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PLATE WARMER EXCHANGER

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FIG. 1

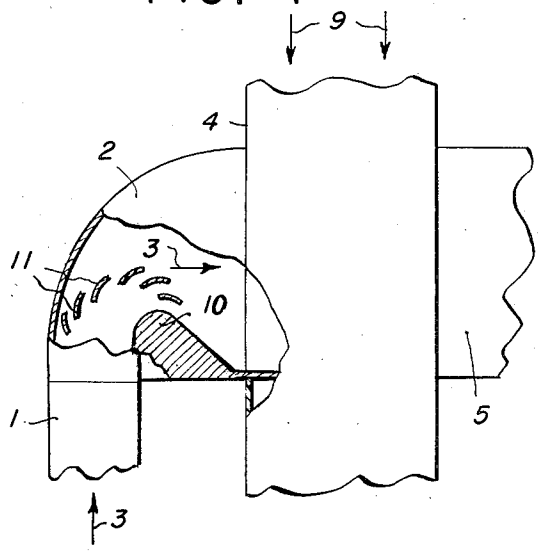


FIG. 2

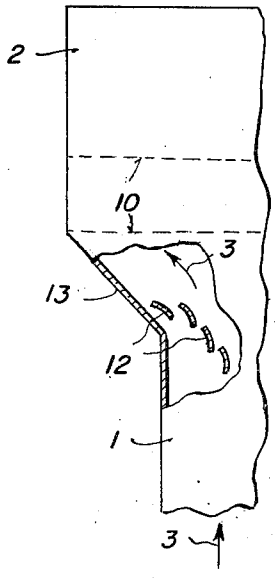
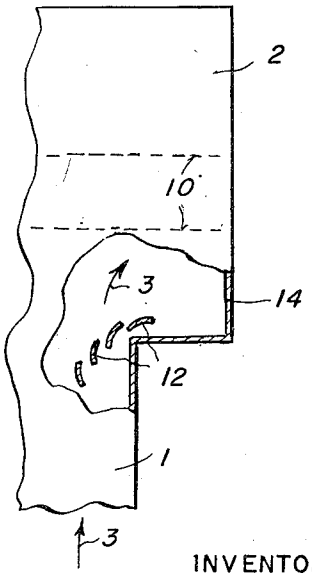


FIG. 3



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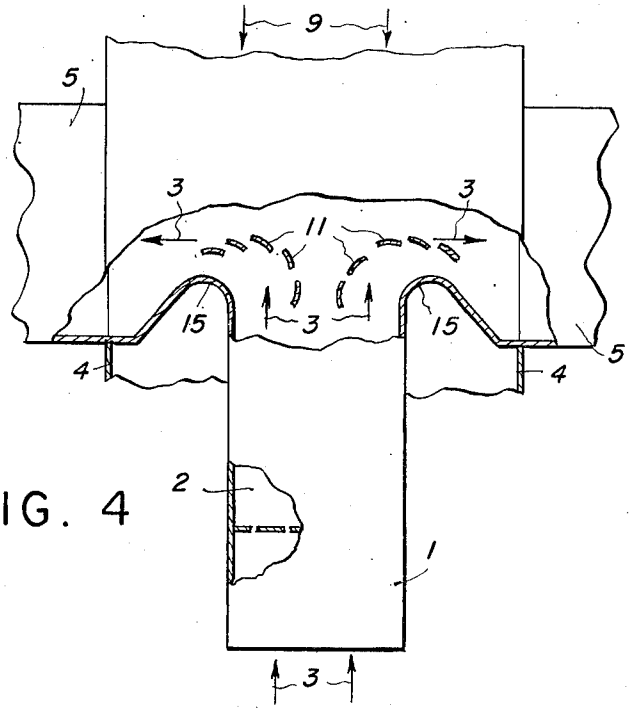
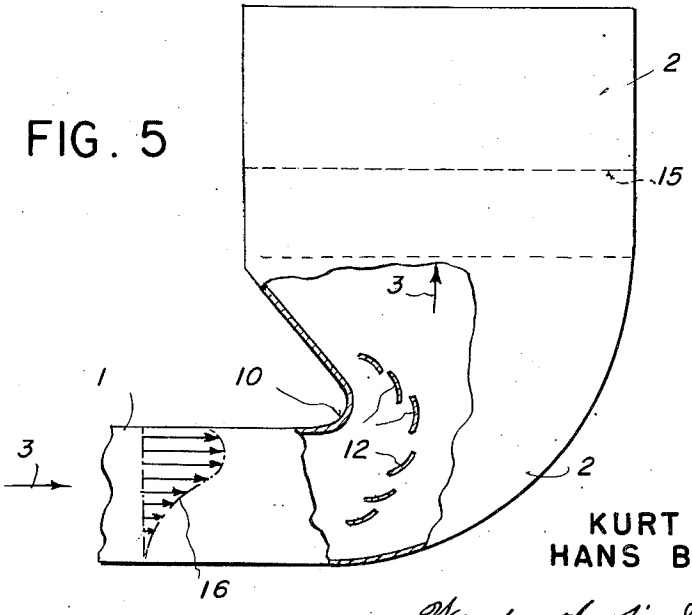


FIG. 4

FIG. 5



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FIG. 6

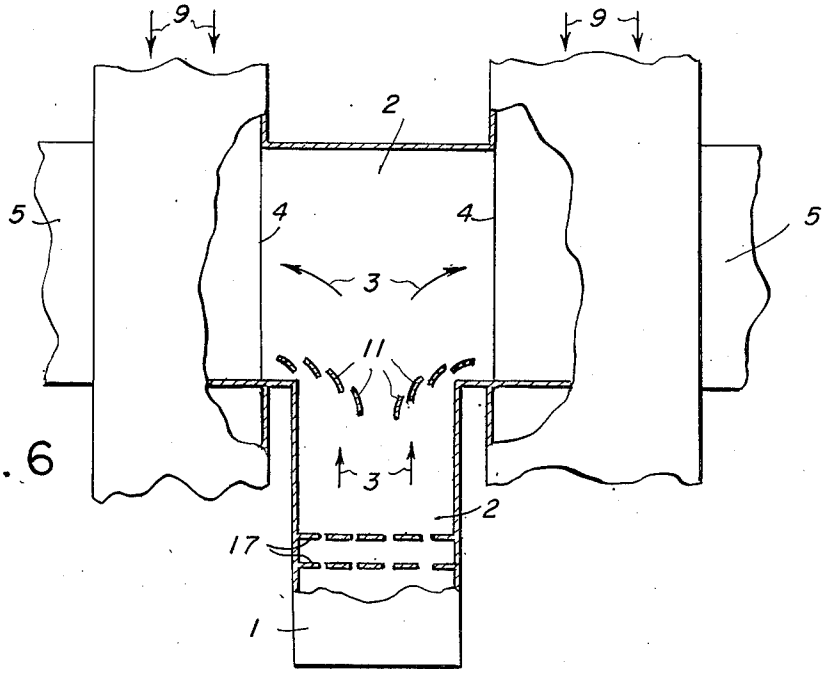
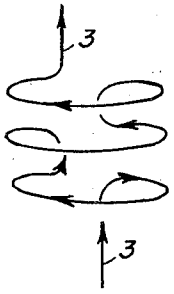


