July 26, 1927. 1,636,958

I. HARTER

HEAT TRANSFER DEVICE

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Fig. 1.

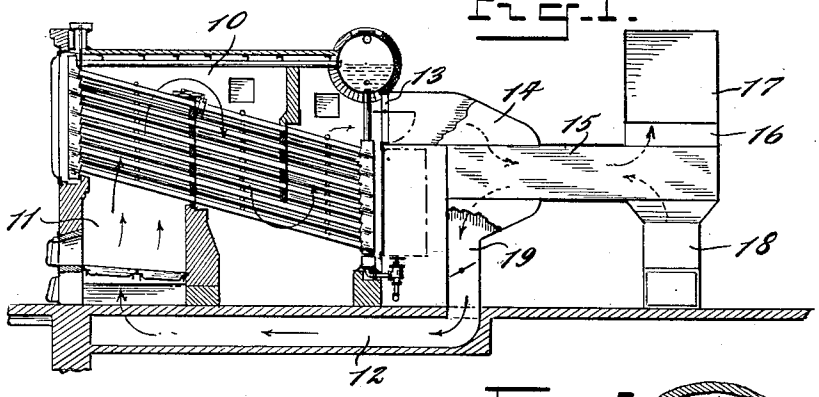
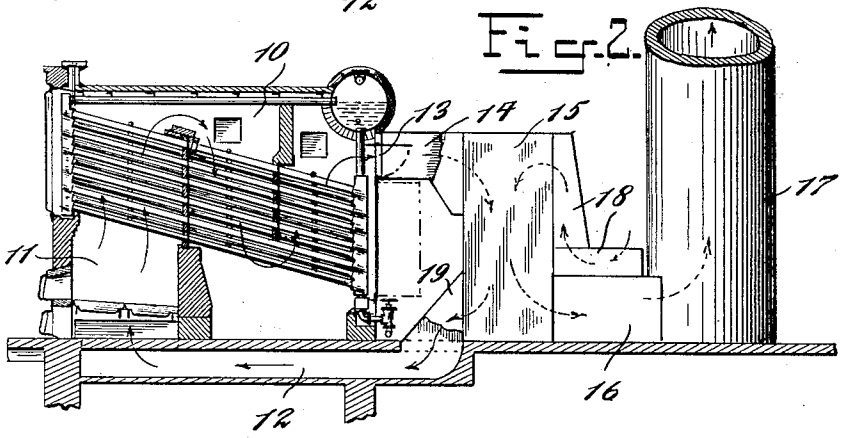


Fig. 2.



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Fig. 4.

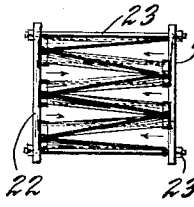


Fig. 3.

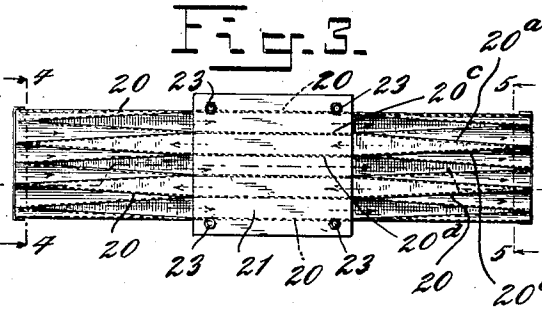


Fig. 5.

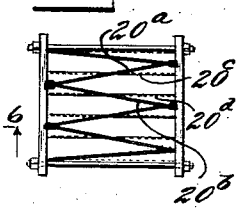


Fig. 7.

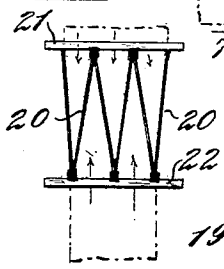


Fig. 6.

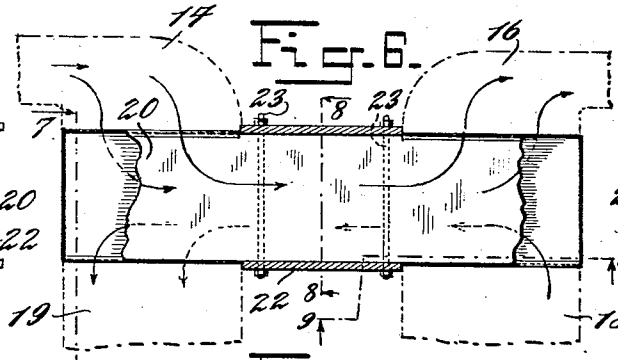


Fig. 8.

