Jan. 2, 1968 A. KRITZLER 3,361,193

REGENERATIVE HEAT EXCHANGERS

Filed Oct. 12, 1965 4 Sheets-Sheet 1

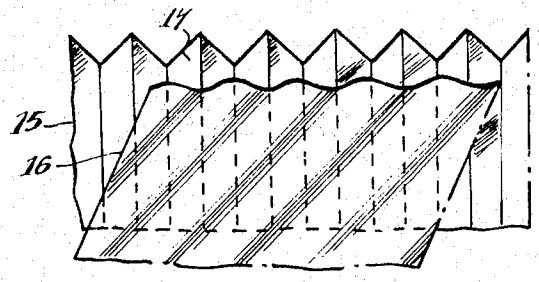

Fig. 1.

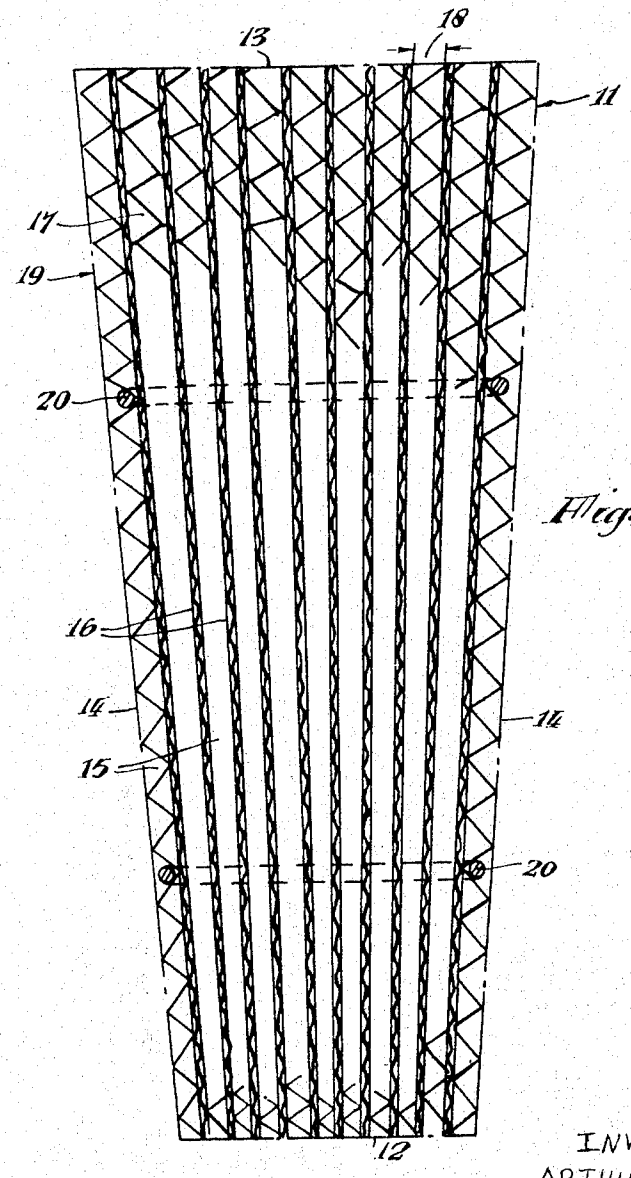

Fig. 2.

