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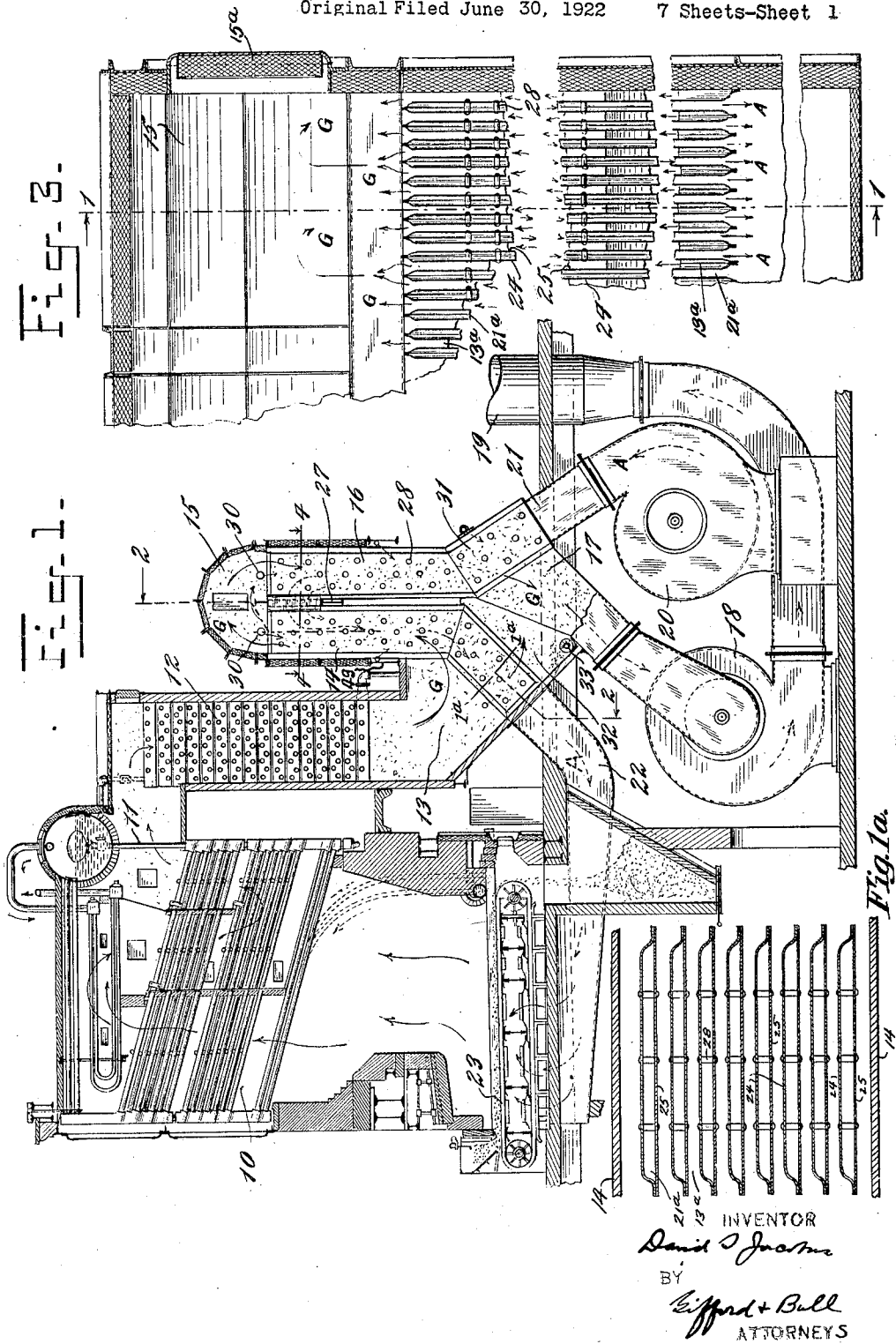
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1,647,997

AIR HEATER

Original Filed June 30, 1922

7 Sheets-Sheet 1



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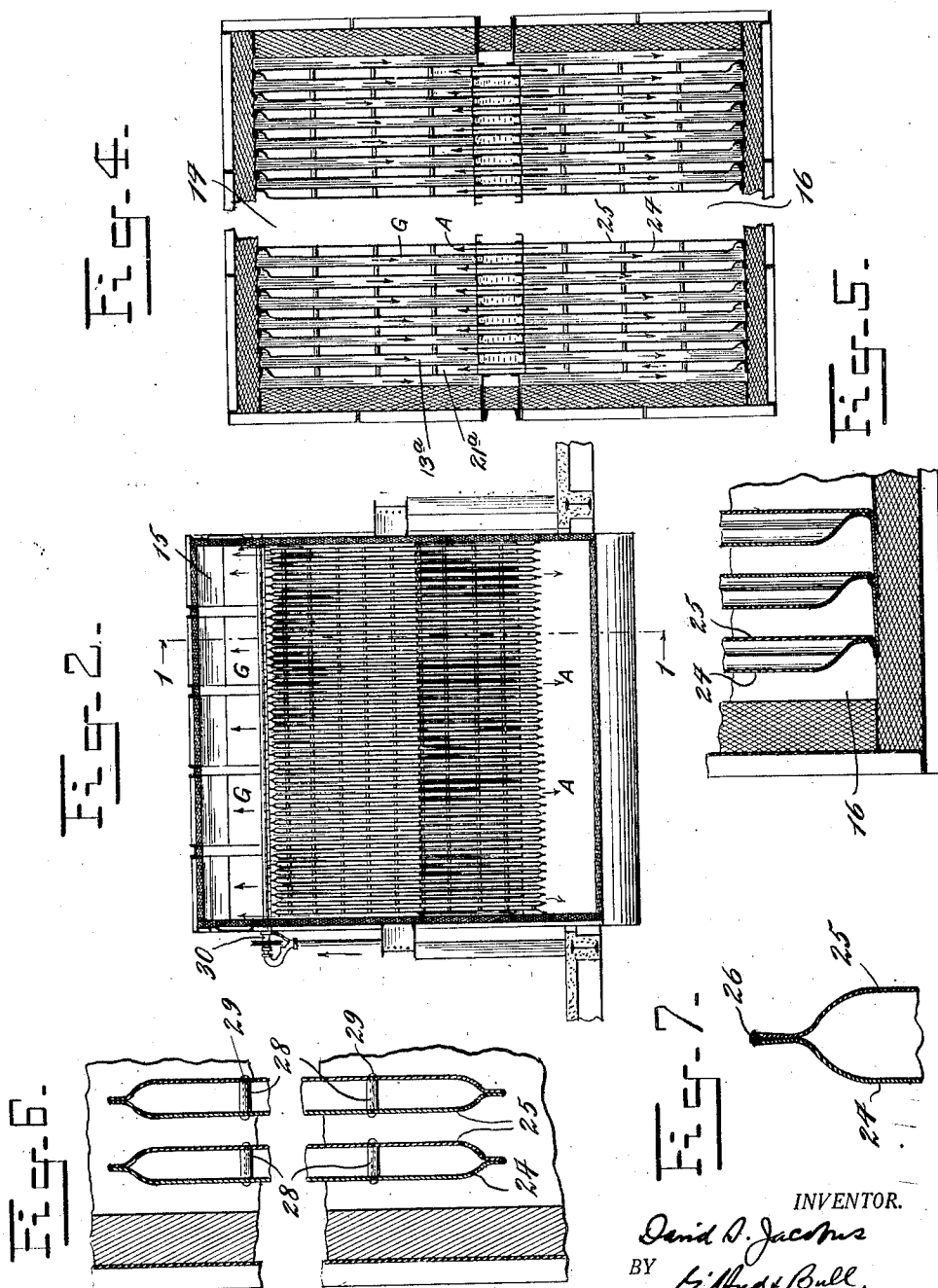
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7 Sheets-Sheet 2



