

Nov. 19, 1957

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2,813,708

DEVICES TO IMPROVE FLOW PATTERN AND HEAT TRANSFER
IN HEAT EXCHANGE ZONES OF BRICK-LINED FURNACES

Filed Oct. 8, 1951

5 Sheets-Sheet 1

FIG. 1

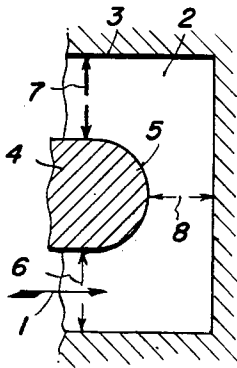


FIG. 2

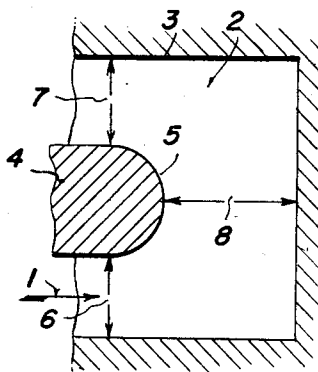


FIG. 3

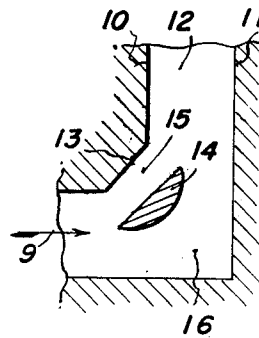


FIG. 4

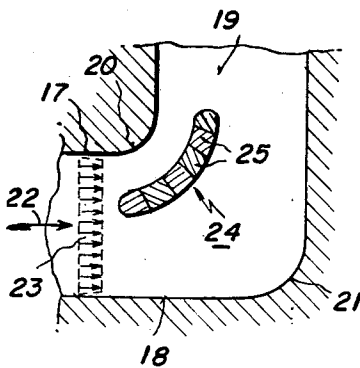


FIG. 5

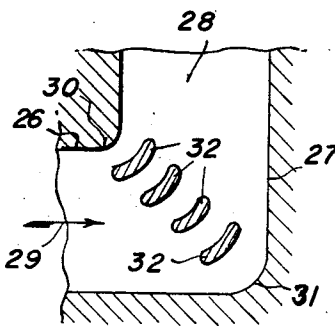


FIG. 6

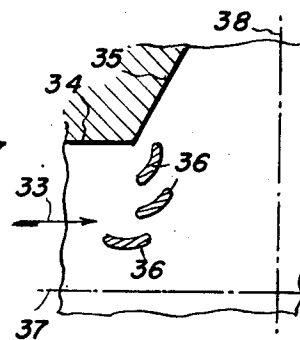


FIG. 7

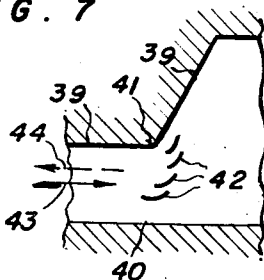
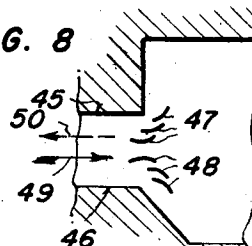


FIG. 8



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FIG. 9

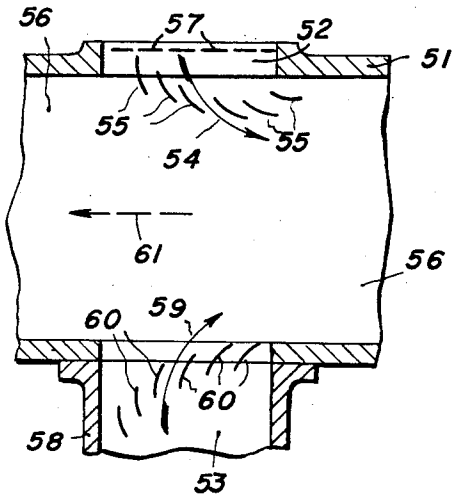


FIG. 10

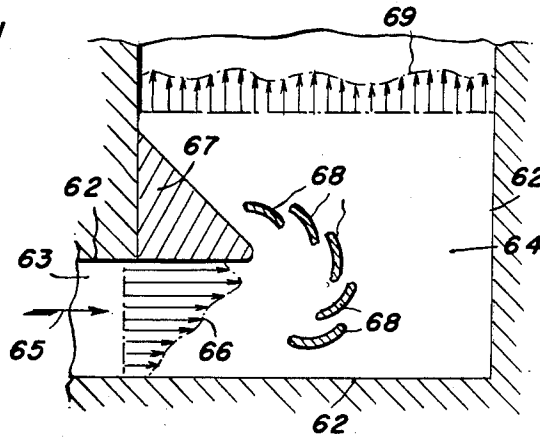


FIG. 11

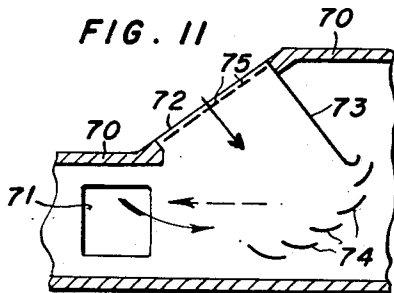


FIG. 12

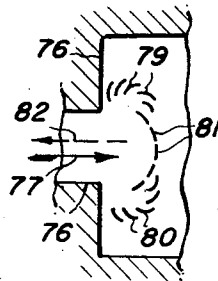


FIG. 13

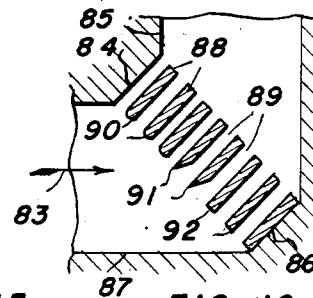


FIG. 14

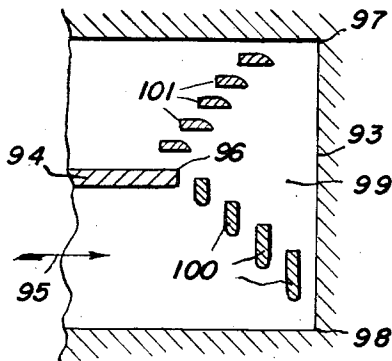


FIG. 15

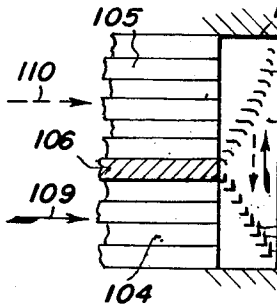
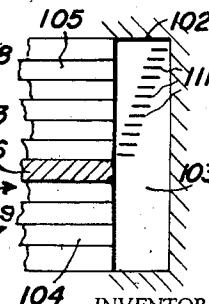