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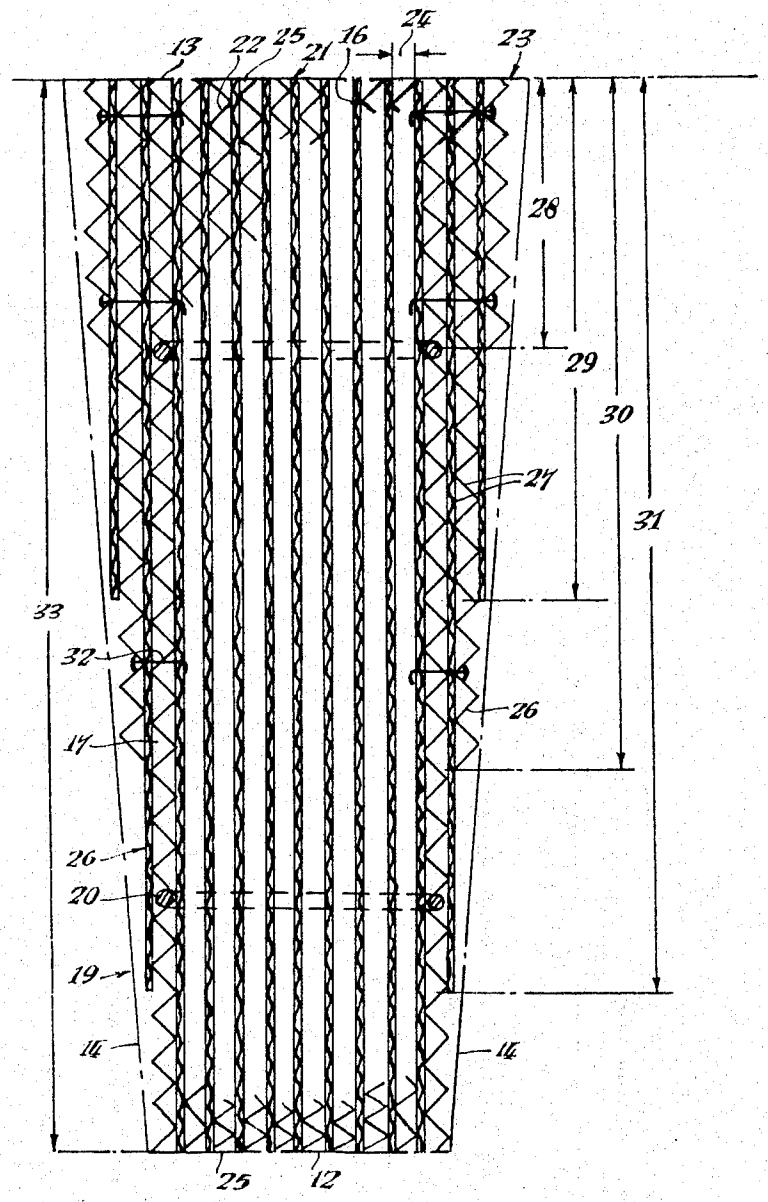
REGENERATIVE HEAT EXCHANGERS

Filed Oct. 12, 1965 4 Sheets-Sheet 2

Fig. 3.