FIG. 24



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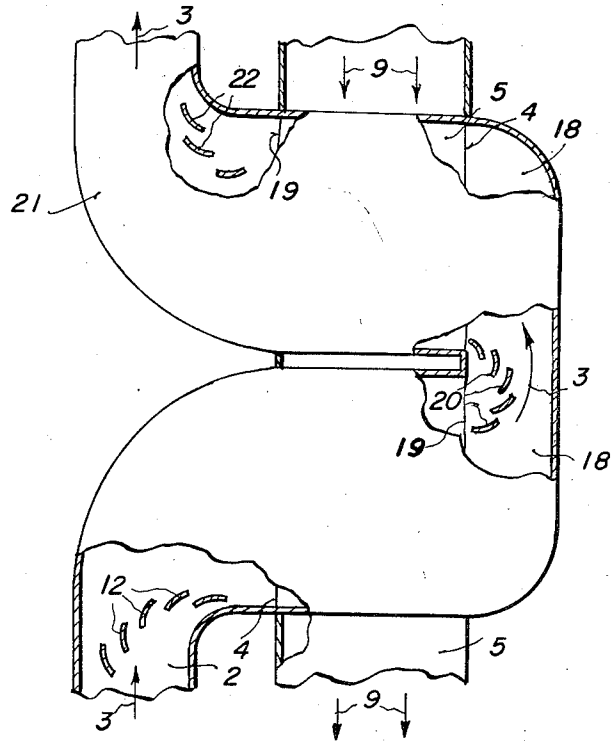


FIG. 7

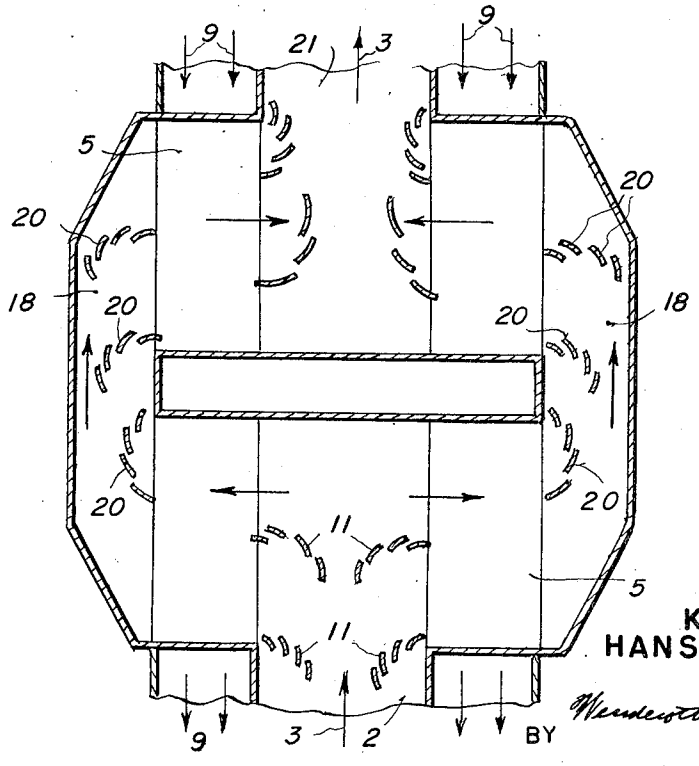


FIG. 8

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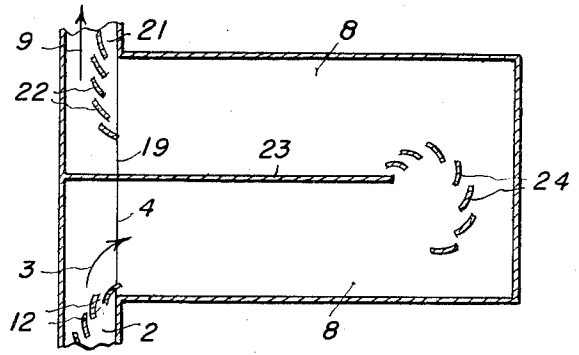