FIG. 16



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FIG. 17

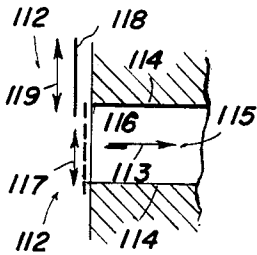


FIG. 18

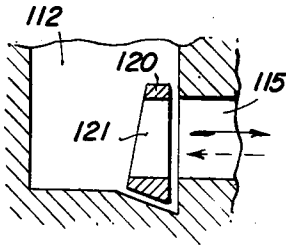


FIG. 19

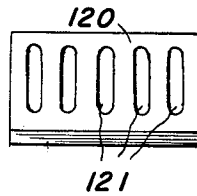


FIG. 20

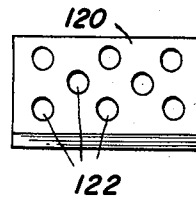


FIG. 21

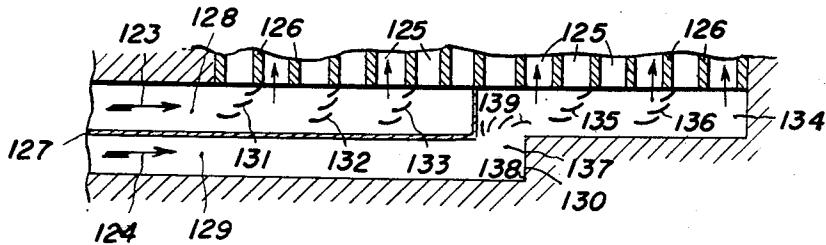


FIG. 22

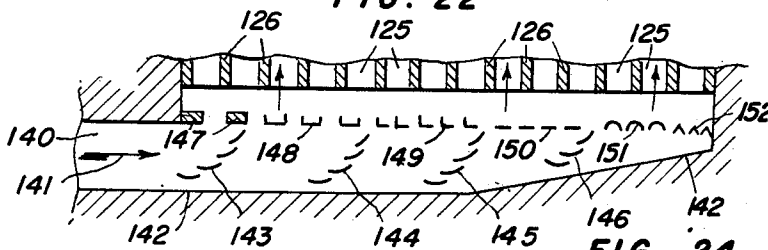
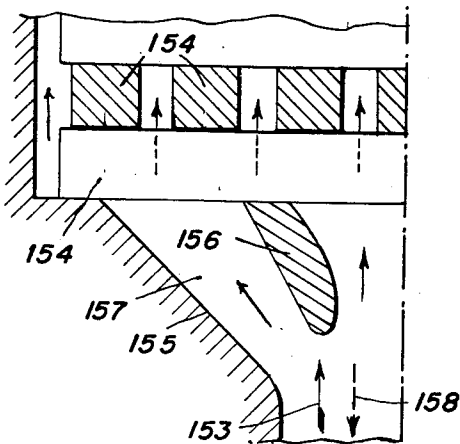
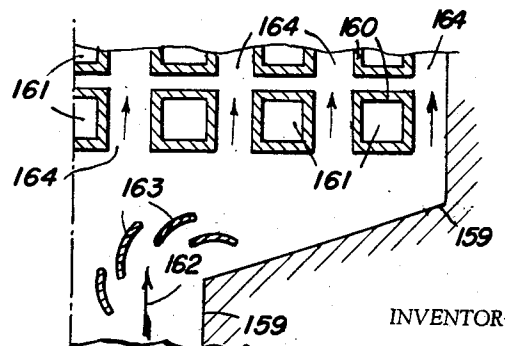


