, various plate combinations are illustrated which may make use of the type of

heat exchange plate described and illustrated in Figs. 3 to 5.

In Fig. 6 a plate designated generally at 122 and having the configuration of the plate shown in Fig. 3, is shown as the intermediate heat exchange plate between plates 123 having spaced parallel ribs 124 and a similar plate which operates to provide channels 125 for flow of gaseous media between the plates 123 and plate 122.

The structure shown in Fig. 7 is similar to that shown in Fig. 6 except that plate 126, between the ribs 127, is undulated and cross undulated in the same manner as the plate 122. It is to be noted that in this embodiment, the principal undulations 117 and 128 of both plates 122 and 126 are arranged so that they lie parallel to each other.

In Fig. 8 the structure is essentially the same as in Fig. 7 except that the principal undulations 117 in plate 122 are at right angles to the undulations 129 in the plate 130.

In Fig. 9 a cross undulated plate 131, with ribs 132 such as shown in Figs. 7 and 8 is utilized in conjunction with a plane plate 133, which acts as a spacer plate between adjacent plates 131.

Fig. 10 illustrates a form of construction in which the general assembly is essentially the same as that of Fig. 9, with the exception that the ribs 134 of the plate 135, instead of having smooth laminar sides, are indented in the same manner as the flat surface of the plate to provide for turbulent flow along surfaces of the ribs.

Fig. 11 shows an alternative construction in which the plate 136 is essentially the same as the plate 122 previously described and is combined with a plane plate 137, the ribs 138 of which are undulated as shown in 139.

In Fig. 12 a plate combination is illustrated in which a plate 140 is combined with a second similar plate 141 such as that shown at 135 in Fig. 10, and in which the major undulations 142 in plate 140 and 143 in plate 141 are parallel to each other, the plate 141, however, having ribs 144 similar to the ribs 134 shown in Figs. 10 and 11, which are deformed in order to prevent laminar flow of the gaseous media along the walls of the ribs.

From the foregoing description of various physical embodiments of the invention, it will be evident to those skilled in the art that the principles of the invention may be applied in many specific physical embodiments. Accordingly, the invention is to be considered as embracing all forms of structure falling within the scope of the appended claims.

I claim:

1. A pack of elements for heat exchangers comprising a plurality of juxtaposed plates providing between adjacent plates a plurality of adjacent channels for flow of heat exchanging fluid, at least every second one of said plates having a surface configuration comprising a multiplicity of parallel furrows extending obliquely with respect to the longitudinal axes of the channels, the crest portions of said furrows being depressed at a plurality of spaced intervals thereon to interrupt the continuity of the walls of the furrows.

2. A pack of elements for heat exchangers comprising a plurality of juxtaposed plates providing between adjacent plates a plurality of adjacent channels for flow of heat exchanging fluid, at least every second one of said plates

having a surface configuration comprising a first series of parallel furrows extending obliquely with respect to the longitudinal axes of the channels and a second series of furrows of less depth than said first series extending transversely across said first series and depressing the crests of the furrows of said first series at the places of crossing, the continuity of the furrows of each series being interrupted at spaced intervals by the furrows of the other series.

3. A structure as defined in claim 2 in which the furrows of the second series are of about half the depth of those of the first series.

4. A structure as defined in claim 1 in which the furrows of the two series extend obliquely in symmetrical relation to the axes of the channels.

5. A pack of elements for heat exchangers comprising a plurality of contiguous plates every other one of which is formed to provide a plurality of parallel spaced ribs engaging the intervening plates to provide a series of relatively wide and shallow parallel channels between adjacent plates for flow of heat exchanging fluid, said intervening plates having a surface configuration comprising a multiplicity of parallel furrows extending obliquely with respect to the longitudinal axes of the channels, the crest portions of said furrows being depressed at a plurality of spaced intervals thereon to interrupt the continuity of the walls of the furrows.

6. A structure as defined in claim 5 in which the ribbed plates have a surface configuration of interrupted furrows like that of the intervening plates.

7. A structure as defined in claim 6 in which the interrupted furrows of adjacent plates are parallel with each other.

8. A structure as defined in claim 6 in which the interrupted furrows of adjacent plates are angularly related with respect to each other.

9. A structure as defined in claim 5 in which said ribs are formed by angularly related walls having alternating shallow depressions and projections along the length of the ribs, whereby to prevent smooth laminar flow of fluid through the passages formed between the walls of the ribs.

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