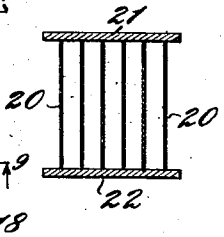


Fig. 9.

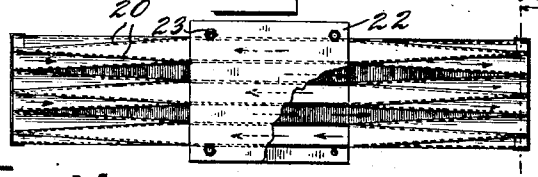


Fig. 10.

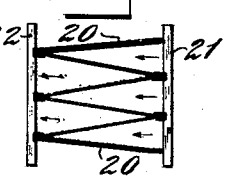


Fig. 11.

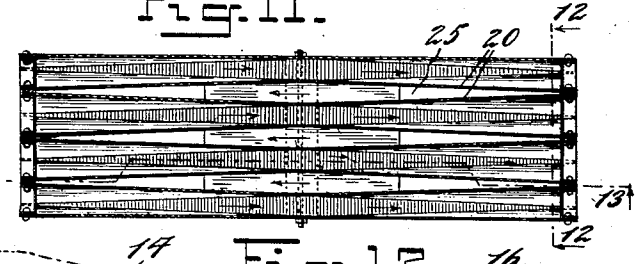


Fig. 12.

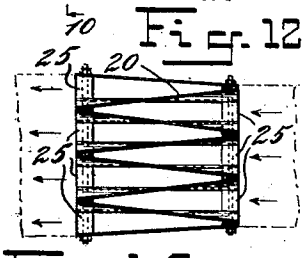


Fig. 13.

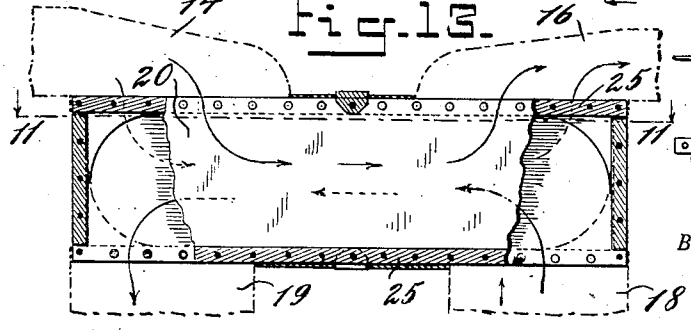


Fig. 14.

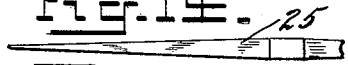
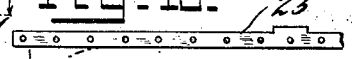


Fig. 15.



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Fig. 16.

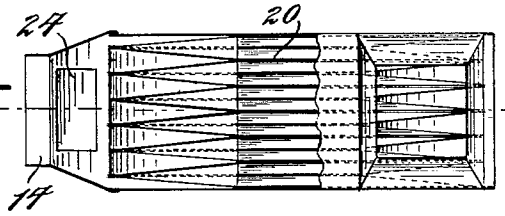


Fig. 17.

Fig. 19.