FIG. 24

FIG. 23



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FIG. 25

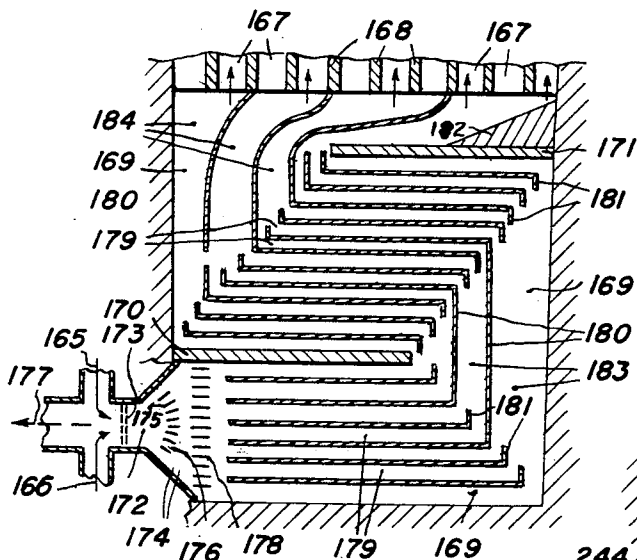


FIG. 31

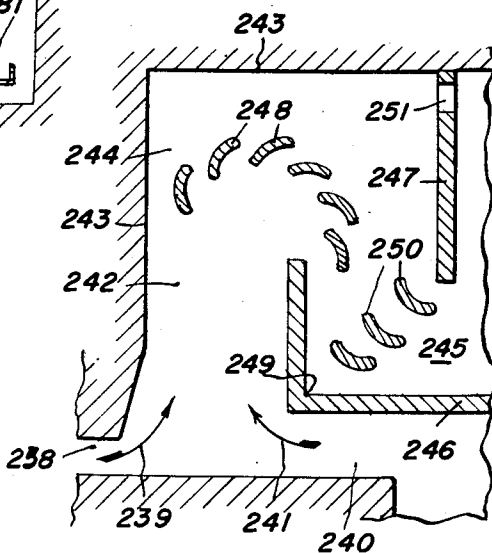


FIG. 32

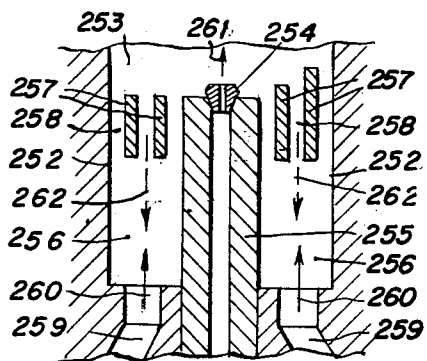
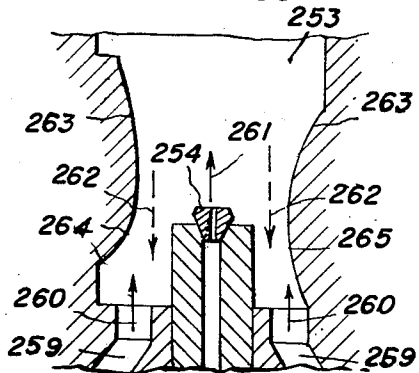


FIG. 33



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FIG. 26

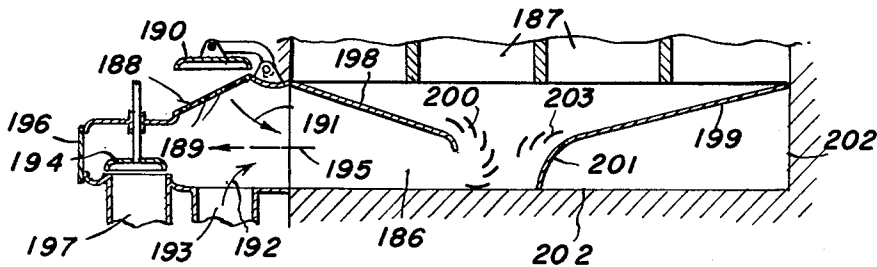


FIG. 27

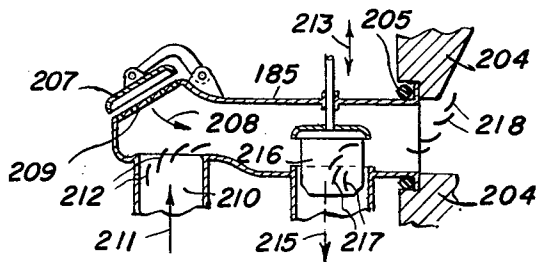


FIG. 28

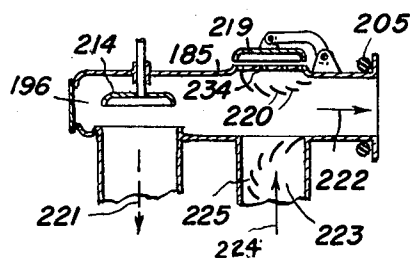


FIG. 29

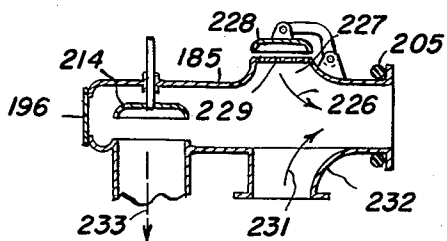
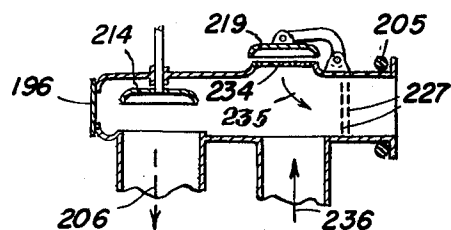


FIG. 30



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DEVICES TO IMPROVE FLOW PATTERN AND HEAT TRANSFER IN HEAT EXCHANGE ZONES OF BRICK-LINED FURNACES

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Application October 8, 1951, Serial No. 250,362

1 Claim. (Cl. 263—51)

In recuperative and also in regenerative heat transmitters or heat exchangers of refractory brick, in industrial furnaces of refractory brick such as muffle furnaces, enameling furnaces, open-hearth furnaces, coke furnaces or similar equipment, heat is transmitted to the brick by flowing burning or burned gases partly by radiation and partly by convection, and from these brick heat is given off again to material in the furnace, to flowing air, or to other flowing gases. In all these processes the flow pattern is of great importance. However the equipment hitherto used is not built to provide a proper flow pattern, at least at the vital points; large detachments of the flow, highly irregular and poorly adapted velocity distributions, poor guiding or widening of the flow at existing sudden bends and abrupt cross-section enlargements, are encountered in most, if not all, of the conventional furnaces. The conventional brick-lined furnaces and heat exchangers may have good flow patterns under one set of operating conditions but frequently this set of conditions is not that which is observed in actual practice and separation of the flow with concomitant poor heat transfer and the development of hot spots occurs in actual practice to materially detract from the efficiency of the furnace and heat exchange operation.

In recuperative and regenerative heat exchangers and heat transmitters and in industrial furnaces there results, due to a sharp deviation of the real flow development from the assumed flow development, extremely irregular heat transitions which at many points are on the one hand extremely high and on the other hand at some points almost lacking. By means of forced convection and as a result thereof heat stresses and local overheating or insufficient heating of the brick material frequently results and the consequence of this, in turn, is loss in the utilization of the thermal properties of the brick, with the additional tendency of the brick to crack due to uneven heating which introduces further hazards to the safety of operation. The flame length is frequently impossible to control due to operations which occur in the flow pattern. A further consequence is the greatly reduced stability of the brick material, the premature destruction thereof, stoppage of section zones due to crumbling brick material, etc. The average hot-air or hot-gas (e. g. weak gas) temperature remains lower than is desirable, while the average waste gas temperature as a rule assumes an undesirably high value. Especially in industrial furnaces such as muffle furnaces, etc., the design entails excessively strong and excessively large eddy zones, which brings about the formation of so-called dead-water areas in and after sudden bends or enlargements in the cross section and the accumulation of slag deposits at such points; such deposits or accumulations cause a continuing weight increase at the affected brick walls or vaults with overheating and harmful control spots developed.