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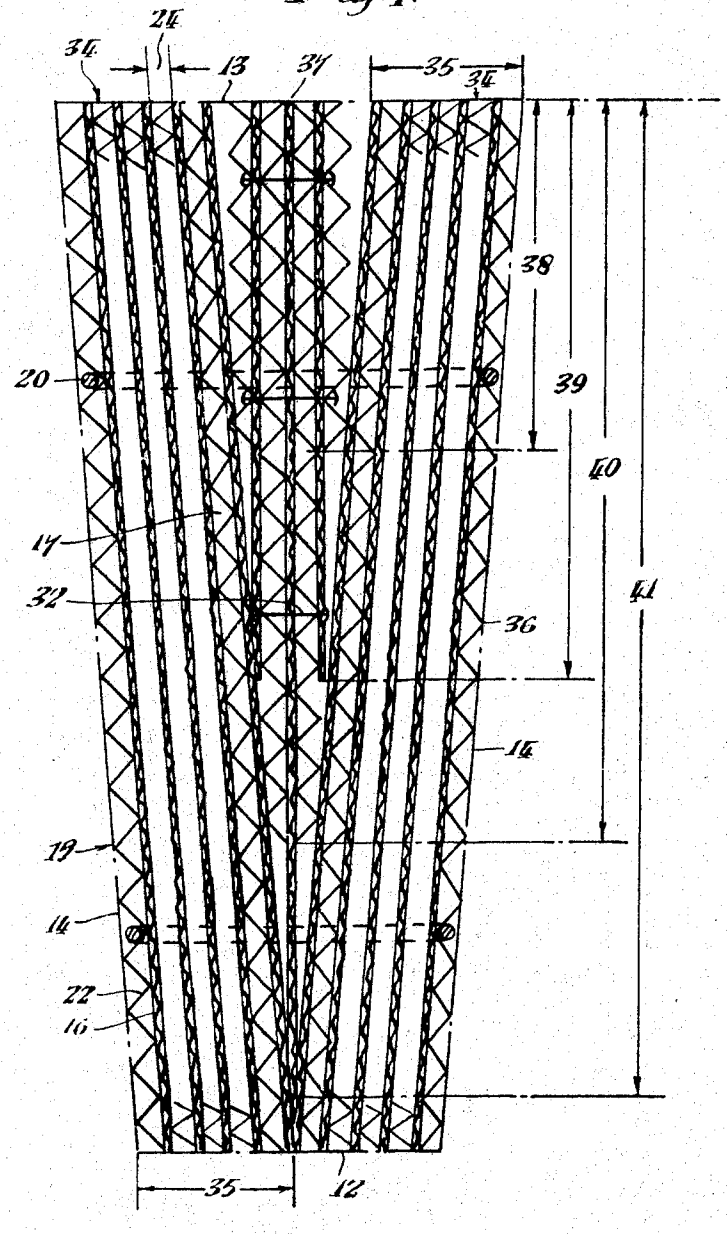
REGENERATIVE HEAT EXCHANGERS

Filed Oct. 12, 1965 4 Sheets-Sheet 3

Fig. 4.



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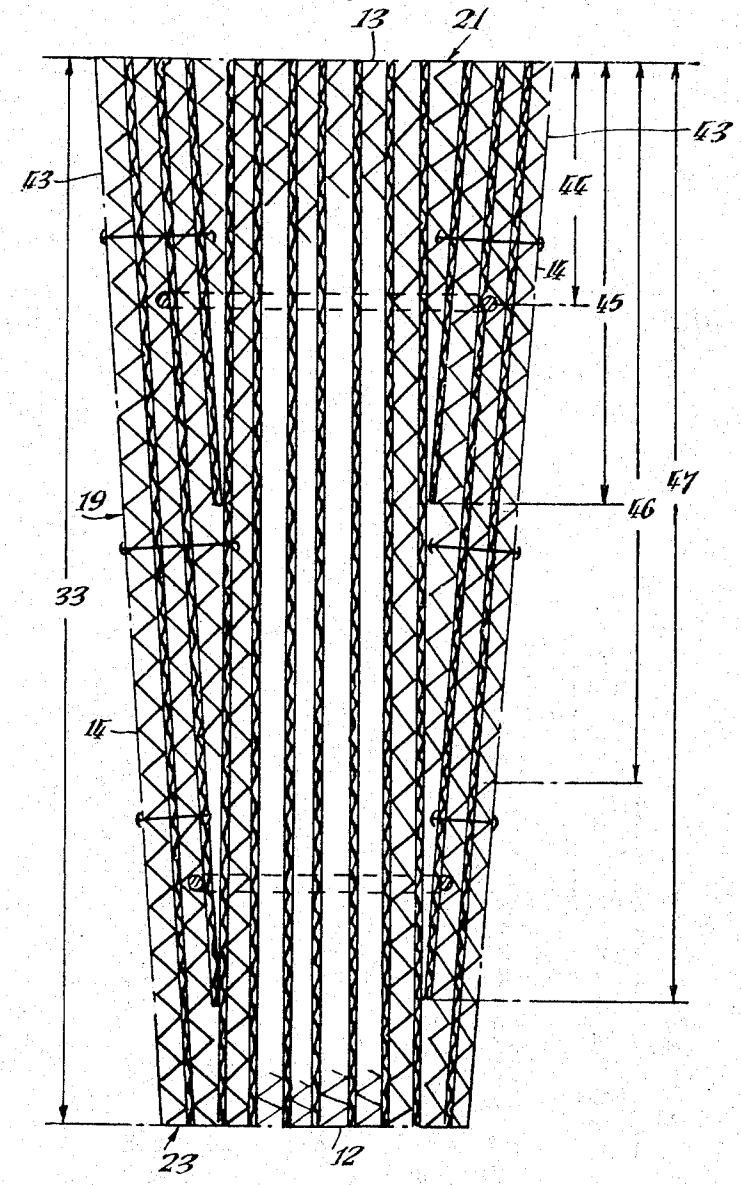
REGENERATIVE HEAT EXCHANGERS