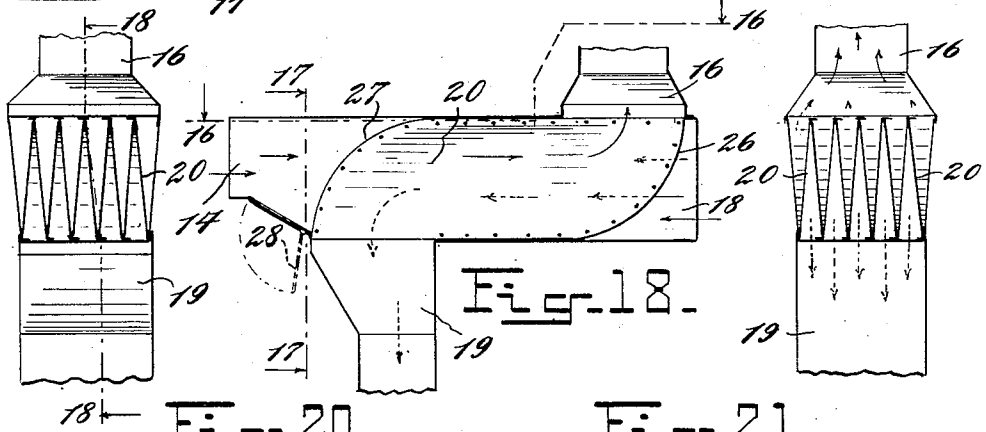
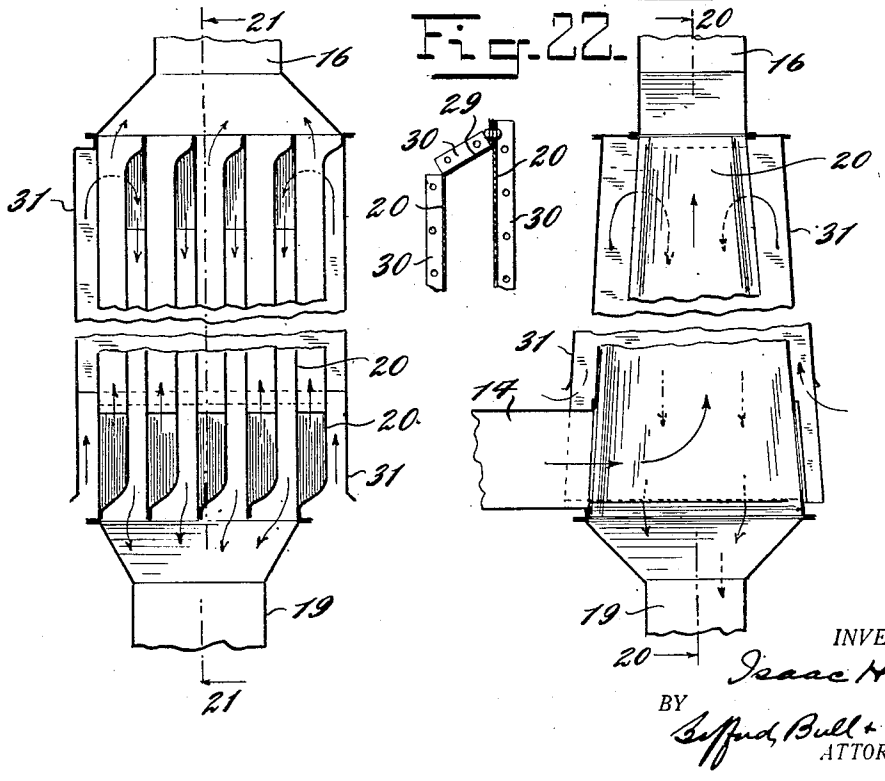


Fig. 18.

Fig. 20.

Fig. 21.

Fig. 22.



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HEAT TRANSFER DEVICE

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Fig. 23.

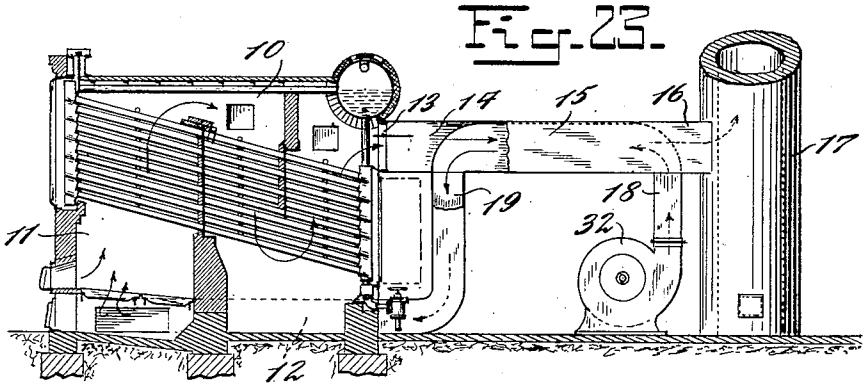


Fig. 24.