The present invention provides devices for the improvement of the flow pattern in the refractory brick-lined channels of coke furnaces, muffle furnaces and the like

wherein the combustion gases and air are subjected to changes in direction due to the connection of the inlet and outlet channels within the furnace so as to provide a poor flow pattern in which there are formed separation zones in the cross section of the fluid stream, static and eddy areas immediately adjacent the main flow of the gases and air through the channels, the improvement by the devices of the present invention comprising providing deflecting means at the boundary of the zone of separation to deflect the gases into the static zone, said deflecting means comprising a staggered series of curved vane guiding surfaces, 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 being sufficient to provide a substantial 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 cords of the vanes, the angle of attack of the first vanes being negative with respect to the direction of the velocity vector of the instant gas stream.

An object of the present invention is to overcome the drawbacks of prior known devices and the invention provides deflecting means at the boundary of the zone of separation in the cross section of the channels between the inlet and outlet openings of brick-lined furnaces, heat exchangers and the like to deflect the gases into the static zone between the zone of separation and the brick-lined channel wall, said deflecting means comprising a staggered series of curved vane guiding surfaces, 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 being sufficient to provide a substantial 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 cords of the vanes, the angle of attack of the first vanes being negative with respect to the direction of the velocity vector of the instant gas stream. By means of the invention pressure losses are reduced, whereby in turn the current costs of operation and also the production costs become smaller; for example, with the same output the equipments may be given smaller dimensions, hence providing a better utilization of space and at the same time more favorable possibilities for more efficient dust-removal chambers and slag-deposit chambers in the equipments.

A further object of the invention is to make it possible to control the heat transition as to quantity and space by varying the heat transmitted by convection, and by reducing the heat transmitted by radiation.

Further objects of the invention will be apparent from the following detailed discussion of preferred embodiments of the invention taken together with the accompanying drawings, in which:

Figs. 1 to 12 are partial views of apparatus embodying the features of the present invention and relating to a streamline principle;

Figs. 13 to 20 are views similar to Figs. 1 to 12 but embodying a resistance principle; and

Figs. 21 to 33 are partial views showing the use of combinations of means in varying devices and equipment.

The invention locates deflecting means at the boundary of the zone of separation for the improvement of the flow, particularly for the elimination of large detachments of the flow and for the improvement of the velocity distribution of the flow through one or more interior cross-sections and also serves for the mutual adaptation of the

velocity distributions through one or more cross-sections traversed alternately in different directions or in neighboring interior cross-sections traversed simultaneously by different media, for example, in crossing flow or in transverse flow.

Flow-influencing means which act according to a streamline principle are for example: flow-influencing stream-lined shaping of the inner channel walls at bends and enlargements in the flow path; roundings of the interior, for example with radii of curvature which are about equal to or larger than the width of the channel section ahead of the rounded part; gradual constrictions, for example in combustion chambers with the narrowest point at about the level of the starting end of the flame, for example the fuel gas outlet of the nozzle, and with gentle enlargement following in the direction of flow. To provide for streamlined shaping of the channels, arched brick construction as is conventionally used may be employed. In one of the embodiments of the invention, the deflecting vanes may be arranged in a diagonal arrangement in the crest of the bend of a channel with such a radius of curvature of the inner bend crest and such inner radii of curvature of the partial channels defined on opposite sides of the vanes and between the walls of the brick-lined channels so that the radius of curvature is about equal to or greater than the inlet width of the partial channel. The division of a large enlargement by guide bodies or walls in two or more partial diffusers may have a total enlargement angle of the partial diffuser up to 10 degrees, and the guide surfaces of the vanes may be staggered in head-sail fashion.

Flow-influencing means acting according to a resistance principle, according to the invention, are for example: stationary grids, multiple grids, perforated plates, slotted plates and the like; closely spaced straight grids with rounded, tapered, or blunt shape of the head; straight grids, angular or rounded grids preferably in diagonal arrangement; grids of equal inlet and outlet width of the grid channels with close grid division; arched or rounded grids of unequal inlet and outlet widths of the grid channels; movable grids; displaceable grids, multiple grids, perforated plates, slotted plates and the like; slotted or perforated sliding bricks with equal or unequal subdivision of breaks such as slots or holes; grids fixed or displaceable as a unit with regulable passage cross-section, for example with shutter-like or slidably arranged grid elements; grids with directing wall effect; subdivision of a big enlargement into partial diffusers with total enlargement angle of the individual diffuser above 10 degrees; and deflecting walls.

Combined flow-influencing means according to the invention are, for example: means connected in series in the direction of flow; means according to the resistance principle as for example grids and guide surfaces or walls; means according to the streamline principle with subsequent means according to the resistance principle as for example guide surfaces and grids or as for example guide walls and grids; combinations of grids with grids lying in another plane and/or with guide surfaces and/or with arcs for example in and at the housing of a regulating valve; functional spatial coordination or combination of means according to the streamline principle; guide bodies or guide walls with or without breaks and with or without arching in spatial flow-functional coordination with guide surfaces, that is, preferably guide surfaces staggered in head-sail fashion; combination of several means according to the resistance principle; guide bodies or guide walls in functional spatial coordination or combination with grids; combination of several means according to the streamline principle, e. g. parallel or series arrangement of several sets of guide surfaces staggered in head-sail fashion or of a set of guide surfaces staggered in head-sail fashion and of a set of deflecting blades or vice versa, etc.

The drawings disclose examples of the foregoing means or individual elements according to the invention.

Figures 1 and 2 show a deflection of the flow arriving according to the arrow 1 by 180 degrees, the flow channel 2 being formed by the outer and inner masonry 3 and 4. At the deflection point the inner masonry 4 has a circular rounding 5. In the inlet the channel width 6 is about equal to the channel width 7 of the outlet, while the channel width 8 at the deflection point is at least nine tenths (Fig. 1) and at most one and a half times (Fig. 2) the dimensions of the channel width 6 or 7. With such proportions or ratios a sufficiently disturbance-free deflection is obtained in such a structural element, applicable to diversified equipment at different points and in diverse combinations especially when the radius of curvature of the rounding 5 is about equal to the channel width 7. Moreover, recuperator channels may be arranged in the inner masonry 4, about perpendicular to the plane of the drawing.