Filed Oct. 12, 1965 4 Sheets-Sheet 4

Fig. 5.



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REGENERATIVE HEAT EXCHANGERS

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6 Claims. (Cl. 165—10)

ABSTRACT OF THE DISCLOSURE

The pack of plates which is disposed in the chamber of a regenerative heat exchanger and which comprises corrugated plates alternating with flat or undulated plates comprises at least one sub-pack which is substantially in parallelogram form together with at least one sub-pack which is wedged shaped but not a parallelogram which are assembled together to form a pack which is trapezoidal in cross section.

This invention relates to regenerative heat exchangers of the kind which comprises, inter alia, a substantially cylindrical regenerative heat exchange member, hereinafter referred to as a regenerator, which is subdivided by radial walls and partitions and by concentric and substantially cylindrical walls and partitions to form chambers which are substantially of trapezoidal shape when viewed along or parallel to the axis of the regenerator, and which extend substantially the whole of the axial length of the regenerator, which chambers are each adapted to receive a pack of plates, the pack of plates in all of the chambers providing the heat exchange mass of the regenerator.

A pack of plates, when disposed in its chamber, also is of trapezoidal shape in end elevation, by reason of its side nearer to the axis of the regenerator having to be shorter than the side remote from the said axis.

The pack of plates, in many cases, comprises corrugated plates alternating with flat or undulated plates, the latter plates providing abutments for the ridges of the corrugations of the former plates whereby passages are provided along which gaseous fluids flow in order, in one event to give up heat to the plates, and in another and alternate event, to take up heat from the plates. The corrugations in the former plates extend substantially parallel to the axis of the regenerator, and from end to end thereof, so that the said gas flow passages also extend substantially parallel to the axis of the regenerator and from end to end thereof.

In the art of regenerative heat exchange regenerators, plates are referred to as "corrugated" plates when they are provided with sharply angular and deep corrugations to provide a transverse thickness, between the planes of the ridges on opposite faces, of approximately 5 mm. to 7 mm., whereas plates are referred to as being "undulated" when they are provided with sharply angular or sinuous corrugations which are shallow to provide a transverse thickness, between the planes of the ridges on opposite faces, of approximately 2.5 mm. Furthermore, when undulated plates alternate with corrugated plates, while the corrugations of the corrugated plates extend substantially parallel to the axis of the regenerator, the corrugations of undulated plates extend at an angle of substantially 30 degrees to the said axis; thereby, the ridges of the corrugated plates extend across the abutting ridges of the undulated plates.

Consequently, in order that a pack of plates should adopt the required trapezoidal shape when in position in the regenerator chamber, it can be made substantially rectangular in end elevation and then compressed, tapered, to provide a shape with one side shorter than the opposite side and with the other two sides tapering towards each other. Alternatively, the corrugated plates are made, by a complicated rolling process, so that the height of the corrugations (that is, the distance between the planes of opposite faces of the plates) varies gradually from one edge which is parallel to the corrugations to the opposite edge, for example, from a corrugation height of approximately 7 mm. at one said edge to a corrugation height of approximately 5 mm. at the opposite edge; thereby, when a plurality of such corrugated plates, alternating with flat or undulated plates, are assembled together to form a pack, the pack has its required trapezoidal shape without having to be compressed.