FIG. 9

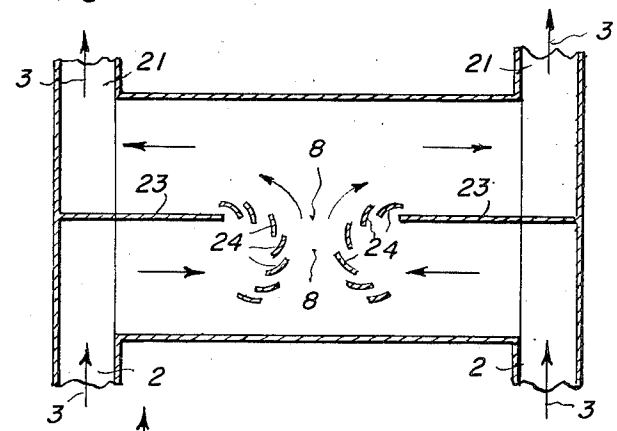


FIG. 10

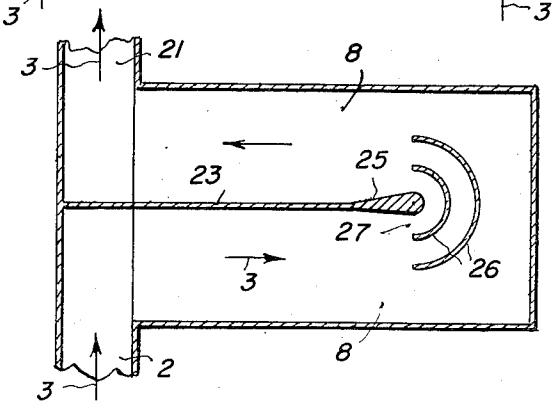


FIG. 11

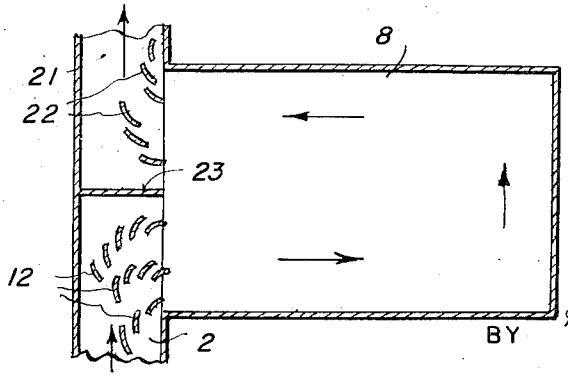


FIG. 12

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FIG. 13

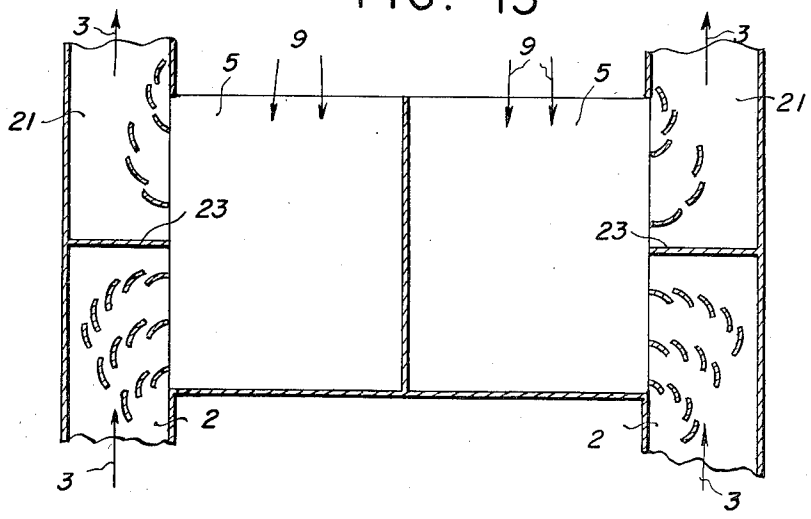


FIG. 14

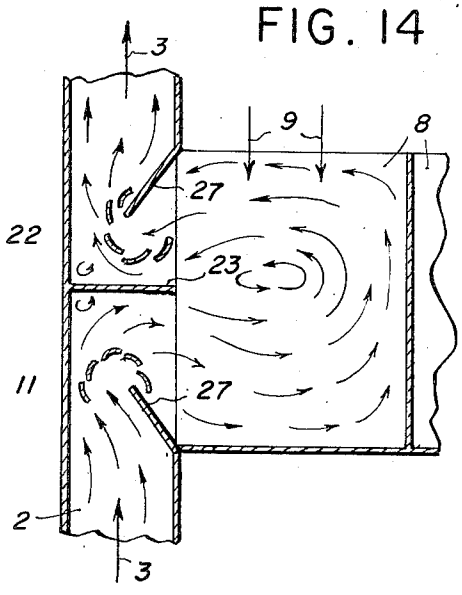
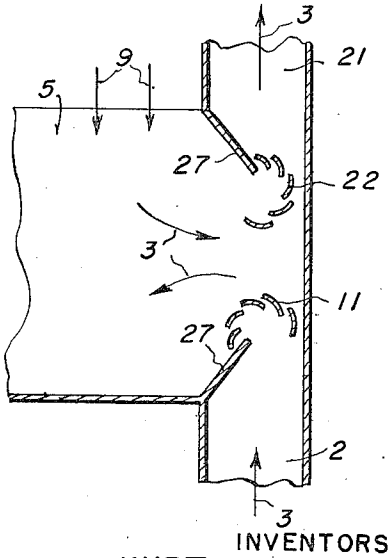


FIG. 15



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FIG. 16

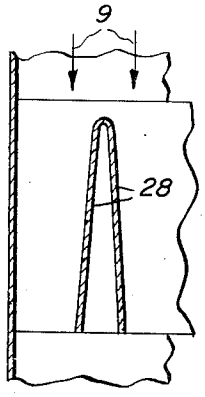


FIG. 17

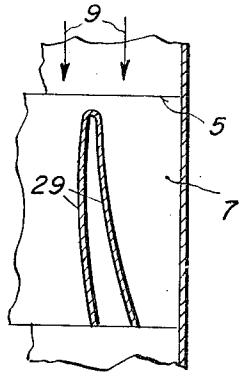


FIG. 18

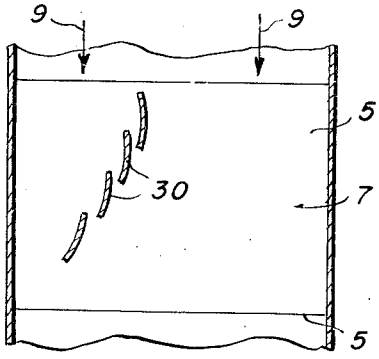


FIG. 19

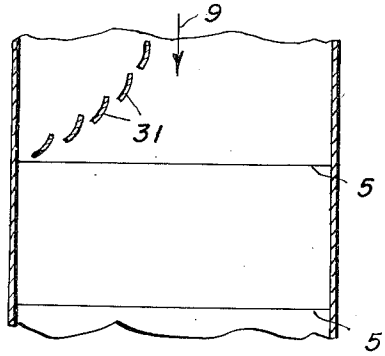
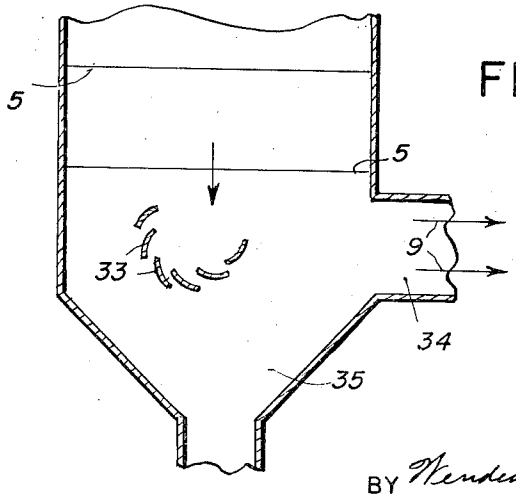