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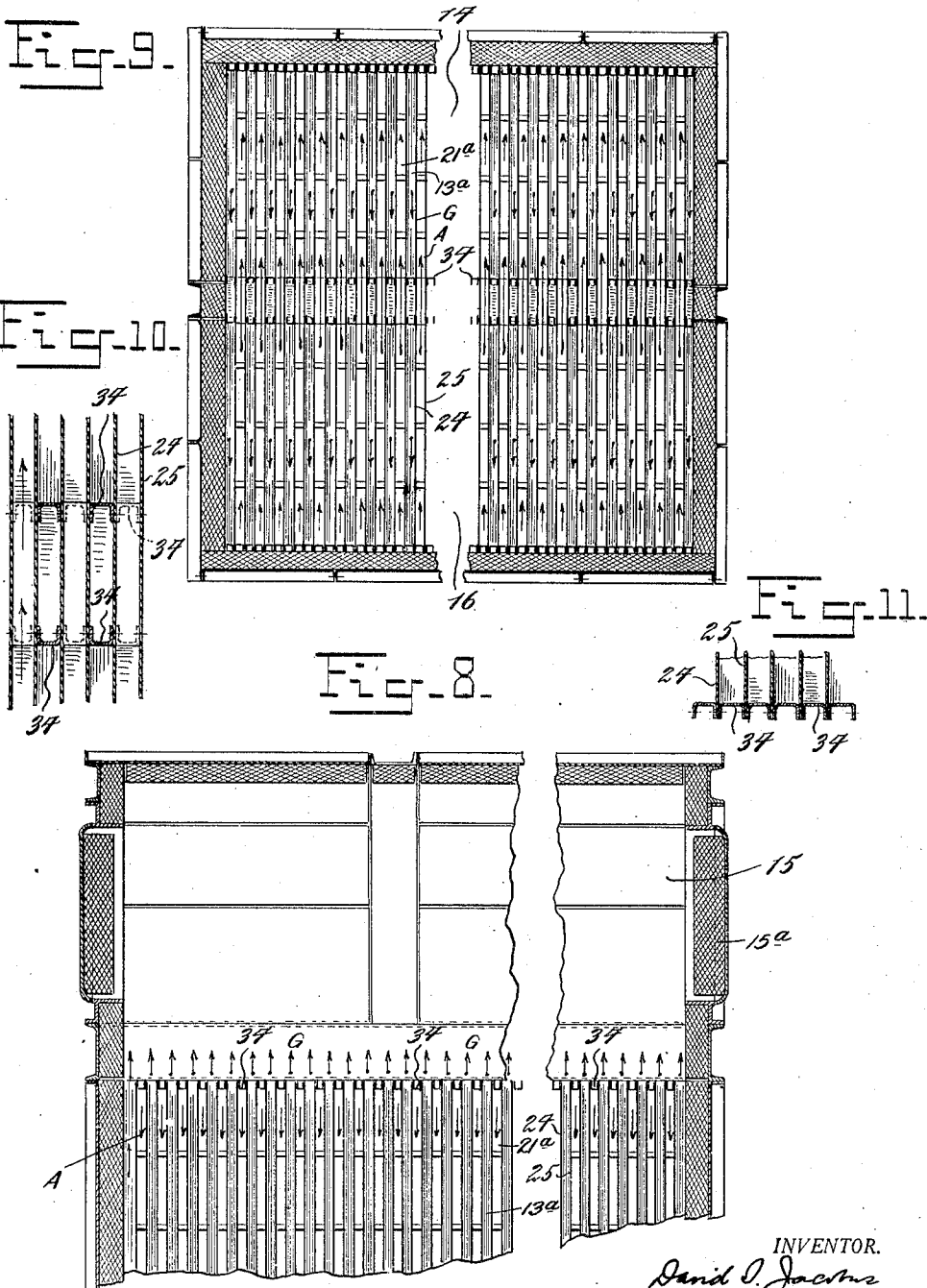
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7 Sheets-Sheet 4