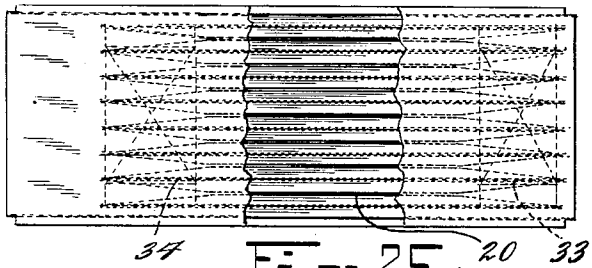


Fig. 25.

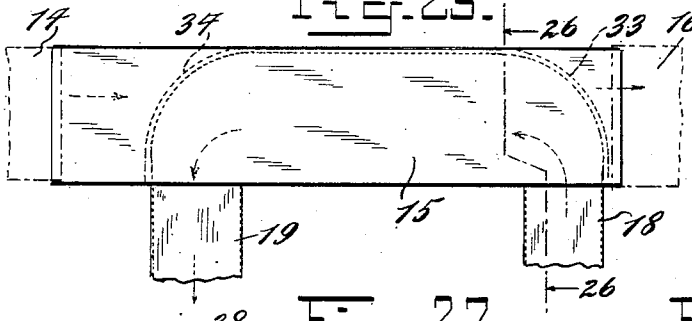


Fig. 26.

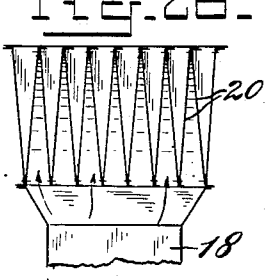


Fig. 27.

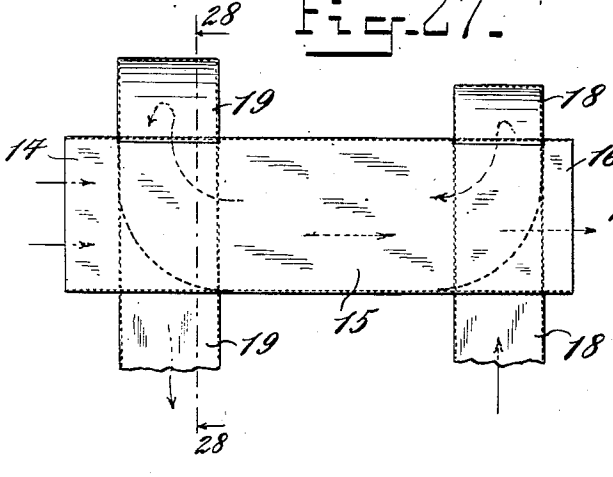
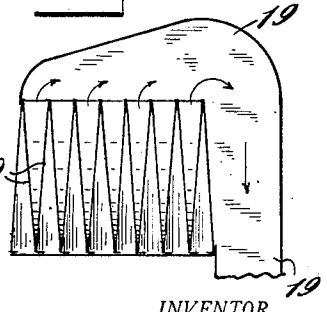


Fig. 28.



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Patented July 26, 1927. 1,636,958

UNITED STATES PATENT OFFICE.

ISAAC HARTER, OF DONGAN HILLS, NEW YORK, ASSIGNOR TO THE BABCOCK & WILCOX COMPANY, OF BAYONNE, NEW JERSEY, A CORPORATION OF NEW JERSEY.

HEAT-TRANSFER DEVICE.

Application filed August 7, 1922. Serial No. 580,003.

My present invention relates to devices by which heat may be transferred from one gaseous medium to another, and particularly to air heaters in which the temperature of the air is raised by the waste heat in boiler flue gases and the like, such air usually being heated in order to be supplied to support combustion in furnaces or the like.