Fig. 3 shows a deflection of 90 degrees. The inflow according to arrow 9 is deflected in the channel 12 formed by the inner and outer masonry 10 and 11. The crest zone 13 slopes and the inside cross-section is subdivided at that point into two partial channels 15 and 16 by the provision of a guide body 14, such as a shaped brick. The flow body 14 can be variously designed, but is preferably flat inside and arched outside. This element, too, which is also suitable also for deflection angles other than 90 degrees, is applicable, like all of the elements later to be shown, in diverse equipment and combinations. With it, flow detachments are not avoided completely but are much smaller than without such a guide body 14.

In Fig. 4 the deflection of the channel 19 formed by inner and outer masonry 17 and 18 is provided with rounded parts at the inside crest 20 and at the outside crest 21. It is particularly suitable when the flow 22 arrives with a velocity uniformly distributed over the cross-section of the inflow, for example according to the velocity distribution diagram 23. The deflection point has installed in it a flow body 24, the rounding of which adapts itself to the crest curvatures 20, 21 and preferably lies closer to the inside crest 20. Such a flow body 24 may be built up of individual arch bricks 25 or the like. In the direction of flow 22, the distance between the inside crest 20 and the flow body 24, may advantageously decrease.

In a deflection according to Fig. 5, in which again inner and outer masonry 26 and 27 forms the channel 28, a deflection grid 32 is provided between the rounded inside crest 30 and the preferably rounded outside crest 31, for the purpose of substantially disturbance-free deflection of the flow 29. For each partial channel the radius of the inside arc should, for disturbance-free inflow 29, be about equal to the inlet width of the partial channel. In the case of greatly disturbed inflow 29, however, this radius should be much greater than said channel width.

Fig. 6 shows for the inflowing flow 33, an abrupt enlargement of the cross-section according to surfaces 34 and 35 of the masonry. For the uniform spreading and possibly also for the deflection of the flow there are provided here guide surfaces 36 of brickwork, staggered in head-sail fashion, in the zone of the crest of the walls 34, 35. Such a design may be supplemented by mirror-symmetry about the axes 37 or 38.

While for the elements according to Figs. 1 to 5 the flow development is independent of the direction of flow, in Fig. 6 and various of the subsequent figures, the flow development is more favorable in the direction shown in the drawing than in the opposite direction, so that in such arrangements for alternating direction of flow more care should be taken in selecting the arrangement. In practice, however, examples according to Fig. 6 and various of the following arrangements are nevertheless to be preferred for alternating direction of flow because

these arrangements are especially effective in one direction and because this direction of flow is then decisive for the purpose of heat transmission.

In Fig. 7 there is an abrupt unilateral enlargement, formed by the masonry walls 39, 40, of the inflow cross-section. At the transition point 41 there is provided a set of guided surfaces 42 staggered in head-sail fashion, and consisting of sheetmetal or cast metal. In this arrangement the diffuser problem occurring in flow direction 43 and the nozzle problem occurring in flow direction 44 are solved in such a way that no essential disturbances of the flow occur and also, for example in the case of poorly distributed inflow 43, a good to uniform velocity distribution exists in the enlarged cross-section. This arrangement can be amplified by mirror-symmetry about the masonry 40 to form a symmetrical element, naturally omitting this masonry wall 40. In the case of a non-uniform flow pattern upstream to said guiding surfaces the non-uniformity is satisfactorily eliminated even when the guiding surfaces of the vanes are located at an entrance of the diffuser.

The unsymmetrical abrupt enlargement of the flow cross-section formed in Fig. 8 by the masonry 45 and 46 is controlled by the arrangement of two sets of guide surfaces 47, 48 staggered in head-sail fashion, which solve the diffuser problem for flow direction 49 and also still sufficiently satisfactorily the nozzle problem for counterflow direction 50. If such a diffuser is highly asymmetrical, more partial guide surfaces are advantageously selected on the side of the bigger enlargement than on the side of the smaller enlargement. The arrangement according to Fig. 8 may also be symmetrical, basing it on the upper or on the lower half of the illustration.

Fig. 9 shows a main conduit 51 with a lateral inflow cross-section 52 and an additional lateral inflow cross-section 53. For the proper introduction of the flow 54 there is provided, at the inflow cross-section 52, a set of guide surfaces 55 in spatially corresponding arrangement and staggered in head-sail fashion and which set protrudes for example into the inside cross-section 56 of the conduit 51. In addition, a displaceable throttle grid 57 may be arranged in the inflow cross-section. In the inflow cross-section 53 of the conduit 58 attached laterally or perpendicularly, a set of guide surfaces 60 staggered in head-sail fashion is arranged, for the proper introduction of the inflow 59, in such a way that it does not protrude into the inside cross-section 56, or only immaterially so. This arrangement gives a deflection and introduction of the flows 54, 59 into the conduit 51 disturbance-free to a very large extent. With counterflow 61 in the conduit 51, the guide surface set 60 does not disturb the flow 61 at all and the guide surface set 55 causes little disturbance of flow and loss of pressure, but in an immaterial and therefore harmless measure because no appreciable response acts upstreamly to the heat exchange zone so that the flow pattern is not affected at that location.

Fig. 10 shows an inflow channel 63 formed of masonry 62, the inside cross-section of which enlarges to a much larger inside cross-section 64, with deflection about at a right angle. Such a construction renders the flow problem especially difficult, above all when the inflow 65 arrives with irregular velocity distribution as shown by way of example in diagram 66. This problem is solved by the arrangement of a guide plate or a guide body 67 with guide surfaces 68 in spatial coordination therewith and staggered in head-sail fashion, so that there results, with deflection of the flow, a sufficiently uniform velocity distribution over the enlarged cross-section 64, as shown for example in diagram 69.

Fig. 11 shows a unilaterally enlarged conduit 70 frequently occurring for inflow and counterflow, possibly with lateral or inclined inflow cross-sections 71, 72. The control of the inflow (arrows in solid lines) occurs by means of a guide plate 73, which may be rounded at the

bottom and which cooperates with a set 74 of guide surfaces in spatial coordination and staggered in head-sail fashion. The inflow cross-section 72 may, in addition, have a displaceable throttle grid 75. Such displaceable throttle grids may, if desired, be resorted to quite generally in the invention for the regulation of the quantity of flow.