Fig-13-

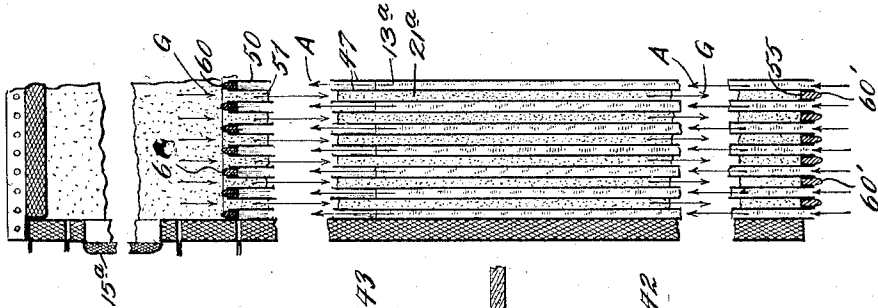
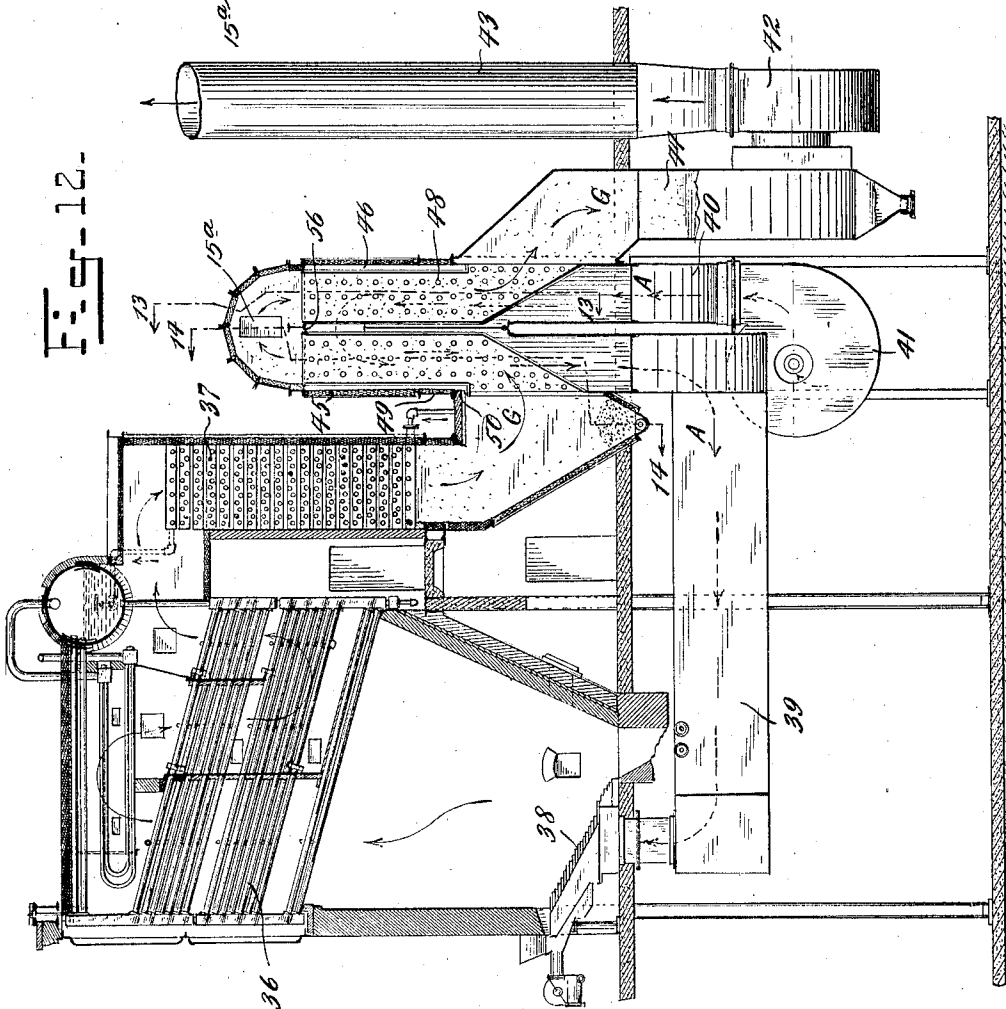


Fig-12-



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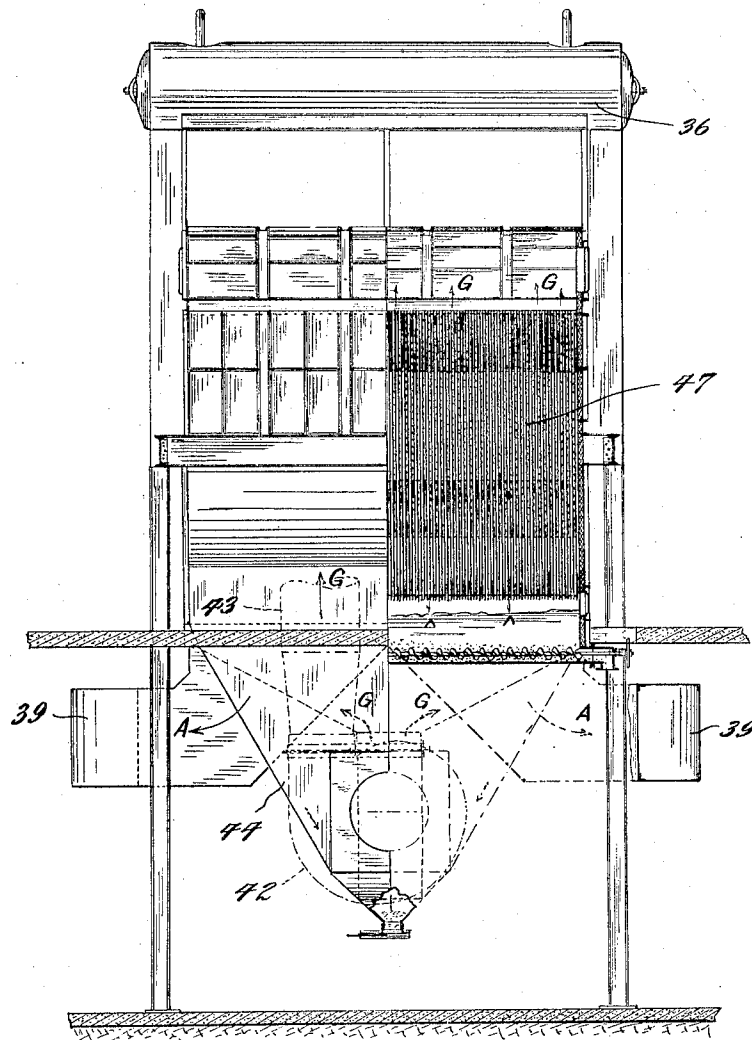
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7 Sheets-Sheet 5

Fig. 14.