My invention will be understood from the following description in connection with the annexed drawings, in which Fig. 1 is an elevation, partly in section, of a steam boiler showing in more or less diagrammatic form my novel air heater applied thereto; Fig. 2 is similar to Fig. 1, but with a modification in the air heater connections; Fig. 3 is a plan of an illustrative form of air heater; Fig. 4 is a section on the line 4—4 of Fig. 3; Fig. 5 is a section on the line 5—5 of Fig. 3; Fig. 6 is a longitudinal section of Fig. 3 on the line 6—6; Fig. 7 is a section on the line 7—7 of Fig. 6; Fig. 8 is a section on the line 8—8 of Fig. 6; Fig. 9 is a bottom view of Fig. 6 with a portion broken away along the line 9—9 of Fig. 6, and Fig. 10 is a section on the line 10—10 of Fig. 9; Fig. 11 shows a modification and is a horizontal section on the line 11—11 of Fig. 13; Fig. 12 is a section on the line 12—12 of Fig. 11; Fig. 13 is a section on the line 13—13 of Fig. 11; Figs. 14 and 15 are respectively plan and elevation of one of the separating members used in the arrangement shown in Fig. 11; Fig. 16 is a view of Fig. 18 on the line 16—16, showing still another modification; Fig. 17 is a section on the line 17—17 of Fig. 18; Fig. 18 is a section on the line 18—18 of Fig. 16; Fig. 19 is an end elevation of the right-hand end of Fig. 18; Figs. 20, 21 and 22 show still another modification, Fig. 20 being a section on the line 20—20 of Fig. 21, Fig. 21 being a section on the line 21—21 of Fig. 20 and Fig. 22 showing an enlarged detail; Fig. 23 shows an application of one form of my air heater to a boiler in which a fan is used to force the air through the heater to the furnace, Fig. 23 being partly diagrammatic and representing a side elevation partly in section; Figs. 24, 25 and 26 show respectively a plan, partly broken away, a side elevation and a section on the line 26—26 of Fig. 25, of still another modification, and Figs. 27 and 28 represent respectively a side elevation and a section on the line 28—28 of Fig. 27, respectively, of a modification.

Like reference characters indicate like parts in the several views.

In the more or less diagrammatic representation of the application of an air heater shown in Fig. 1, a boiler 10 of the ordinary type has a furnace chamber 11 to which air may be supplied through a duct 12. The gases from the furnace 11, after passing over the tubes of the boiler, flow through the gas outlet 13 into a gas duct 14 from which it passes through the air heater represented generally in Fig. 1 by 15 into an outlet gas duct 16 leading to the stack 17. The incoming air is drawn through the air inlet duct 18 into and through the air heater 15 and then into an outlet duct 19 communicating with the duct 12 leading to the furnace chamber.

The arrangement shown in Fig. 2 is the same as that shown in Fig. 1 except that the air heater 15 stands in a vertical position, so that the gas inlet duct 14 and the gas outlet duct 16 are on opposite sides of the air heater 15 as are the air inlet duct 18 and the air outlet duct 19. In both figures, the arrows indicate the direction of the flow of the waste gases and the air to be heated, and it will be noted that the flow is in opposite directions, as is true of all of the various modifications which I have shown, this arrangement being used preferably because the coolest or incoming air contacts with the coolest or outgoing gases and the hottest gases with the hottest air, thus following the counterflow principle.

The air heater represented generally by 15 in Figs. 1 and 2, is made up, in the illustrative form shown in the drawings, of a plurality of metallic sheets spaced apart to form channels positioned side by side with a gas outlet and a gas inlet duct connected to these channels, so that through one set of alternate channels air will flow in one direction and through the remaining alternate channels gas will flow in the opposite direction, so that there will be a plurality of streams of each kind of gas flowing through channels separated only by a conducting wall, so that the heat in the waste gas may readily be transmitted to the air.

I form these channels so that the entrance to and preferably also the exit from each channel will be comparatively wide so as to offer the minimum resistance to the flow of the gases. Preferably, I also arrange the channels so that the cross-section shape will change progressively from the entrance of the channel to the central portion thereof, so as to give the gases not only an easy entrance to the channel, but so as to prevent the gases flowing in lanes through the channels, the change in shape causing the gas streams to change their direction so as to keep bringing the gases from the interior of the stream to the outside and into contact with the wall which separates the two adjacent streams. In some cases, I have accomplished some of these results by making the channels substantially uniform in cross-section throughout their length but making this cross-section other than rectangular.