FIG. 20



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FIG. 21A

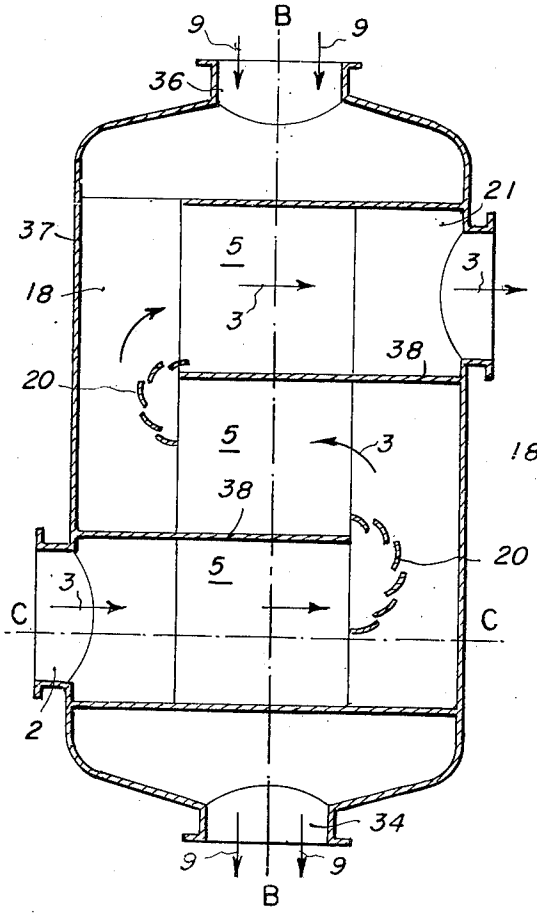
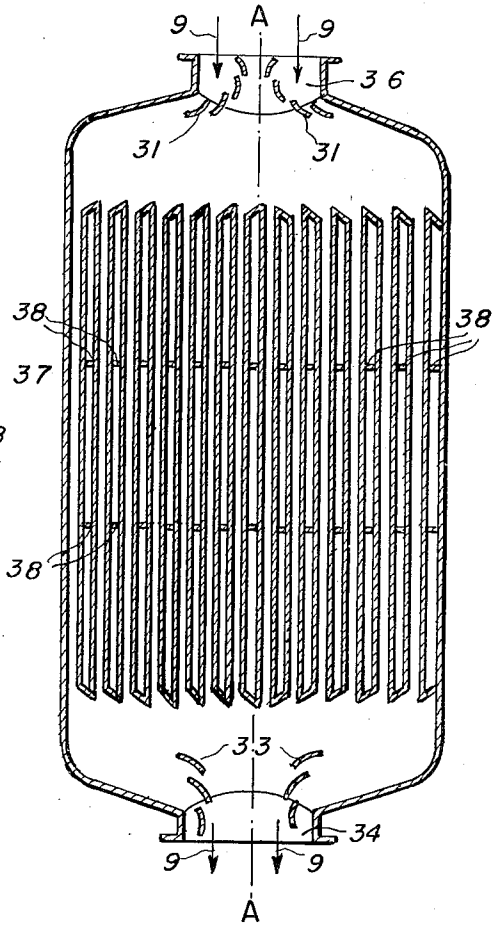


FIG. 21B



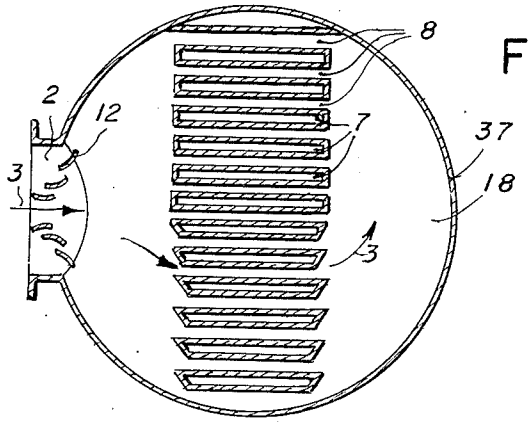


FIG. 21C

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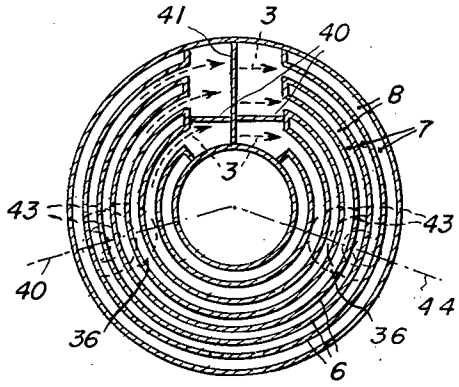


FIG. 22

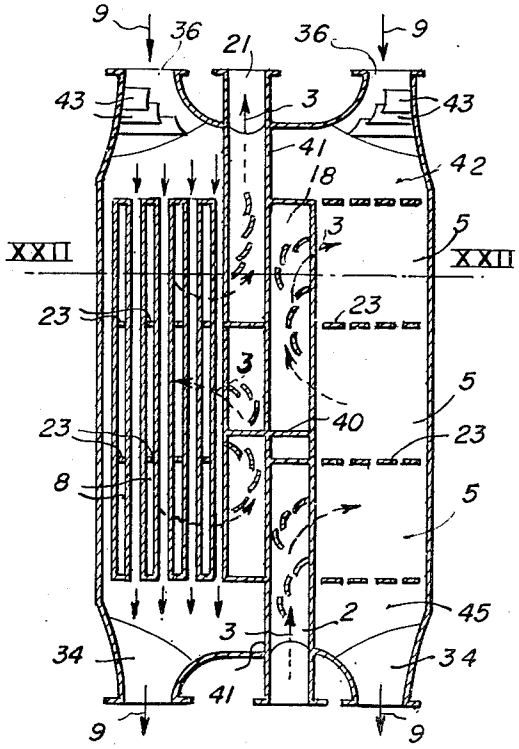


FIG. 23

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ATTORNEYS

United States Patent Office 2,768,814 Patented Oct. 30, 1956

2,768,814

PLATE WARMER EXCHANGER

Kurt Frey, Goggingen, near Augsburg, and Hans Behrens, Hamburg-Duvenstadt, Germany; said Behrens assignor to said Frey

Application October 23, 1951, Serial No. 252,734
Claims priority, application Germany October 27, 1950
2 Claims. (Cl. 257—256)

The invention relates to a plate heat-exchanger having metallic heat-exchange elements. Such plate heat-exchangers have, for some time, been becoming increasingly important, especially for heat exchange between gaseous media, for example, air and flue gas.

The principles of the operations which occur during heat exchange have become well known from the knowledge concerning the flow in the case of friction-affected media and from special researches in heat technology.