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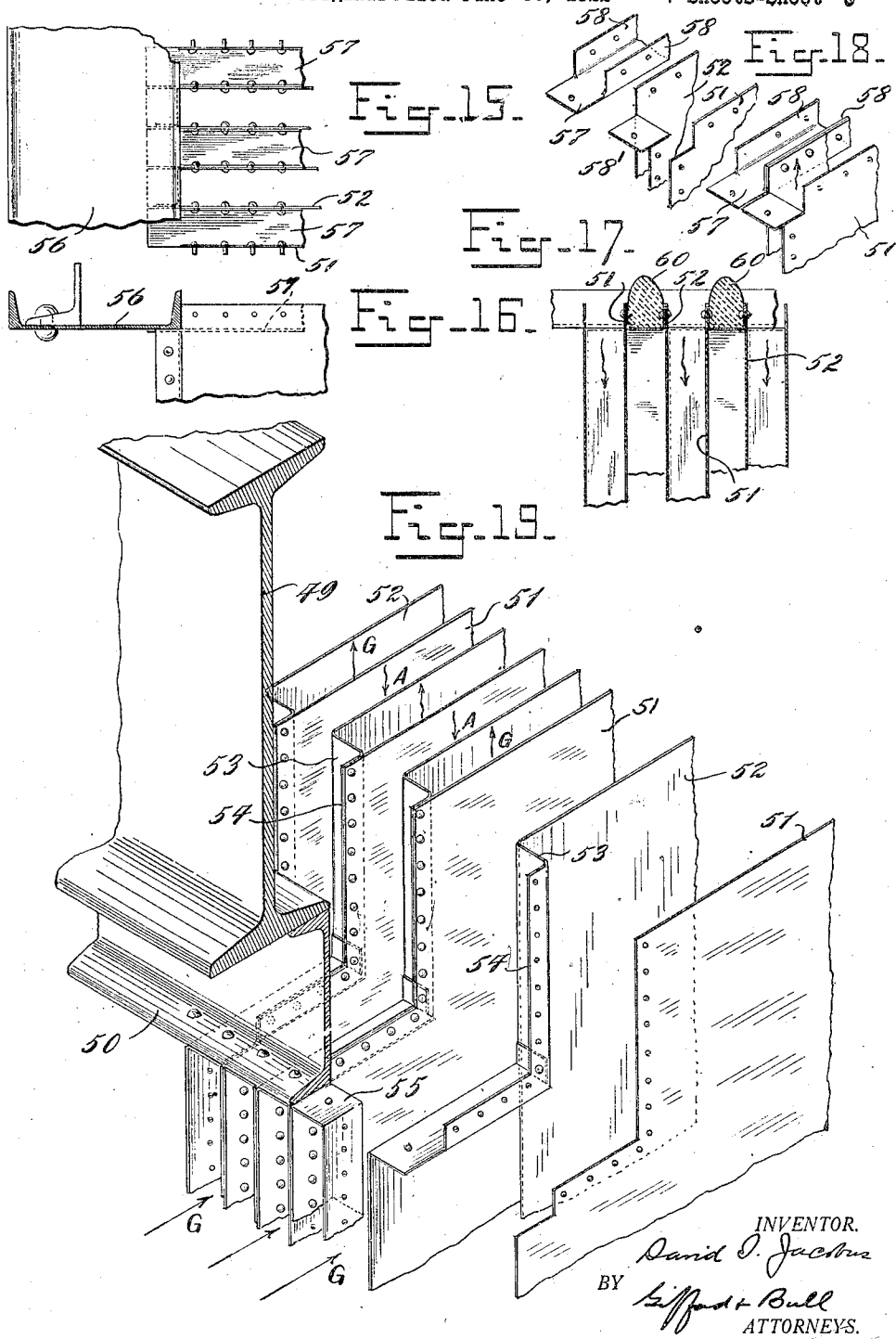
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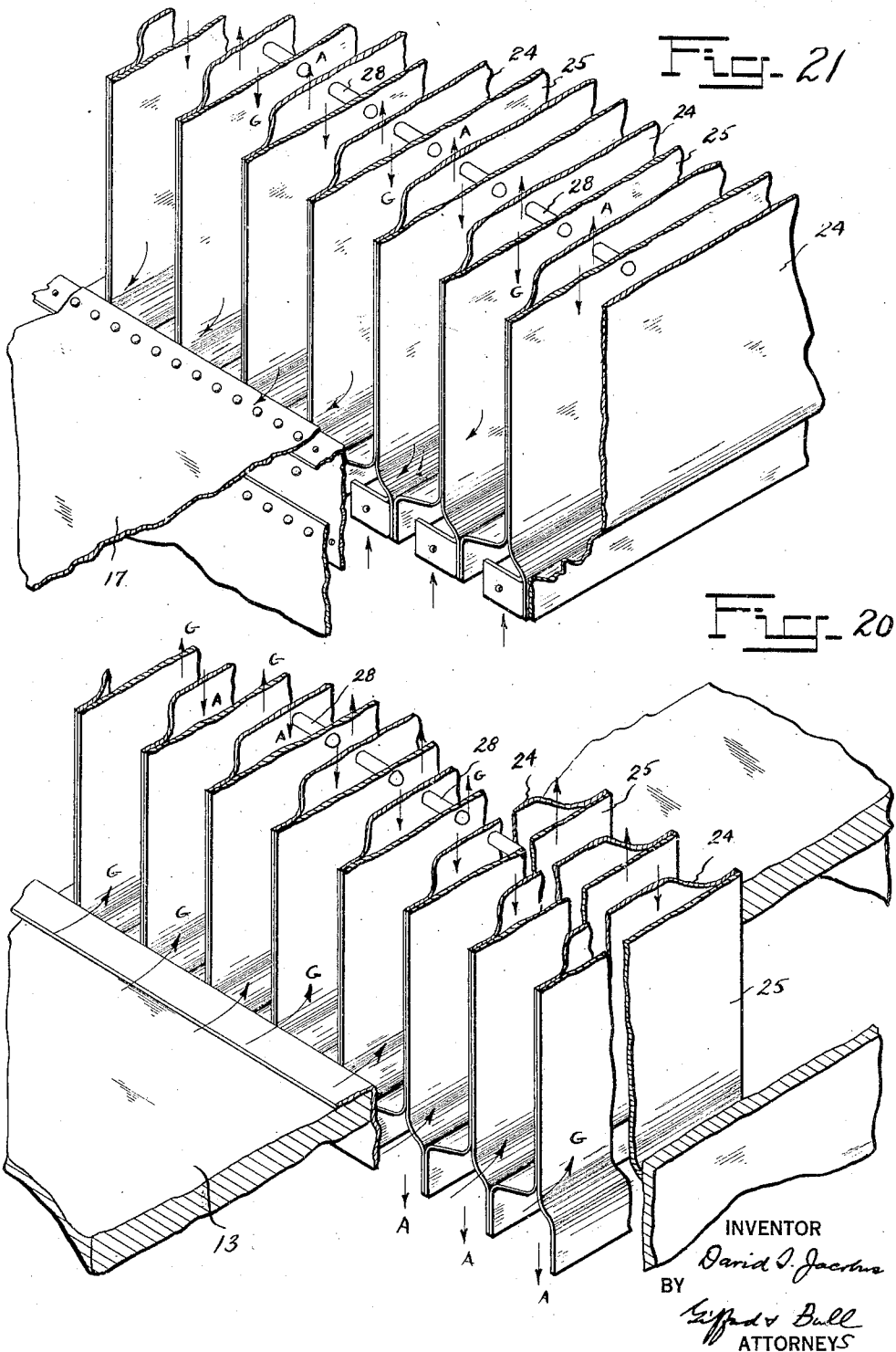
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7 Sheets-Sheet 7