Referring now to the arrangement shown in Figs. 3 to 10, inclusive, the air heater 15 is formed of plates 20 held at the center by the covers 21 and 22 through which pass bolts 23, the plates being parallel at this central portion so that the ducts are arranged side by side with a rectangular cross-section. From a point adjacent either end of the covers 21, 22, the plates 20 are twisted or bent so that the ends are in the relation shown in full lines in Fig. 5, each pair of adjacent plates making opposite angles with the axis of the channel. In other words, the ends of the plates are positioned as shown at 20^a and 20^b in Fig. 5, and the angle between these two plates becomes decreasingly less until the central portion of the channel is reached, when the plates are in the relative positions shown at 20^c and 20^d of Fig. 5. As shown in Fig. 6, the gas inlet duct 14 extends over the tops of the plates 20 at the left of Fig. 6, and therefore would communicate with the large upper ends of the channels whose bases of the triangular sections extend upward, and similarly the gas outlet 16 will communicate with the open bases of the tringular sections of the same channels at the right-hand end of Fig. 6. Similarly the air inlet duct 18 and the outlet duct 19 communicate with the open bases of the triangular sections of the alternate channels so that the air will enter through the duct 18 and flow through those channels to the air outlet duct 19. In both cases, it will be noted that the gas or air, as the case may be, enters one of the ducts through the wide open base portion of a triangular section and flows vertically until it turns abruptly into a horizontal direction in Fig. 6, flowing through a channel whose cross-section is changing from a triangular to a rectangular section and then, after flowing through this rectangular section, passes into another triangular section which becomes increasingly narrow at the bottom and wide at the top until the air or gas passes out of the outlet 19 or 16, as the case may be. In its travel, therefore, the air or gas passing through this channel has not only been drawn longitudinally through the channel, but, by reason of the constant changes in shape and in direction, the stream has been stirred up, as it were, so as to constantly bring the gas or air from the center to the outside and back again.

The length of the central portion between the covers 21 and 22 may obviously be made as long as desirable, and this length may be reduced to a minimum, as shown in the modification illustrated in Figs. 11 to 15, inclusive. In this case the plates 20 are fastened at the tops and bottoms to separating pieces 25, these separating pieces being shaped so as to give the variation in cross-section to the channels as described above and also as illustrated in Figs. 11 and 12.

In Figs. 16 to 19, inclusive, I have illustrated a modification in which the waste gases enter the duct 14 in a horizontal direction and pass into the gas outlet duct 16 in a vertical direction. Similarly, the air enters the heater in a horizontal direction through the duct 18 and passes out in a downward direction through the duct 19. The channels in the arrangement shown in Figs. 16 to 19, inclusive, do not change to a rectangular cross-section at the center, but are triangular throughout, though obviously they may have a central rectangular section, if desired. The ends of alternate channels at the right of Fig. 18 are brought together, as at 26, however, to close the ends of such channels so as to direct the gases upward into the flue 16, and similarly, the ends of the plates forming the opposite group of channels are brought together, as at 27, to direct the air streams downward into the duct 19. In this form, it will be noted that the gas at one end and the air at the other enter the open ends of the triangular sectioned portions of the channels and each flows out sidewise at the opposite ends of the channels. A door 28 may be provided to remove the dust dropped by the incoming gases in the duct 14.

In the arrangement shown in Figs. 20 to 22, inclusive, the gas enters through the horizontal duct 14 and passes into the sides of the channels formed by the plates 20, the channels in this arrangements having parallel walls throughout their lengths except at the ends where each pair of plates is brought together, as shown best in Fig. 22, the portion 29 extending from one plate 20 to the opposite plate 20 and the flange 30 being used to fasten the edges of the plates to the walls of the member which surrounds the channels. The air enters at the bottom of the casing 31 and flows upward and thence into openings in the sides of alternate chan-

nels, from which it flows downward, as indicated by the arrows in Fig. 20, to the air outlet 19. Similarly, the hot gases enter through the duct 14 into the sides of alternate channels and flow upward, as indicated by the arrows in Fig. 20, to the gas outlet duct 16.

Fig. 23 is similar to Figs. 1 and 2, except that the air, instead of being drawn through the air heater by the natural or forced draft of the furnace, will be forced through the air heater 15 by a fan 32, the air heater furthermore being arranged so that the waste gases flow through the heater with no substantial change of direction, where as the air changes its direction twice in passing through the air heater. This arrangement is advantageous in that the draft of the furnace is not interfered with by altering the direction of the flow of the gases, and by using the fan 32, the resistance of the passage of the air may be overcome.