The plate heat-exchangers operate on the principle of forced convection; in the case of gases, the heat-absorbing medium undergoes an increase in volume, a nozzle effect (increase of speed, reduction of the thickness of the friction layer) therefore occurring in the case of a constant cross-sectional area. In the case of heat-evolving gases, the relationships are reversed; in this case, there is a diffusor effect while the cross-sectional area remains constant (reduction of speed, increase of the thickness of the friction layer or separation of flow).

In the case of tube heat-exchangers, to which the invention does not relate, these fundamental physical relationships are also found; however, an important difference lies in the fact that, in the case of a cross current or transverse current behind each tube, a detachment remains and that the flow through the flow paths takes place, not, as in the case of plate heat-exchangers, along smooth walls but with a continuous change of cross-sectional area and, therefore, with a greater loss of pressure; another important difference lies in the fact that the flow through the tubes gives a division into considerably smaller cross-sectional areas than in the flow through passages in the case of plate heat-exchangers.

These differences from plate heat-exchangers are an important reason why means and methods, which are correct and advantageous from the point of view of flow and heat technology, cannot, without difficulty, be applied with success to plate heat-exchangers and vice versa.

A longitudinal flow in the tubes of tube heat-exchangers has proved to be so unfavourable from the point of view of heat economy, that it is deliberately avoided as far as possible in all the known constructions. The enforcement of a transverse flow instead of a longitudinal flow in tube heat-exchangers has caused considerable difficulties and has been rendered possible only by the employment of expedients. Expedients which have been proposed are deflection gratings and guiding surfaces stepped like foresails.

In the case of such tube heat-exchangers, there are employed constructions in which, by means of reversing floors, the flow is caused to proceed in opposite directions through the tubes as it were in storeys. Guiding surfaces stepped like foresails have also been proposed for the deflection in such floors.

There is, per se, the same division into zones in the case of plate heat-exchangers, namely, inlet zone with inlet pipe, heat-exchange zone and outlet zone with outlet pipe. In contradistinction to tube heat-exchangers, there are in the heat-exchange zone, in the case of plate heat-exchangers, numerous parallelly connected, mostly very flat partial passages, between which no heat exchange can take place within this zone from partial passage to partial passage, whereas, in the case of tube heat-exchangers, there is communication between the individual flow paths; this is physically and in practice a fundamental difference, added to which there is great difference with regard to the character of the walls which has already been mentioned.

These differences are so important that, up to the present, the flow through plate heat-exchangers has been regarded as practically satisfactory when deflecting paddle-like guiding surfaces were arranged, at least in the inlet and outlet pipes. The following defects have been recognised for such arrangements:

Regard has not been had to the fact that the flow has a greatly disturbed distribution of speed over the cross-section on entering the inlet pipe, owing to the fan and partly also owing to abrupt deflections or enlargements of the cross-section or owing to slide valves or regulating valves or the like, and that the means employed for influencing the flow do not prevent this flow or do not prevent it sufficiently, but pass it on if no account is taken, as is indeed not done in practice, of powerful throttle-like effects which cause great losses of pressure; the result of this is a bad (non-uniform and, in certain circumstances, even negative) admission to the plate heat-exchanger. Regard has also not been had to the fact that the means employed can, in the case of uniform inlet, owing to the conditions (sudden deflections or sudden enlargements), operate only in a throttling manner and, consequently, great losses of pressure and detachment of flow result with an insufficient admission to the plates (passage inlets), if it is desired to keep the losses due to throttling within tolerable limits. These two defects are so great that the narrowing of the free cross-sectional flow, which in itself has an improving effect, in the inlet plane of the plate heat-exchanger, is not sufficient to effect a sufficiently uniform admission. In addition, the losses of pressure cannot again be introduced. The conditions at the outlet pipe are similar; they are especially important at this place if an inlet pipe again adjoins the outlet pipe. Obviously, there has been a misunderstanding of the physical knowledge relating to flow that turbulent flows are necessary for the temperature-conductivity of flows, since this knowledge, which applies to the difference between laminar and turbulent flows, has been erroneously applied also to coarsely turbulent flows, in which no heat-economy equivalent is afforded for the loss of pressure or for the loss of heating surface. The coarsely turbulent eddying, on the contrary, represents the change from the forced convection to the free convection and is therefore harmful.

Hitherto, the possible construction of elbow parts, in which, with small losses of pressure, secondary flows are produced, which increase the temperature-conductivity, has not been realised in the case of plate heat-exchangers, in view of the fact that the correct knowledge of the actual physical processes did not obviously exist in heat-exchanger production. Finally, owing to the non-observance of the formation of the friction layers and detachment of flow and, further, owing to the inappropriate selection of the speed distribution, the fact has hitherto been disregarded in flow technology that, in plate heat-exchangers, temperatures in excess of the dew-point temperature may take place locally, which excesses cause corrosions that destroy the material and that, further, local excess temperatures may occur which

result in a scaling of the material. Hitherto, corrosions and the like have been combated merely by mechanical means, for example by protecting caps, which, however, are themselves subject to corrosion.

The invention affords the means for a practical solution of the whole problem which is presented as follows in a simple manner:

Practically faultless passage of the flowing media through the whole plate heat-exchanger, from the point of view of avoidance of coarse turbulence, reduction of loss of pressure or energy, favourable utilisation of material with regard to heat economy and the avoidance of excess of temperature as well as of exceeding the scaling temperature.

The invention solves this problem by the preferably combined employment of partly known means for influencing the flow, i. e., fitting-in of conducting bodies, guiding-body like formation of the contour of the walls, guiding surfaces, especially stepped guiding surfaces or the like, in the inlet and outlet zones, preferably, therefore, in the inlet and outlet pipes; also, the fitting-in of guiding bodies, walls and guiding surfaces, especially stepped guiding surfaces in the passages, i. e., between the heat-exchange walls; fittings of the same or similar kind in deflection chambers, with or without a deflection wall, which are produced by assembling series-arranged heat-exchangers.

These expedients may, according to the invention, be employed in the first place for the passage of the heat-absorbing medium, for example air; the appropriate employment for the passage of the heat-evolving medium, for example flue gas, also gives advantages. A further important idea of the invention is to be seen in the fact that, with the employment or assistance of the means stated, by suitable passage of flow in the passages and by suitable adjustment of the speed distribution over the cross-sections of the passages in the heat-evolving and in the heat-absorbing parts, there is provided a close approximation to the ideal case in which there takes place, on all the heat-exchanging walls or plates, a passage of heat which is uniformly distributed over the whole of the heat-exchanging surface, there being produced in the flow, instead of large eddies, only small eddies which increase the temperature conductivity.