In either event, a pack of plates so made has the disadvantage of having differential hydraulic radii, which may be excessive on the outer longer side, that is the side remote from the axis of the regenerator, thus providing a poor heat exchange coefficient, or which may be too small at the inner shorter side, nearer the axis of the regenerator, with the attendant risk of the flow passages being plugged with soot or dirt deposited by the flowing gases. When the corrugated plates are rolled to provide a differential in the height of the corrugations, the virgin flat plates must be cut to a definite shape and size before the rolling is effected, and the resultant shape may be affected by tolerances in the thickness of the plates causing the preshaped virgin plate to produce a larger or smaller resultant shape. Furthermore, the cost of such rolling, including the manufacture of the special rolls required, is very large.

The object of the present invention is to provide a pack of plates for a regenerator which is of the required trapezoidal shape and which can be produced cheaply and easily from corrugated plates having a constant corrugation height.

According to this invention, a pack of plates for disposing in a trapezoidal chamber of a substantially circumferential regenerator of a regenerative heat exchanger comprising corrugated plates alternating with undulating or plain plates is characterised in that each corrugated plate has corrugations all of equal height, and that at least one first sub-pack which is substantially a parallelogram in cross section is assembled together with at least one second sub-pack which is rectilineal but not a parallelogram in cross section to provide a pack which is trapezoidal in cross section, all of the plates in a sub-pack being parallel to each other.

Referring to the accompanying drawings:

FIG. 1 is a perspective view of a pair of alternating corrugated and undulated plates in a regenerator pack of plates;

FIG. 2 is a diagrammatic end elevation of a pack of plates as hitherto constructed;

FIGS. 3, 4 and 5 are diagrammatic end elevations of packs of plates according to three different embodiments of the invention.

Referring to FIG. 2, the pack **11** of plates shown therein is trapezoidal in end elevation, that is when viewed along or parallel to the axis of the regenerator, so that it can be placed in a similarly shaped chamber of the regenerator with the short side **12** near the axis of the regenerator, the opposite longer side **13** remote from the axis, and the two other sides **14**, **14** extending along radii of the regenerator. Corrugated plates **15** alternate with undulated plates **16** to provide gas flow passages **17** which each extend parallel to the axis of the regenerator and between the axial ends of the regenerator.

The arrangement of a corrugated plate **15** and an adjacent undulated plate **16** is shown in FIG. 1, which illustrates how the ridges of the corrugated plate abut and

lie across the ridges of the undulated plate thereby to provide the gas flow passages 17.

The corrugations in the corrugated plates 15 have a height 18 varying from approximately 7 mm. at the edge of the plate disposed at the side 13 of the pack to approximately 5 mm. at the edge of the plate disposed at the side 12 of the pack. The outline of a regenerator chamber into which the pack of plates is placed is shown at 19. The plates 15 and 16 are held together, to form the pack 11, by binding wires 20.

In the embodiment of the invention shown in FIG. 3 a sub-pack 21 of alternating corrugated plates 22 and undulating plates 16 is provided as a core for the complete pack 23, the corrugations of the plates 22 having a height 24 which is constant throughout each plate. All of the plates 22 and 16 are of the same width 33, which is substantially equal to the mean radial length of the sub-chamber 19. Thereby, the sub-pack or core 21 is rectangular in end elevation as seen in FIG. 3, having the sides 25 of the rectangle substantially equal in length to the short side 12 of the pack. The plates 22 and 16 in the rectangular sub-pack 21 are bound together by encircling binding wires 20. In each of the remaining two triangles 26 at the outer sides 14 of the pack there is disposed an assembly 27 of alternating corrugated plates and undulating plates which is substantially a right-angled triangle, the alternating plates having varying widths 28, 29, 30 and 31. Each assembly 27 is secured to the rectangular sub-pack 21 by nails 32 or other suitable fastening devices so as to form an integral trapezoidal pack 23. The corrugations in any corrugated plate in the sub-pack 21 and in the triangular assemblies 27 are all of the same height 24, and consequently the corrugated plates which are used are comparatively cheap because they do not require to be produced by complicated and expensive rolling methods. All of the plates in the pack 23 are substantially parallel to each other.