UNITED STATES PATENT OFFICE.

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AIR HEATER.

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My present invention relates to devices for transferring heat from hot gases to air and will be understood from the following description and the annexed drawings, in which Fig. 1 is a side elevation, partly in section, of a steam boiler with an air heater embodying my present invention connected thereto, the section being taken on the lines 1—1 of Figs. 2 and 3, respectively; Fig. 1^a is a section on the line 1^a—1^a of Fig. 1 on a somewhat enlarged scale; Fig. 2 is a section of the air heater shown in Fig. 1, taken on the line 2—2 of Fig. 1; Fig. 3 is an enlargement of portions of Fig. 2; Fig. 4 is an enlarged section on the line 4—4 of Fig. 1; Fig. 5 is an enlarged detail of Fig. 4; Figs. 6 and 7 are enlarged details of Fig. 2; Fig. 8 is a view similar to Fig. 3, showing a modification; Fig. 9 is a view similar to Fig. 4, showing the modification of Fig. 8; Figs. 10 and 11 are enlarged details of Figs. 8 and 9; Fig. 12 is a side elevation, partly in section, of a steam boiler with an air heater illustrating a modification connected thereto; Fig. 13 is a section on the line 13—13 of Fig. 12; Fig. 14 is a rear elevation, partly in section on the line 14—14 of Fig. 12 and having some of the parts broken away; Figs. 15, 16 and 17 are plan, side elevation and end elevation, respectively, of a detail of the arrangement shown in Fig. 12; Fig. 18 is a perspective of the several parts forming the arrangement in Figs. 15, 16 and 17, and Fig. 19 is a perspective of the several parts at another point in Fig. 12; Fig. 20 is a perspective view of a part of Fig. 1 on a large scale, showing a part of duct 13 and the air and gas ducts in the lower part of duct 14 showing the relation of the air and gas ducts and the connection of the latter to duct 13; Fig. 21 is a view similar to Fig. 20 of the duct 17 and the air and gas ducts in the duct 31.

Like reference characters indicate like parts in the several views.

In Fig. 1, I have illustrated a steam boiler 10 of a well-known type, the hot gases from which pass through the gas outlet 11 and downwardly over an economizer 12 into a flue 13. From this flue, the hot gases pass upwardly through a flue 14 around the air heater, which is to be described more specifically hereinafter, passing at the top through

a cross flue 15 which is circular in cross-section, in the illustrative form, and then downwardly through a vertical flue 16 to a gas outlet flue 17 which is connected, in the form illustrated, to a fan 18 by which the gases are forced to the stack 19.

A fan 20 forces air through a flue 21 into the air heater, the air flowing upwardly through the ducts of the air heater and then across through a horizontal connection which will be described more fully hereinafter, into the second set of air ducts through which the air passes downwardly to an air outlet flue or duct 22 from which it may be supplied to the combustion chamber through the chain-grate stoker 23, which I have adopted for purposes of illustration.

In the form illustrated, the air ducts are formed of metallic sheets placed side by side with their edges bent toward each other and sealed, preferably by welding, to form a gas-tight joint. This arrangement is illustrated on a large scale in Fig. 7, in which the plates 24 and 25 are brought together and the edges closed by a weld, as at 26. The connected edges 26, in the form illustrated, extend crosswise at the tops of the air ducts and are formed preferably in this manner for a reason to be pointed out more specifically hereinafter. The vertical edges may be formed as shown best in Fig. 5, by bending the plate 24 at its edge over toward the plate 25, leaving enough of the latter to provide a means for fastening each duct, formed by a pair of plates 24 and 25, to the side walls of the flues 14 and 16. If desired, however, the vertical edges may be joined, as shown in Fig. 7, and the ducts located by inserting the edges 26 into slots or the like in the walls of the flues 14, 16.