The said and further means of the invention, as well as different kinds of combinations of these and special means are represented in diagrammatic form, in various examples of employment and construction in the accompanying drawings, of which:

Fig. 1 is a partial elevational view, partly in section, of a heat-exchanger with a one-sided inlet pipe.

Fig. 2 is a side elevation, partly in section, of one modification of inlet pipe of Fig. 1.

Fig. 3 is a side elevation, partly in section, of a further modification of inlet pipe of Fig. 1.

Figs. 4 and 5 are, respectively, front and side elevations, with parts in section, of a T-shaped inlet pipe constructed according to the invention.

Fig. 6 is a front elevation, partly in section, also showing a T-shaped construction of inlet pipe.

Fig. 7 is a view partly in elevation and partly in section through an embodiment involving a plurality of superposed heat-exchangers.

Fig. 8 is a view corresponding to a vertical section through Fig. 7.

Figs. 9 to 15 are sectional views showing, in alternative embodiments, deflection between heat-exchanging plates according to the invention, the details of the several embodiments being set forth in the detailed description which follows; Fig. 14 also includes lines of flow.

Figs. 16 to 20, respectively, inclusive show additional partial sectional views of further embodiments according to the invention.

Figs. 21A, 21B and 21C illustrate, somewhat diagrammatically, a cylindrical heat-exchanger, Fig. 21A being a sectional view taken along line A—A of Fig. 21B, Fig. 21B being a sectional view taken along line B—B of Fig. 21A, and Fig. 21A being a sectional view taken along line C—C of Fig. 21A.

Fig. 22 is a sectional view taken along line XXII of Fig. 23.

Fig. 23 is a sectional view through a modified form of heat-exchanger.

Fig. 24 is a flow diagram for Figs. 22 and 23.

Referring first to Figs. 1 to 3, the feed pipe **1**, which comes, for example, from the blower, opens into the inlet pipe **2** which causes a deflection of the air flow **3** through 90° on an abrupt widening and leads the air from the inlet cross-section **4** to the heat-exchanger **5** proper. This heat-exchanger proper **5** is, in the known manner, constructed of plates which form flue-gas passages and air passages, the inlet and outlet edges being bevelled in the known manner. The flue-gas passages are traversed in transverse and cross flow as shown by the double arrow **9**. In the elbow-like outlet pipe **2** there is provided a filling body **10** which, together with the remaining parts of the wall, forms a diffusor-like enlargement. For the purpose of regulating the flow, there are provided, in the inlet pipe **2**, independently, or, as represented, in conjunction with the filling body **10** or similar elements, stepped guiding surfaces **11** which distribute the flow in the plane of Fig. 1 sufficiently uniformly over the passage-inlet cross-section **4**. For the purpose of distributing the flow in the direction or plane perpendicular to the aforesaid plane, i. e. in that of Figs. 2 and 3, there are provided, in the region of the abrupt widening, stepped guiding surface **12**. The widening may have, for example, the contour of an oblique wall, as shown in Fig. 2, or, as shown in Fig. 3, the wall contours **14** as a sudden widening. There is obtained, as the result of the whole arrangement, the well distributed inflow to the inlet apertures of the air passages which are now all sufficiently uniformly met and passed through by the flow. To a certain extent, the guiding surfaces **12** may be omitted from the widening (Figs. 2 and 3), if a sufficiently uniform distribution of the flow **3** in the pipe **2** is obtained by the damming and distributing action of the guiding surfaces **11** (Fig. 2).

Figs. 4 and 5 show similar constructions in front and side elevation; in this case, the feed pipe **1** communicates with a T-shaped inlet pipe **2** which possesses, instead of filling bodies **10**, a construction which is equivalent thereto from the point of view of flow technology, owing to suitable shaping of the wall parts **15**. Again, there are provided symmetrically arranged stepped guiding surfaces **11** which, without any harmful formation of eddies, deflect and spread the air stream **3** and uniformly distribute it over the inlet cross-section **4**. Here, in contradistinction to the representation in Figs. 1 to 3, where it extends vertically, the feed pipe **1** extends horizontally; the inlet pipe **2** produces a deflection of the air stream **3** through 90° with a widening in the manner of a diffusor with a large angle of widening, which widening is produced by filling bodies **10** or a suitable shaping of the contour of the wall. The stepped guiding surfaces **12** or the like, which are provided in the inlet pipe **2** and are independent or co-operate functionally with the filling body **10** or the like, distribute the flow over the cross-section with a uniform distribution of speed or pressure. In this way, detachments of the flow are largely obviated by such expedients; again (this is fundamentally of special importance), the distribution of speed in the feed pipe **1** and at the entrance into the inlet pipe **2**, which is in practice almost always non-uniform somewhat as shown by the diagram **16** in Fig. 5, is rendered uniform; in other words, this means that, on employing the means according to the invention, flow may be permitted without endangering the uniform distribution of flow over the inlet cross-section of the heat-exchanger.

This gives, for the construction, conditions which are simpler and easier to control, for example owing to saving of space.

Fig. 6 illustrates a likewise T-shaped construction of the inlet pipe; however, there has been chosen here an example in which, owing to the conditions as regards space which frequently occur in practice, the width of the inlet pipe must remain greatly restricted, so that the fitting-in of filling bodies 10 or correspondingly shaped wall parts 15 (Fig. 4) is impossible. The invention here provides for the employment, in the region of deflection, of guiding surfaces 11 which are symmetrically arranged in mirror-image fashion, in which case there may be placed in front of them, for the purpose of assisting the distribution of speed, throttling grids 17; however, in their place, guiding surfaces 12 may be fitted in independently or in conjunction with throttling grids, throttling screens or the like. Also, such an arrangement permits a very non-uniform distribution of speed 16 in the feed pipe 1, as is caused in most cases by, for example, centrifugal blowers.

Figs. 7 and 8 show the application of the ideas according to the invention to the construction, frequently employed in practice, with a plurality of separate heat-exchangers 5 which are superposed on one another in the manner of storeys. In the inlet pipe 2 there are again provided guiding surfaces 12 and guiding surfaces 11 in single or multiple arrangement for the purpose of distributing the flow in the two principal directions. The outlet pipe, behind the first heat-exchanger 5, which is traversed by the air stream 3, as well as the inlet pipe of the next heat-exchanger 5 of the upper storey, are united in the known manner to form a deflecting chamber 18, in which the deflection is effected, with a simultaneously obtained uniform distribution of speed over the inlet cross-section 4, without any substantial disturbance of flow, by stepped guiding surfaces 20 in single or multiple arrangement. After passing through the second heat-exchanger 5, the heated air stream 3, which issues through the outlet cross-section 19, is discharged through the outlet pipe 21 with deflection and reduction of cross-section, stepped guiding surfaces 22 or the like being provided here also for regulating the flow or for obtaining a discharge which is free from detachment and undisturbed.