In the embodiment of the invention shown in FIG. 4, two sub-packs 34, 34 are each formed of alternating corrugated plates 22 and undulating plates 16, the corrugations of the plates 22 all being of the same invariable height 24, the plates 22 and 16 being so assembled together that each sub-pack 34 is of rhomboid form in end elevation, as seen in FIG. 4, having their end sides 35 substantially equal to half the dimension of the short side 12 of the complete pack 36. The two sub-packs 34 are disposed with a short side 35 of each co-planar to form the short end 12 of the pack 36, with the two sub-packs diverging from each other to leave a triangular space therebetween which is substantially filled with a triangular assembly 37 of alternating corrugated and undulating plates. The plates in the triangular assembly 37 have varying widths, 38, 39, 40 and 41, and they are secured together by nails 32 or other suitable fastening means. The whole pack 36, comprising the two rhombic sub-packs 34 and the triangular assembly 37 is bound together by encircling binding wires 20 to provide an integral pack. The corrugations in the corrugated plates 22 of the two sub-packs 34 and the assembly 37 are all of the same height 24, and therefore all of the plates in a sub-pack 34 or in the assembly 37 are substantially parallel to each other.

An advantage provided by the construction shown in FIG. 4 is that only a triangular portion of the pack need be nailed. The outer binding wires 20 hold all the plates of the pack together, even though the nail connections 32

of the triangular parts of the pack loosen a little, for instance, during transportation of the packs.

The embodiment of the invention shown in FIG. 5 is a modification of that shown in FIG. 3, in that the pack 23 comprises a rectangular sub-pack 21 providing the core of the pack and two outer irregularly shaped assemblies 43 composed of alternating corrugated and undulating plates, the plates in the assemblies 43 having varying widths 33, 44, 45, 46 and 47. The assemblies 43 in FIG. 5 differ from the assemblies 27 in FIG. 3 in that the wider plates, having the width 33, are disposed at the outside of the pack 23 while the shorter width plates are disposed inwardly of the pack. Consequently, while the plates in the sub-pack 21 are not parallel to the plates in the assemblies 43, all of the plates in the sub-pack 21 or in each of the assemblies 43 are substantially parallel to each other.

Obviously, in all of the embodiments shown in FIGS. 3, 4 and 5, the undulated plates 16 can be substituted by flat or uncorrugated plates, that is plates which are known in the art of regenerative heat exchangers as "plain" plates.

The packs of plates according to the present invention are simpler and cheaper to manufacture than previously, more particularly because all the corrugated plates are rolled straight from the strip or plate material and can be cut to the correct dimensions after rolling. Another advantage is that the trapezoidal cross-sections of the packs can have a greater conical taper than the prior art packs can provide.

What I claim and desire to secure by Letters Patent is:

1. In a regenerative heat exchanger having a regenerative portion containing a mass of plates which comprises corrugated plates alternating with undulating or plain plates, each corrugated plate having corrugations all of equal height, the improvement wherein the mass of plates comprises a plurality of sub-packs wherein at least one first sub-pack is substantially a parallelogram in cross-section and at least one second sub-pack is wedge-shaped and said at least one first and second sub-packs are assembled together to form a pack which is trapezoidal in cross-section and wherein all of the plates in a sub-pack are parallel to each other.

2. The improvement according to claim 1 wherein one first sub-pack is centrally disposed between two outer second sub-packs.

3. The improvement according to claim 2 wherein each second sub-pack comprises plates which vary in width.

4. The improvement according to claim 3 wherein the shorter width plates are disposed towards the outside of the pack.

5. The improvement according to claim 3 wherein the shorter width plates are disposed toward the centrally disposed first sub-pack.

6. The improvement according to claim 3 wherein one second sub-pack is centrally disposed between two outer first sub-packs.

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