In the illustrative form, there are two series or sets of these air ducts, one in each of the vertical flues 14, 16, and adjacent the tops of these ducts, the side walls of each of the ducts are opened out and joined to the side walls of the corresponding duct in the other flue, as shown best in Fig. 4, so as to form a passage between each air duct in the flue 16 with the corresponding air duct in the flue 14. These extensions of the plates 24 and 25 may be used to support the ducts in position by resting on a beam 27 extending across the heater.

The lowermost ends of these air ducts are left open, and each extending through the closed lower ends of the flues 14, 16, so that the air passes from the fan 20 through the duct 21 directly into the air ducts and similarly passes out from the ends of these air ducts into the main outlet air duct 22, the air passages being marked 21^a and the arrows indicating the travel of the air being marked "A" in the several views.

As has been described before, the hot gases pass into the vertical flue 14 from the flue 13, flowing between the air ducts in that flue and finding an entrance thereto which is comparatively unobstructed because of the form of the edges of the air duct. For instance, if the edges of these ducts are formed as shown in Fig. 7, it will be obvious by reference to Fig. 6 that the entrance and the exit spaces for the gases will be wide at the entrance and gradually become narrower. It will also be noted that the gases enter the spaces between the air ducts at an angle to the path which the gases will follow after they begin to flow between the air ducts, and since these spaces between the air ducts are, in effect, ducts for the gases, it will be noted that the gases enter their ducts at an angle to the path of the gases through the main portion of the ducts. Similarly, the gases pass out of the flue 16 at an angle to the path which they have been following through that flue, and, in effect, pass out of a plurality of ducts into the main outlet gas duct at an angle to their course of travel through the gas ducts of the air heater. The gas passages between the air ducts 21^a are marked 13^a and the arrows indicating the travel of the gas are marked "G" in the several views.

It will be understood that in practice, the plates 24 and 25 will be comparatively long and wide, and, at the same time, will be spaced relatively close together so as to form narrow ducts, and it is desirable that these plates should be held in their parallel positions against deformation which may occur because of the temperature to which the plates are submitted. To this end, I have provided spacing members 28 between the plates with a rivet 29 or the like passing through the plates and through these spacing members. The spacing members 28 are preferably arranged as shown in Fig. 1, so as to lie in straight lines, whereby the soot and dust which will collect on the outer walls of the plates 24 and 25 may be readily cleaned by passing a brush down through the gas ducts formed between the air ducts, or by a dust blower, such as 30, located above the air ducts of the heater.

In operation, in the arrangement shown, the air is forced by the fan 20 into the main air inlet 21 from whence it flows into the ends of a set of the air ducts, passing upward to the horizontal connection between

the air ducts and thence downward through the second set of air ducts in the flue 14 to the main air outlet 22. At the same time, the hot gases enter the gas ducts in the flue 14 formed between the air ducts and at the side of such gas ducts and pass upward and out of these narrow gas ducts into the main connecting duct 15 from which they again pass in a downward direction into the narrow gas ducts formed in the flue 16 to the main gas outlet 17 which is connected at the sides of the small gas ducts.

Since it is desirable to reduce the resistance to flow of the furnace gases as much as possible, I have arranged in my preferred form to have the entrance and exit from the narrow gas ducts of the air heater, so that the resistance to flow will be minimized, and the constructions shown in Figs. 5 and 7 will have this result. Also, by having the gas and air enter their respective ducts in different directions, I am enabled to provide separate ducts for each of them without difficulty or interference between the two, as would be the case if both the gas and air entered or left the air heater in the same or parallel directions.

I also prefer to arrange the air ducts in the manner shown in Fig. 1, so that there will be a counterflow between the gas and the air. Consequently, the incoming air which is relatively cool contacts first with the coolest gases and progressively contacts with hotter and hotter gases. Because, however, the temperature of the gas has been considerably reduced after passing through the air heater, the cold air from the duct 21 is liable to cause the deposition of moisture from the chilled gases on the exterior of the walls of the air ducts at their lower ends. This would soon lead to rusting and destruction of the walls, particularly if the ducts were made of sheet iron, as would be desirable because of its relative cheapness. By arranging the air heater so that the gases pass downward as they leave the air heater, any moisture which collects will flow downward and away from the walls of the air duct. Moreover, by arranging the air ducts in sections, as shown in Fig. 1, I am enabled to remove the lower end of a section and replace it in the event that the moisture destroys such portion, this replacement of a portion avoiding the necessity of taking down the entire air heater. Such separable section may be the angular portion 31. Furthermore, in order to provide more effectually against the necessity of renewal, I may make such removable portion of some better, though more expensive material, as copper, or special non-corrosive steel, without greatly increasing the cost and at the same time, providing a rust-resisting material at the place most liable to be affected by moisture from the gases. Moreover, by ar-

ranging the flues 14 and 16 vertically, I economize in floor space and provide an arrangement by which the soot has a tendency to fall away from the walls of the air ducts.

5 The cross flue 15 is preferably made large enough to permit access through the door 15^a to the upper ends of the gas ducts for cleaning purposes. By providing a hopper 32, the principal part of the dust which will
10 be deposited on the first section of the air heater, can be readily removed as by a screw conveyer 33 without shutting down the heater.

In Figs. 8 to 11, inclusive, I have shown an
15 arrangement similar to that just described, except that the air ducts, instead of having their edges drawn together to form an easy entrance to the gases, are made up of flat plates held apart at their edges by channel-
20 shaped distance pieces 34, these channel pieces being omitted at the upper portions of the air ducts where the cross connection is formed.

In the arrangement shown in Figs. 8 to 11,
25 inclusive, it will be noted that the alternate gas and air ducts are formed between a series of parallel plates spaced apart in the respective flues and entrance to the gas ducts will be obtained by omitting the separating
30 pieces 34 between alternate ducts at the point of entrance to the gas ducts of the air heater. The same arrangement will also be used at the gas exit.