In addition, Fig. 7 shows a single straight flow of the stream of flue gas 9, whilst Fig. 8 shows a double arrangement thereof.

Whereas, in the case of the examples hereinbefore shown, a deflection flow between the plates 6 has not been shown, this possibility will be elucidated in connection with the figures to be hereinafter described. This expedient, according to the invention, which has not hitherto been employed, is of special importance, because it allows the influencing of the flow and of the distribution of speed within the passages 8 and, if required, also within the passages 7. This part of the invention is specially effective in connection with the expedients already described.

In the case of Fig. 9, the inlet cross-section 4 and the outlet cross-section 19 lie in one plane at the same passage end; the inlet pipe and the outlet pipe 21 are arranged superimposed on each other. Inserted in the passage 8 is a partition 23 which does not extend right through the passage and which separates the inlet pipe 2 from the outlet pipe 21. The guiding surfaces 12 are provided, in the manner already described or in some other appropriate manner, in the inlet pipe 2 and the oulet pipe 21, with the result that an undisturbed inflow and outflow into and out of the passage 8 is produced. The deflection around the end of the partition 23 is effected free from disturbance to a high degree with the arrangement of suitably formed stepped guiding surfaces 24, which are arranged spatially in relation to the partition 23 in the passage 8 itself and which are welded in, for example electrically. It has been found in practice that the whole heat-exchange surface of such a passage 8 is effectively traversed by undisturbed flow 3.

A modification is shown in Fig. 10, in which the passage 8 is connected at its two ends to an inlet pipe 2 and an outlet pipe 21 respectively and in which partitions 23 are appropriately inserted on the left and right to a greater or smaller extent in the passage 8; two sets of stepped guiding surfaces 24 are arranged between these two partitions 23.

A further modification is shown in Fig. 11, in which the partition 23 has, on its end, a thickened portion 25 or the like, the cross-section of which is rounded as shown on one side and with which circularly bent guide blades 26 are associated. In this case, regard is to be had to the fact that the radius of curvature (r_1) of the thickened portion 25 should be at a ratio of about 1:1 to the width (b_e) of the next partial passage 27. The radius of curvature (r_1) of each guide blade 26 should also be at a ratio of about 1:1 to the width (b_e) of the outwardly adjacent partial passage; in this way, there are obtained, with a uniformly distributed flow, a deflection, which is sufficiently free from disturbance, in this region and a sufficiently uniform sweeping of the wall plates by the flow.

In the embodiment represented in Fig. 12, the partition 23 may be dispensed with in the region of the passage 8 when the guiding surfaces 12 and 22 are, in a special arrangement, principally in a multiple arrangement, provided in the inlet pipe 2 and in the outlet pipe 21; surprisingly, the effect is obtained in such a manner that an air stream corresponding substantially to the course shown in Figs. 11 and 13 is obtained, with the absence of the wall friction of the partition 23. In that case, even guiding surfaces 24 can be dispensed with in the passage 8, so that the invention provides the surprising possibility of controlling or of rendering uniform, with the aid of means located outside the passage 8, namely with the aid of, preferably, multiply arranged stepped guiding surfaces 12 and 22 in the inlet pipe 2 and in the outlet pipe 21, and to reverse the flow with only a small amount of eddying in the region of the separating layer of the flow in the opposite direction. This action is substantially maintained to a sufficient extent even if the part of the partition 23, which, in the embodiment shown in Fig. 12, separates the inlet pipe 2 from the outlet pipe 21, is wholly or partially dispensed with. It is obvious that such possibilities are adapted to contribute to the simplification of such constructions.

Fig. 13 shows a double arrangement of what is shown in Fig. 12, partly with a T-shaped construction of the kind shown in Fig. 6. In such a double arrangement, there may be employed, as shown in Fig. 14, in the inlet pipe 2 and also in the outlet pipe 21, a filling body which is shrunk together to form a plate 27 and with which corresponding guiding surfaces 11 and 22 are associated. The actual flow, which is indicated in this Fig. 14, shows that there is a sufficiently uniform flow in the passage 8.

Fig. 15 shows that the partition 23 between the inlet pipe 2 and the outlet pipe 21 can also be dispensed with in this case in certain circumstances.

In Figs. 16, 17 and 18 there are shown means which influence the flow of flue gas 9 or the flow of the heat-evolving medium as well as the formation of the friction layer between the plates of the heat-exchanger 5; although these plates form passages of constant cross-sectional area, these passages are, owing to the withdrawal of heat and the resulting diminution in volume of the flowing medium, equivalent to a diffusor in which friction layers rapidly become thicker, lead to detachment and, on the one hand, impair the transference of heat and, on the other hand, effect cooling of the flue gases near the wall to below the dew-point and cause deposition of soot. In Fig. 16 there is shown, as such a

means, a straight and somewhat wedge-shaped partition 28, in Fig. 17 there is shown a curved partion 29 and in Fig. 18 there are shown stepped guiding surfaces 30 in which the partial surfaces advantageously have, in part, a greater thickness of cross-section.

The influencing or the rendering uniform or regular distribution of the flow of flue gas 9 before its entry into the flue-gas passages 9 may, as shown in Fig. 19, be effected by fittings (known in flow technology) located in front of the heat-exchanger 5, for example the guiding surfaces 31 shown in the drawing. As shown in Fig. 20, fittings (known in flow technology) for the flue-gas flow 9 may also be provided after its emergence from the heat-exchanger 5; in the example shown in Fig. 20, a filling body, which has been shrunk together to form a plate 32, is shown with stepped guiding surfaces 33 which co-operate with the latter functionally; this arrangement effects a deflection of the flue-gas flow 9 and a discharge into the flue-gas discharge 34 with a good or uniformly distributed speed without the occurrence of detachment. The arrangement shown, for example, in Fig. 20 gives the special advantage that the distribution of the flue gases on flowing through the heat-exchanger is controlled more favourably and no damming zone for the flue gases occurs in the region of the cold-aid inlet. In the region of the intentionally selected low speeds, there is provided the ash-separating chamber 35 which preferably extends conically downwards. For the purpose of having regard to changes of temperature in the flowing media, in the case of a plurality of superimposed individual heat-exchangers 5, their heights may be made different as can be seen from Figs. 19 and 20.