According to Fig. 12 there exists a sudden large cross-section enlargement, formed by the masonry 76, for the inflow 77. The control of the flow is achieved by arranging on both sides at the end of the inflow channel, but in the enlarged zone, preferably in symmetrical arrangement, two sets of guide surfaces 79, 80 staggered in head-sail fashion. Between the sets there may be provided an arched, possibly a perforated, slotted, or broken guide plate 81 or a corresponding guide body. This arrangement, too, permits of counterflow 82 and it also permits a very irregularly distributed inflow 77.

The examples described so far relate to means and elements which operate essentially on the streamline principle. Figs. 13 to 20 show means and elements which control the flow essentially according to the resistance principle. Some of the above and the following means and elements or arrangements and applications can, however, be combined with one another as desired and to good purpose, it being unnecessary to show such combinations for all needs occurring in the practice, which are extremely varied and numerous depending on the model and nature of the equipment but if the elements are properly employed and arranged, it will always be possible to improve or to perfect the flow conditions.

In Fig. 13 is shown an inflow and outflow with equal cross-section, a grid brick arrangement, consisting of individual flat bricks 88 which leave open partial channels 89, arranged for the flow 83 in the diagonal line through the crest between the sloping inside crest 84 of the inside masonry 85 and the outwardly sloping outside crest 86 of the outside masonry 87. There may be used rounded flow approaching edges 90, pointed and externally gently rounded flow approaching edges 91, as well as blunt flow approaching edges 92.

According to Fig. 14, the chamber formed by the masonry 93 is divided by a partition 94 in such a way that there results a deflection of the flow 95 by 180 degrees. In the diagonals between end 96 of the partition 94 and the possibly also rounded or outwardly sloping corners 97, 98 of the deflection space 99 there are provided as flow-guiding means, cross-wise or at right angles to the arriving flow, flat bricks 100, 101 having blunt, rounded, or pointed and rounded end faces.

In Fig. 15 there are, adjacent to the deflection space 103, and formed by the masonry 102 bricklaid inflow channels 104 and outflow channels 105 thereabove arranged parallel therewith. Here the sum of the inside cross-sections of the inflow channels 104 is often smaller than the sum of the inside cross-sections of the outflow channels 105. Such arrangements with a partition such as 106 are frequently found in regenerative and recuperative equipment in refractory construction. The deflection space 103 contains, again in diagonal arrangement, deflecting blades 107 and 108, which may have an angular or rounded shape. By such an arrangement the inflow 109 and counterflow 110 are controlled sufficiently disturbance-free. This satisfies the prerequisite of a uniform charging (admission) or flow through the channels 104, 105 in both directions of flow 109, 110.

In the model according to Fig. 16 the design corresponds to a large extent to that shown in Fig. 15. Since here only one permanent direction of flow 109 is provided, it suffices to have one grid 111 of close spacing arranged diagonally in the upper portion of the deflection chamber 103.

Figs. 17 to 20 show regulations of the inflow cross-section frequently occurring in a regenerative and recuperative plants, with means for favorably affecting this

regulation of the quantity of inflow. Air, for example, is to be introduced from a channel 112 in direction 113 into the channel 115 bounded by the masonry 114. For this purpose there are arranged, at the entrance of the duct 115, a slidable grid as indicated by the double arrow 117 and in front thereof a full brick or full sheet 118, movable as indicated by the double arrow 119. According to Fig. 18, the grid is designed as a sliding brick 120 which is provided with slots 121 according to Fig. 19 or with holes 122 or the like according to Fig. 20; the size, shape, distribution, and spacing of these slots 121 or holes 122 may vary.

Obviously there exist different possibilities of application of the means and elements according to the invention as will be set forth hereinafter.

In Fig. 21 two inflows 123 and 124 are to be distributed over the channels 125 of the brick lining 126 or the like, and in such a way that as far as possible all channels carry an approximately equally large flow. Such arrangements are found in recuperative and regenerative plants, the inflow cross-section being subdivided by an angularly bent partition 127 into two channels 128, 129 in such a way that approximately half the number of channels 125 are open to the inflow 123 and the inflow 124. In practice several partitions 127 may be used. The masonry has a step 130. For the proper distribution of the flow there are arranged below the brick lining 126, which may also consist of grid bricks, several sets of guide surfaces 131, 132, 133 staggered in head-sail fashion in the channel 128, and in like manner, in the recessed and higher-positioned portion 134 of the channel 129, similar guide surface sets 135, 136. For the double deflection 137 there is again provided, between the crest 138 of the partition 127 and the equally high, upper edge of the step 130, a guide surface set 139 effecting the disturbance-free deflection of the flow 124 and preferably consisting of guide surfaces staggered in head-sail fashion.

In Fig. 22, a flow 141 arriving through a channel 140 is to be uniformly, or more or less uniformly, divided over a plurality of vertical channels 125 of the brick lining 126. The masonry 142 bounding the channel 140 at the bottom ascends toward its end, and in this channel 140 guide surface sets 143, 144, 145, 146 are arranged at intervals. On the horizontal line between the upper edges of these guide surface sets, and below the channels 125, there may be arranged additionally throttle grids or the like. The throttle grid elements may have for example a rectangular section 147, U-section 148, angular section 149, flat section 150 (bar grids, perforated plates), curved section 151, or an angular section 152 open for example toward the inflow direction.

According to Fig. 23, the inflow 153 consisting, say, of fuel gas or burning or burned gas, is to flow through a brick lining which consists for example of brick billets 154 arranged in stage-like criss-cross superposition with passage interstices. The masonry 155 again forms a big and abrupt enlargement of the inside cross-section, the diffuser problem occurring in flow direction 153 being solved by the arrangement of a shaped brick 156 with or without spacing from the lowest course of the brick billets 154 in the diffuser 157. The counter-current 158 is heated air.

In Fig. 24, the masonry 159 forms a very strong diffuser-like enlargement of the inside cross-section. This is concerned with a recuperative process in which the hollow bodies arranged in superposition in the enlarged portion, such as hollow bricks 160, house channels 161 traversed crosswise to the plane of the drawing, with heat transmission through the walls of the hollow bricks 160. The inflow 162 is distributed favorably over the vertical channels 164 located between the hollow bricks 160 by the guide surfaces 163 arranged at the beginning of the diffuser, arranged as shown for example in staggered head-sail fashion.