In the arrangement illustrated in Figs. 12
35 to 19, inclusive, the ducts are formed of sheets riveted at their edges and in connection with the illustration of this modification, I have shown the air heater applied to a boiler in a somewhat modified manner.
40 In Fig. 12, the boiler 36 has an economizer 37 and an underfeed stoker 38 to which air may be supplied through the ducts 39. In a manner similar to that heretofore described, the air is forced into the air heater
45 through the air inlet duct 40 by a fan 41 and after passing through the air heater, flows through the ducts 39 to the furnace. Similarly, the furnace gases are drawn through the boiler, economizer and air heater
50 by a fan 42 and a stack 43. the gases flowing from the air heater through an outlet flue 44.

The air heater is made up of a pair of vertical flues 45 and 46 having therein a series of ducts made up of sheet metal walls
55 47 spaced apart and held at their edges in the manner heretofore described and preferably having spacing members 48 between their side walls. In this form of my invention, the edges of the sheets are not bent
60 as hereinbefore described, but are formed as best shown in Fig. 19, which is a perspective view of the portion of the air and gas ducts at the upper part of the gas inlet shown in Fig. 12. At this point, a beam 49 extends
65 across the air heater, and in the arrangement

shown, a channel 50 is attached to the lower side of this beam to support the ducts. In the form illustrated, each duct is made up of a flat sheet metal plate 51 and a similar
70 plate 52 having its edges bent, as shown at 53 and 54, to provide a spacing portion and a fastening portion, the portion 54 being riveted to the edges of the plate 51, as shown in the completed ducts at the left of Fig. 19. Member 55 may be provided between the
75 several ducts to stiffen the edges of the plates at the entrance and exit openings of the ducts and also to provide an additional means of attaching the ducts to the support, such as the channel 50. 80

In the arrangement shown in Fig. 12, the construction of the ducts by which the horizontal connection is made between the two sets of vertical air ducts is shown in Figs. 15, 16, 17 and 18. A channel 56 supported
85 in any suitable manner may form the upper part of this horizontal connection, and the upper edges of the plates 51 and 52 may be notched, as shown, to extend around the edge of the channel 56. Between alternate plates
90 is placed the spacing member 57, having up-turned flanges 58, 58 to which the upper edges of the plates 50 and 51 may be riveted, this distance piece 57 also serving to close
95 the upper ends of alternate ducts to divert the air or gases in such ducts into a horizontal path. In the space between the plates 50 and 51, not provided with the distance
100 pieces 57, the part of the plate which is cut out to form the notch, as 58', may be bent down and fastened to the channel 56 to hold the ducts formed of the plates 50 and 51 in spaced relation. It will be understood, as shown, that in this case the several
105 plates or distance pieces are riveted together along their edges.

If desired, the distance pieces 57 and the members 55 at the gas and air inlets may be filled up with any suitable plastic material to form a shape somewhat like that shown
110 in Figs. 13 and 17 at 60 and in Fig. 13 at 60'. This provides a flared and therefore a relatively easy entrance to the several gas passages formed between the air ducts or
115 to the air ducts between the several gas passages. This filler material should preferably be of some cement-like substance which would set permanently and not disintegrate under heat.

It will be unnecessary to describe the
120 method of operation of the arrangement shown in Fig. 12 which is substantially the same as that heretofore described with the arrangement shown in Fig. 1.

While I have shown the gas as entering
125 the gas ducts at an angle and leaving the same at an angle, it will be obvious that the condition may be reversed, so that the air will enter and leave at such an angle, and indeed, if desired, my air heater may be ar- 130

ranged so that the air or gas may enter or leave at an angle to the main direction of flow, as desired.

It will also be understood that, although I have shown my air heater in connection with a boiler having an economizer and a forced draft with means for regulating the flow of air to different parts of the stoker, my invention may be used in connection with any arrangement where it is desired to heat air by hot gases. It will also be understood that, if desired, the device may be arranged so that the air ducts and gas ducts are horizontal and so that there will be a continuous straight-line flow through the air heater instead of a flow through parallel sets of air ducts, as shown in Fig. 1.

I claim:—

1. In a device for transferring heat from hot gases to air, two sets of vertically disposed heat-exchange ducts, each set comprising a plurality of parallel ducts arranged side by side, alternate ducts of each set being connected at the upper portions of the ducts, a main air inlet and a main gas outlet connected respectively to the lower end portions of alternate ducts of one of said sets and a main air outlet and a main gas inlet connected respectively to the lower end portions of alternate ducts of the other of said sets.

2. In a device for transferring heat from hot gases to air, two sets of vertically disposed heat-exchange ducts, each set comprising a plurality of parallel ducts arranged side by side, alternate ducts of each set being connected at the upper portions of the ducts, a main air inlet and a main gas outlet connected respectively to the lower end portions of alternate ducts of one of said sets and a main air outlet and a main gas inlet connected respectively to the lower end portions of alternate ducts of the other of said sets, one of said main ducts for each set being connected to its heat-exchange ducts at the sides thereof, whereby the flue passing between said main ducts and its heat-exchange ducts passes at an angle to the direction of flow of fluid through said heat-exchange ducts.

3. In a device for transferring heat from hot gases to air, two sets of vertically disposed heat-exchange ducts, each set comprising a plurality of parallel ducts arranged side by side, alternate ducts of each set being connected at the upper portions of the ducts, a main air inlet and a main gas outlet connected respectively to the lower end portions of alternate ducts of one of said sets and a main air outlet and a main gas inlet connected respectively to the lower end portions of alternate ducts of the other of said sets, said main ducts being connected to their heat-exchange ducts so that the gas and air flow in opposite directions through the heat-exchange ducts and the gases flow down-

wardly towards the main gas outlet duct.

4. In a device for transferring heat from hot gases to air, a plurality of long and wide heat-exchange ducts, each formed of a pair of parallel metallic plates spaced apart, the side edge of at least one plate at each side of the duct being bent toward the other plate and connected thereto, a flue in which said ducts are held side by side and spaced apart to form passages between them, and main inlet and outlet gas ducts and main inlet and outlet air ducts connected respectively to opposite end portions of said heat-exchange ducts and said flue, to cause the air and gases to flow in opposite directions through said ducts and said flue.