In Figs. 24, 25 and 26, I have shown in detail the arrangement illustrated in Fig. 23. In this arrangement, the plates 20 are placed at an angle to the axis of the channel to form alternate channels of triangular cross-section which, if desired, may be made rectangular in the central portion as explained in connection with the modification shown in Figs. 3 to 10, inclusive. The ends of alternate plates are brought together, as indicated by dotted lines at 33, 34, the air inlet duct 18 and outlet duct 19 communicating with openings in the base portions of the triangular sections of alternate channels. The waste gases enter from the left of Fig. 25 and flow straight through the channels to the right of Fig. 25. The air enters through the duct 18 and turns and flows in the opposite direction and then downward to the air outlet 19.

The arrangement shown in Figs. 27 and 28 is similar to that shown in Figs. 24, 25 and 26, except that the air inlet and outlet ducts 18 and 19 are connected to the tops instead of the bottoms of the channels. In this arrangement, the waste gas channels have their widest portions at the bottom instead of at the top, as in the arrangement shown in Figs. 24, 25 and 26, so that dust which may be dropped from such waste gas may be more readily removed from the channels by doors or the like at the bottom of the air heater.

If desired, the flow areas through the several ducts may be arranged so that they will enlarge or decrease more or less approximately as the gas or air passing through them tends to increase or decrease in volume, as the temperatures of the gases or air are raised or lowered in their passage through the ducts by reason of the heat transferred through the walls of the ducts. This arrangement causes the gases and air to flow at substantially a uniform velocity throughout the length of the respective ducts. Such an arrangement is illustrated in the form shown in Fig. 21.

While in the description and appended claims, I have used the word "triangular" to describe the cross-section other than rectangular which the channels may have, it will be understood that by this term, I do not mean to restrict myself to a section which is truly triangular in the geometrical sense. Obviously, such a section may have curved instead of straight sides, and moreover, the two sides need not meet at a point, as indeed they do not, in the forms illustrated, except at the very ends of the channels. For example, in Fig. 3, while the edges of the plates 20 meet at the edges to form a true triangular cross-section at the very end, these edges become further and further apart as the central portion of the air heater 15 is approached until the triangular portion merges into the rectangular portion.

It will be understood that the construction and application of the heat transfer device which I have disclosed can be varied within wide limits and that the arrangements which I have shown are merely illustrative.

I claim:—

1. A heat-transfer device comprising a pair of adjacent channels separated by a heat-conducting wall, each channel being generally triangular in cross-section at an end and rectangular in another portion.

2. A heat-transfer device comprising a pair of symmetrically and oppositely disposed channels separated by a heat-conducting wall, each of said channels having an end generally triangular in cross-section and progressively changing to a rectangular section at a point removed from the end, one of the channels having an entrance at the end and on the side at the base of the triangular section.

3. A heat-transfer device comprising a pair of symmetrically and oppositely disposed channels separated by a heat-conducting wall, each of said channels having each end generally triangular in cross-section and progressively changing to a rectangular cross-section for a portion of the length of channel between the ends.

4. A heat-transfer device comprising a pair of symmetrically and oppositely disposed channels separated by a heat-conducting wall, each of said channels having each end generally triangular in cross-section and progressively changing to a rectangular cross-section for a portion of the length of channel between the ends, one of the channels having an entrance at one end and an exit at the other end, each located on the side of the channel at the base of the triangular section.

5. A heat-transfer device comprising a

plurality of sheet metal plates spaced apart to form a channel between each pair of plates, the central portions of said plates being parallel and the end portions of the plates being bent alternately in opposite directions to give each channel a substantially triangular cross-section at each end with the bases of such sections for alternate channels on the top of said device and the bases of the sections for the remaining channels on the bottom of said device, said channels being closed at the top and bottom at the central portion.

6. A heat-transfer device comprising a plurality of sheet metal plates spaced apart to form a channel between each pair of plates, the central portions of said plates being parallel and the end portions of the plates being bent alternately in opposite directions to give each channel a substantially triangular cross-section at each end with the bases of such sections for alternate channels on the top of said device and the bases of the sections for the remaining channels on the bottom of said device, said channels being closed at the top and bottom at the central portion, and each of a set of alternate channels having a portion of the base of its triangular section at each end open to form an entrance or an exit.