In Figs. 21A, 21B and 21C, a cylindrical heat-exchanger is shown. In this embodiment, the heat-exchanger is equipped with a cylindrical casing 37; this may be advantageous and even necessary in the case of media under pressure. The casing 37 may also be lined with brickwork, as in the case of the flue-gas passage shown in Fig. 1. The inlet pipe 2 is provided with fins 12 which widen the air stream 3 horizontally, preferably stepped guiding surfaces and in mirror-image like symmetrical double arrangement. After passing through the first of a number of superimposed individual heat-exchangers 5, the air stream 3 arrives into the deflecting chamber 18 and is there passed, in the manner already described, by guiding surfaces 20 to the next higher individual heat-exchanger 5 and, in the same way, after passing through the latter, is passed through the next deflecting chamber 18 and, after passing through the last individual heat-exchanger 5, is discharged through the outlet pipe 21 which, in certain circumstances, is also provided with guiding surfaces (not shown). The separation of the passages 8 and the confining of the deflecting chambers 18 are effected by suitable partitions 38. The flue-gas flow 9 passes vertically downwards; in the flue-gas inlet 36 there are provided, in single or multiple arrangement, guiding surfaces 31 which distribute the flow of flue gas uniformly or in any desired speed distributor over the individual flue-gas passages 7 and, after passing through the flue-gas passages 7, if required with guidance and, consequently, with the rendering uniform of the speed by means of the guiding surfaces 33 arranged there, the flue gases pass through the flue-gas outlet 34.

It is precisely in the case of such arrangements with multiple deflection that the means of the invention prove to be specially successful; without their employment, the flow cannot really be controlled. In such arrangements, obviously, guiding surfaces or other flow-influencing means can again be arranged inside the passages 7 and 8.

In Figs. 22 and 23 it is shown that it is also possible, with special constructive means, to make the passages 7 and 8 annular. However, the annular passages 7 and 8 are provided with an interruption for the purpose of creating feed pipes and deflecting chambers, the end plates 39 being anchored by members 40 which are resistant to tension and, preferably, also to pressure; this arrangement possesses the advantage that, in the case of a very different pressure of the two flowing media, a statically favourable construction, which is constant as regards shape and is resistant to pressure, of the plates 6 or passages 7 is obtained. The members 40 may be divided and connected to the vertical partition 41 which divides the space produced by the interruption of the annular shape of the passages 7 and 8 vertically into halves. This space is, by means of this vertical wall 41 and horizontal partitions 23, divided into inlet pipes 2, vertically staggered deflecting chambers 18 and outlet pipes 21. The air stream 3 flows, while being influenced or deflected with the avoidance of disturbances by means of guiding surfaces provided in the inlet pipe 2, the deflecting chambers 18 and the outlet pipe 21, in a peculiar manner which can be seen from Fig. 24. The stream 3, which enters through the inlet pipe 2, is, after deflection, led through the annular passages 8 of the first of the individual heat-exchangers 5, which are superimposed on one another in the manner of storeys, and, after issuing from the passages 8, rises through the first deflecting chamber 18 to the next storey and flows through (in the direction opposite to that in which it flowed in the first storey) the passages 8 and then again reaches the next deflecting chamber 18 in the storey above and flows, again in the opposite direction, through the next, for example the uppermost, storey 5 and is there, after issuing from the passages 8, discharged through the outlet pipe 21. This continual change is favourable for the uniform exchange of heat. The introduction of the vertically descending stream of flue gas takes place through the flue-gas inlets 36 to the distributing chamber 42. These flue-gas inlets 36 are, as shown in Fig. 22, placed in such a manner that the lateral widening of flow is effected practically uniformly with the employment of guiding surfaces 43 (shown in dot-and-dash lines in Fig. 22). Thus, as can be seen from Fig. 22, they are, having regard to the width of the total space 18, 21, not arranged diametrically but on the sides 44 of a suitable obtuse angle. The stream 9 of flue gases which issues at the bottom after passing through the passages 7 is discharged from the collecting chamber 45 through similarly shaped flue-gas outlets 34.

With regard to the invention, it is also to be stated that the success has already been proved by experiments carried out in practice. The fitting-in of the means according to the invention in a suitable adaptation in a heat-exchange installation which has hitherto been regarded as economical as regards heat and especially favourable from the point of view of flow technology, gave, with values which remained at least equally good as regards heat economy, a measured reduction of the whole loss of pressure to a quarter of the value measured before the fitting-in of the means according to the invention; this means an enormous advance on the improvements otherwise obtained in this field only with trouble and in small partial steps.

What we claim is:

1. In a plate heat-exchanger having metal heat exchange elements and comprising an inlet zone, an outlet zone and a heat exchange zone from said inlet zone to said outlet zone permitting flow from said heat exchange zone to said outlet zone, and means defining flow passages in the inlet, heat exchange and outlet zones having abrupt enlargements of the cross-sectional areas of flow and deflections in the direction of flow, that improvement comprising means providing flow guiding surfaces in said zones at those points of deflection where the gases in the heat exchanger undergo a change in direction, the gases tending to produce a separation zone in the cross section of the flow passage, said guiding surfaces including deflecting means at the boundary of the zone of separation to uniformly deflect the gases into the static and eddied zones thereby forming a substantially uniform

cross sectional flow pattern; said deflecting means comprising a staggered series of curved vanes, partially overlapping each other, the curved vanes being each disposed on the suction side of the subsequent vane, the resultant curvature of the series being greater than the curvature of any single vane, the amount of overlap of the vanes with respect to each other providing a jet directed velocity vector in a direction substantially tangential to the resultant curvature of the series, the resultant curvature of the series being defined by the curve which joins the intersections of the chords of the vanes, and the angle of attack of the first vanes being negative with respect to the direction of the velocity vector of the incident gas stream.

2. A plate heat exchanger as claimed in claim 1, and throttling grids arranged between said guiding surfaces and said heat exchange zone.

References Cited in the file of this patent

UNITED STATES PATENTS

1,927,095	Lucke	Sept. 19, 1933
1,964,845	Dietze et al	July 3, 1934

FOREIGN PATENTS

328,076	Great Britain	Apr. 24, 1930
612,012	Great Britain	Nov. 8, 1948
624,676	Great Britain	June 14, 1949