According to Fig. 25, inflows 165 or 166 are to be distributed over channels 167 with multiple deflection; these channels 167 may be, for example, inlet means to combustion chambers of coke ovens. In this case a large chamber 169 serving as a regenerating chamber is located alongside the brick lining 168 and the channels 167, which chamber is partly partitioned by partitions 170, 171. The lining 168 and channels extend vertically but all start in a common horizontal plane. The inflow 165 or 166 opening perpendicularly into the inlet conduit 172 may be deflected in a manner not shown, by guide plates or the like. Throttle grids 173 may be arranged in the inflow channel 172, there being adjacent to the inflow channel 172 a big enlargement 174 which at the inflow forms a diffuser and which, for proper distribution possesses either guide surfaces not shown or, as shown, guide plates 175 or walls in such number, length and arrangement that the enlargement 174 is divided into several individual diffusers 176 of smaller enlargement angle. In case of counterflow 177, of course, these diffusers form nozzles. For further uniformity of flow there may be arranged behind these guide plates 175, a throttle grid 178 which also has a directing wall effect and which consists of flat bricks or flat plates with many parallel, preferably narrow partial channels. The inside cross-section behind the throttle grid 178 is lined with lining bricks and forms a partial regenerator 179. Subsequently the flow is deflected by 90 degrees and once more by 90 degrees, the inside cross-section of the first regenerator section 179 widening to the inside cross-section of the regenerator section 179 lying between the partitions 170 and 171. To control this flow, known guide walls 180 are not sufficient despite the proposals for improvement in the inlet. Additional means according to the invention in the form of deflecting walls 181 are necessary. Appropriately also the second generator section 179, which lies between the partitions 170 and 171, is additionally equipped at its two ends with such deflecting walls 181. At the partition 171, an end slope 183 may be built up of masonry or otherwise produced. The partial channels 183 and 184 resulting from the guide walls 180 can be given an outwardly increasing width. As compared with the usual system, there are thus obtained much more effective regenerators 179 or respectively much smaller dimensions and at the same time a uniform distribution of the total flow over the channels 167, this leading also to a uniform flow through the subsequent combustion chambers for example of coke ovens and thus ultimately also to a still more uniform coke quality over the entire length of the coke chamber as well as resulting in smaller losses or smaller inputs per unit weight of the coke produced.

Fig. 25 shows the device 185 in a simplified schematic manner. Device 185 is presented in more detail in Figs. 26-29 and is shown in part in Fig. 9. The device 185 controls the incoming gas 166, the incoming air 165 and the outgoing gas 177.

In Fig. 26, a distribution chamber 186 is arranged below a standing regenerator or recuperator 187 or the like; and a regulating device with housing 185, which in this case need not necessarily be provided with guide surfaces or the like, being located in front of the distribution chamber 186. The air inlet opening 188 has, in this illustrated embodiment, a displaceable, for example shutter-like throttle grid 189, and is also controlled by the air damper 190. Opposite the air inflow 191 there is introduced through the conduit 193 a weak gas or other gas flow 192, while in the front portion of the housing 183 there is arranged the outflow valve 194 for the flow 195 going out in the opposite direction or leading to the outflow conduit 197 thereof. The distribution chamber 186 is designed so that it distributes well even a relatively unarranged inflow 191, 192 over all inside cross-sections of the regenerator 187 or the like. The partitions 198, 199 in the distribution chamber 186 include two sets of

slotted vanes 200 and 203 in stepped formation below regenerator 187. See the modification and location in Figs. 21 and 22. Partitions 198 and 199 form a sharp elbow and an abruptly widened diffuser so that, in the case of incoming flow 191, 192, a sharply enlarged diffuser of constant channel width is provided perpendicularly to the plane of the drawing up to the regenerator 187. It is advantageous, depending on the passages to the regenerator 187, to reduce this width in the direction of the regenerator for the purpose of as extensive as possible a reduction of the enlargement visible in the plane of the drawing. The stepped formation provided by vanes 200 and 203 acts satisfactorily also when the upstream flow contains a highly irregular flow pattern. For this reason no particular features are needed to guide incoming air 191 and incoming gas 192 and both are readily mixed due to arising eddies. However, the eddies are unfortunately caused at an undesirable location, namely most at the inner corner of inlet 193 resulting in an effect that the quantities of air and weak gas which are required as maxima may not be delivered, or may not get the favorable composition with regard to combustion. If the rate of air would be too little the man-hole 196 may be used as inlet of secondary air flow, too.

In case of reverse flow 195 coming from the regenerator during the heating period this assembly of items 198, 199, 200 and 203 acts also satisfactorily, but causes a larger drop of pressure. Actually designs of different loss of pressure are desired when said apparatus are operated in batteries of single units used in parallel.

Partitions 198 and 199 may be built of metal, partition 199 may be alternately shaped by the upper surface of bricks arranged in order to diminish the flow cross section of the rear end of chamber 186 opposite to the entrance of flow through device 185. The end of the partition 198, formed for example of a bent sheetmetal wall, possesses in spatial coordination a set 200 of guide surfaces staggered in head-sail fashion, while at the arc 201 of the partition 199 of brick or of sheetmetal, which is made to extend to the bottom 202 of the masonry and which may in part be curved, there is arranged preferably an additional flow-regulating and flow-diffusing guide surface set 203.

In Figs. 27 to 30 are shown variants of the regulation of the inflow and outflow as necessary in arrangements according to Figs. 25 and 26 and for example in furnaces such as coke ovens.

To the masonry 204, which forms a big enlargement of the inside cross-section, there is adjacent, according to Fig. 27, the housing 185 of the regulating organ, with packing by means of packing rings 205 or the like. The housing presents a movable damper 207 for the flow of incoming air 208. For aiding uniformity of the flow in adjusting the required quantity of air, the inlet cross-section is here provided with a displaceable throttle grid 209. The inlet cross-section which, in case weak gas 211 is to be used instead of air, is located diametrically opposite, possesses a set of guide surfaces 212 staggered in head-sail fashion, for deflection. In case of inflow 208 or 211, the outlet valve 214 movable in the direction of the double arrow 213 is closed. If outflow 215 is to be achieved, then, with the damper 207 closed and at the inlet 210 closed at a point not visible, the outflow valve 214 is more or less raised; its stiffening plate 216 possesses guide surfaces, such as a set of guide surfaces 217 staggered in head-sail fashion, which effect a deflection of the outflow 215 previously already influenced by the guide surfaces 218, to a large extent disturbance-free.