7. A heat-transfer device comprising a plurality of sheet metal plates spaced apart to form a channel between each pair of plates, the central portions of said plates being parallel and the end portions of the plates being bent alternately in opposite directions to give each channel a substantially triangular cross-section at each end with the bases of such sections for alternate channels on the top of said device and the bases of the sections for the remaining channels on the bottom of said device, said channels being closed at the top and bottom at the central portion, and the base of each triangular section being approximately twice the width of the channel at the portion with parallel sides.

8. A heat-transfer device comprising a plurality of sheet metal plates spaced apart to form a channel between each pair of plates, the central portions of said plates being parallel and the end portions of the plates being bent alternately in opposite directions to give each channel a substantially triangular cross-section at each end with the bases of such sections for alternate channels on the top of said device and the bases of the sections for the remaining channels on the bottom of said device, said channels being closed at the top and bottom at the central portion, and the base of each triangular section being approximately twice the width of the channel at the portion with parallel sides, each of a set of alternate channels having a portion of the base of its triangular section at each end open to form an entrance or an exit.

9. A heat-transfer device comprising a plurality of adjacent channels separated by heat-conducting walls, each channel having a portion triangular in cross-section which progressively changes the angular relation of its sides.

10. A heat-transfer device comprising a plurality of sheet metal plates spaced apart to form a channel between each pair of plates, at least a portion of each pair of plates making opposite angles with the axis of the channel and forming a channel, the cross section of which progressively changes in form, whereby at least a part of each channel is triangular in cross-section.

11. A heat-transfer device comprising a plurality of adjacent channels separated by heat-conducting walls, each channel having a portion triangular in cross-section as regards the angular relation of sides.

12. A heat transfer device comprising a plurality of adjacent channels separated by heat conducting walls, each channel being triangular in cross section at each end and rectangular in the middle portion, the triangular portions of adjacent channels being reversely arranged.

13. A heat transfer device comprising a plurality of adjacent channels separated by heat conducting walls, each channel being triangular in cross section at each end and rectangular in the middle portion, the triangular portions of adjacent channels being reversely arranged to form two sets of channels, an inlet and an outlet for the heating medium connected to the wider triangular portions of one set of channels, and an inlet and an outlet for the heated medium connected to the wider triangular portions of the other set of channels.

14. A heat-transfer device comprising a plurality of adjacent channels separated by heat-conducting walls, each channel having a portion triangular in cross section which progressively and uniformly changes the angular relation of its sides.

15. A heat-transfer device comprising a plurality of channels for the flow of gas and air with metallic walls therebetween through which heat is conducted from the gas to the air, an inlet to and an outlet for gases from one set of channels, an inlet to and an outlet for air from the other set of channels, said inlet and outlets being so arranged as to provide a counterflow for the gases and the air, the channels being constructed and arranged to cause the flow area for one of the fluids to change from the inlet toward the outlet ends.

16. A heat-transfer device comprising a plurality of parallel sheet metal plates spaced apart to form a channel between each pair of plates, an inlet for gases to and

an outlet for gases from one set of channels, an inlet for air to and an outlet for air from the other set of channels, said plates being constructed and arranged to cause the flow area of the channels for the gases to decrease from the inlet toward the outlet ends and the flow areas for the air to increase from the inlet toward the outlet ends.

17. A heat-transfer device comprising a plurality of sheet metal plates spaced apart to form a channel between each pair of plates, one set of alternate channels for conducting gases and the other set for conducting air so that heat is conducted from the gases through the sheet metal plates to the air, an inlet for gases to and an outlet for gases from one set of channels, an inlet for air to and an outlet for air from the other set of channels, the parts being constructed and arranged to provide a counterflow for the gases and air, the channels being formed to cause the flow areas for the gases to decrease from the inlet toward the outlet ends.

18. A heat-transfer device comprising a plurality of sheet metal plates spaced apart to form a channel between each pair of plates, one set of alternate channels for conducting gases and the other set for conducting air so that heat is conducted from the gases through the sheet metal plates to the air, an inlet for gases to and an outlet for gases from one set of channels, an inlet for air to and an outlet for air from the other set of channels, the parts being constructed and arranged to provide a counterflow for the gases and air, the channels being formed to cause the flow areas for the gases to decrease from the inlet toward the outlet ends, and the flow areas for the air to increase from the inlet toward the outlet ends.

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