In Fig. 28, the position of the valves and dampers is selected somewhat differently, there being arranged for the air inlet damper 219 a guide surface set 220 which is located somewhat inside the housing 185 but without substantially disturbing the counterflow 221 and if desired a regulatable throttle grid 234 is again additionally provided. Through this measure—at variance with the usual

throttling by means of a full plate—the incoming flow 222 is influenced particularly favorably. The gas flow 224 or the like arriving from conduit 233 is favorably deflected and distributed by guide surfaces 225 which are arranged in the interior of the inlet conduit and which do not protrude into the interior of the housing 185 and here apply without gap against the conduit 223. The outflow valve 214 is here shown open. It may also have flow-regulating means (not shown). In this variant, however, this merely reduces the draft requirement. Hence it is thus possible, particularly if this is appropriately done within a draft course at several individual points to make more powerful for example, especially the valves farther removed from the smoke stack, say according to the rule that the valve resistance is reduced the farther the valve is removed from the smoke stack, so that all valves or regulating organs of a complete plant pass about an equally large amount of air.

According to Fig. 29, the favorable deflection of the air inflow 226 is achieved in that at the inlet cross-section 227, which can be regulated and closed by the movable damper 228, there is arranged a likewise regulable throttle grid 229 which is followed, in accordance with the deflection desired, by a gentle rounding 230 of the housing 185 at this point. Also for the gas inflow 231 or the like a gentle rounding 232 is provided. This rounding has the advantage of an inside space, substantially free from insertions, of the housing 185 and hence of an undisturbed outflow 233, which is controlled by the outflow valve 214.

The embodiment according to Fig. 30 shows an air damper 219 with throttle grid 234 in the cross-section of the air inflow 235. Here the gas inflow 236 has no special flow-regulating means; rather, its flow regulation is here achieved according to the resistance principle by a simple, or better a double or multiple throttle grid 237, this being sufficient for some conditions. The outflow valve 214 for the regulation of the outflow 206 corresponds to that of Figs. 28 and 29. In all these housings 185 of Figs. 26 to 30, there is provided in known manner a removable front plate 196 for the purpose of repair, cleaning, control, etc. In the valve models according to Figs. 26 to 30, which are suitable for regenerators, recuperators, and other equipment, the housings 185 may be selected smaller than previously, as their inside cross-sections are better utilized with better distribution over the regenerators and the like. This affords the operative advantage that a less intensive heat radiation takes place.

In Fig. 31, for example, a hot air flow 239 arriving through the inlet 238 and coal-distillation gas flow 241 arriving from the inlet 240 come together diametrically under deflection by 90 degrees in the strongly enlarged cross-section 242 for the purpose of joint combustion, as is often the case in muffle furnaces for the production of enamel ware and the like, that is, for the heating of the muffle from the outside. The masonry 243 subsequently forms a deflection space 244 where the flow is deflected by 180 degrees. Such deflections may repeat several times. In Fig. 31, only one more rectangular deflection 245 is shown diagrammatically, these deflections being bounded by a partition 246 provided with a sharp bend 249 and by a straight partition 247. In the deflection space 244 there is provided a set of guide surfaces 248 staggered in head-sail fashion, while in the deflection space 245 there is arranged, for example diagonally, a deflection grid 250 or the like. In this way this difficult flow can be controlled. Additionally a small partial flow may be guided from the deflection space 244, through an opening 251 possibly provided in the wall 247 at the top, to the subsequent chambers not shown. In the example of Fig. 31 there are preferably shown means operating on the streamline principle; they disturb the flame expansion much less than the means

according to the resistance principle theoretically likewise applicable according to the invention.

Figs. 32 and 33 show the application of means of the invention in combustion chambers or respectively burners in refractory construction.

The combustion chamber 253, bounded in Fig. 32 by the masonry 252, contains a nozzle 254 on a masonry channel 255. In the space 256 between the masonry channel 255 or the like and the outside wall 252 there are arranged flat shaped bricks 257, for example set on edge, which leave free partial channels 258, so that a favorable de-eddying of the air inflow 260 arriving through the channels 259 takes place. The result of such an arrangement is a combustion of the gas flowing out through the nozzle 254 with a longer flame. The shaped bricks 257 with the function of guide surfaces may be of different heights or staggered.

According to Fig. 33, the outside wall 263 of the combustion chamber 253 is provided in the combustion zone with constrictions or the like 264, 265, with the narrowest point preferably at the level of the nozzle 254. This, too, gives a good conveyance of the current of air 260 to the gas 261 to be burned and an orderly, long-flame combustion, as is usually desired. The counter-flow 262 is indicated for the sake of making it complete.

It is obvious that modifications and combinations not specifically shown and described can be utilized within the theory of the teachings of the present invention without departing from the scope thereof as defined in the appended claim.

I claim:

A heat exchanger for coke furnaces, muffle furnaces, enameling furnaces and the like having refractory or brick-lined channels for the regenerative or recuperative heating of air by the combustion gases from the furnaces, said channels being bent at an angle varying from about a right angle to about 180 degrees and in which channels the air and gases are subjected to changes in direction, deflecting means in said channels at the channel bends to uniformly deflect the gases in the bent portions of said

channels, thereby forming a substantially uniform cross sectional flow pattern, said deflecting means comprising a staggered series of curved vane guiding surfaces positioned in its channel to provide a suction side relative to the air and gases in the channel, 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 said resultant curvature of the series being defined by the curve which passes through the intersections of the chords of the vanes, the amount of the overlap of the vanes with respect to each other being sufficient to produce a jet velocity vector of the gases flowing in the channel in a direction substantially tangential to said resultant curvature of the series, and the angle of attack of the incident gases in said channel to the first several vanes at one end of said series being negative with respect to the direction of the velocity vector of the incident gas stream, whereby static and eddied zones of gas flow in the bends of said channels are substantially eliminated by said deflecting means.

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