5. In a device for transferring heat from hot gases to air, a plurality of long and wide heat-exchange ducts, each formed of a pair of parallel metallic plates spaced apart, the side edge of at least one plate at each side of the duct being bent toward the other plate and connected thereto, a flue in which said ducts are held side by side and spaced apart to form passages between them, main gas inlet and outlet ducts connected respectively to opposite end portions of said flue and main air inlet and outlet ducts connected respectively to opposite end portions of each of said heat-exchange ducts.

6. In a device for transferring heat from hot gases to air, a plurality of long and wide heat-exchange ducts, each formed of a pair of parallel metallic plates spaced apart, the side edge of at least one plate at each side of the duct being bent toward the other plate and connected thereto, a flue in which said ducts are held side by side and spaced apart to form passages between them, main air inlet and outlet ducts connected respectively to opposite end portions of said flue and main gas inlet and outlet ducts connected respectively to opposite end portions of each of said heat-exchange ducts at the sides thereof.

7. In a device for transferring heat from hot gases to air, two sets of vertically disposed heat-exchange ducts, each formed of parallel metallic plates spaced apart with their side edges bent toward and connected to each other, a pair of vertical flues, each having one of said sets of ducts therein, the ducts of each set being held side by side and spaced apart to form passages between them, the ducts of each set and the flues being connected respectively at the upper portions thereof, main air inlet and outlet ducts connected respectively at the lower end portions of each set of said ducts and main gas inlet and outlet ducts connected respectively at the lower ends of each of said flues.

8. In a device for transferring heat from hot gases to air, two sets of vertically disposed heat-exchange ducts, formed of parallel metallic plates spaced apart with their

side edges bent toward and connected to each other, a pair of vertical flues, each having one of said sets of ducts therein, the ducts of each set being held side by side and spaced apart to form passages between them, the ducts of each set and the flues being connected respectively at the upper portions thereof, main air inlet and outlet ducts connected respectively at the lower end portions of each set of said ducts and main gas inlet and outlet ducts connected respectively at the lower ends of each of said flues, with the air inlet and the gas outlet adjacent, whereby the gas and the air flow in opposite directions through the heat-transfer device and the gas flows downward toward the gas outlet.

9. In a device for transferring heat from hot gases to air, two sets of vertically disposed heat-exchange ducts, formed of parallel metallic plates spaced apart with their side edges bent toward and connected to each other, a pair of vertical flues, each having one of said sets of ducts therein, the ducts of each set being held side by side and spaced apart to form passages between them, the ducts of each set and the flues being connected respectively at the upper portions thereof, main air inlet and outlet ducts connected respectively at the lower end portions of each set of said ducts and main gas inlet and outlet ducts connected respectively at the lower ends of each of said flues, the main air ducts being connected to the sides of the heat-exchange ducts.

10. In a device for transferring heat from hot gases to air, two sets of vertically disposed heat-exchange ducts, formed of parallel metallic plates spaced apart, the side edges of at least some of the plates being bent toward an adjacent plate and connected thereto, a pair of vertical flues, each having one of said sets of ducts therein, the ducts of each set being held side by side and spaced apart to form passages between them, each duct being closed at the top and having a connection with a duct of the other set through its side at a point adjacent its top and the flues having their tops connected by a connecting flue above the tops of the ducts.

11. In a device for transferring heat from hot gases to air, two sets of vertically disposed heat-exchange ducts, formed of parallel metallic plates spaced apart, the side edges of at least some of the plates being bent toward an adjacent plate and connected thereto, a pair of vertical flues, each having one of said sets of ducts therein, the ducts of each set being held side by side and spaced apart to form passages between them, each duct being closed at the top and having a connection with a duct of the other set through its side at a point adjacent its top and the flues having their tops connected by a connecting flue above the tops of the

ducts, said connecting flue having doors and being of sufficient size to permit access to the spaces between the ducts, whereby the outer walls thereof may be freed from soot.

12. In a device for transferring heat from hot gases to air, a heat-exchange duct composed of relatively long and wide parallel, metallic plates spaced apart with a relatively short distance between them and a plurality of spacing devices located within the boundaries of the plates and connected only to said plates to prevent said plates moving apart, said devices having portions between the plates to prevent said plates moving together, whereby the plates are maintained in parallel relation, and means at the edges of the plates to maintain the duct in position.

13. In a device for transferring heat from hot gases, a heat-exchange duct having two parts extending in a generally vertical direction, each part being composed of a pair of relatively long and wide metallic plates spaced apart and the plates of the two parts being placed end to end to form a continuous duct, the lower of said parts being shorter than the upper, and means connected to the edges of the plates to maintain the parts in alinement.

14. In a device for transferring heat from hot gases, a heat-exchange duct having two parts extending in a generally vertical direction, each part being composed of a pair of relatively long and wide metallic plates spaced apart and the plates of the two parts being placed end to end to form a continuous duct, the lower of said parts being shorter than the upper and of a different metal, and means to maintain the parts in alinement.

15. In a device for transferring heat from hot gases to air, two sets of connected heat-exchange ducts, one of which is substantially vertical, flues in which said ducts are maintained in spaced relation, and the two sets in alignment, and a gas outlet and an air inlet in the lower one of the sets, whereby the gas flows downward and the air flows upward in said sets of ducts.

16. In a device for transferring heat from hot gases to air, two sections of connected heat-exchange ducts extending in a generally vertical direction, flues in which said ducts are maintained in spaced relation, and a gas outlet and an air inlet in the lower one of said sections, whereby the gases and the air flow in opposite directions through the device, the section containing the gas exit being located so that moisture collected thereon will gravitate away from the other section.

17. In a device for transferring heat from hot gases to air, a plurality of long and wide heat-exchange ducts, each formed of a pair of parallel metallic plates spaced apart, the side edges of at least one plate at each side of the duct being bent toward the other plate

and connected thereto, a flue in which said inlet being connected to one side of an end ducts are held side by side and spaced apart portion of said flue and said flue having an 10 to form passages between them, main gas extension on the opposite side of the ducts inlet and outlet ducts connected respectively from said gas inlet and unoccupied by said 5 to opposite end portions of said flue and air ducts, whereby a dust pocket is formed in main air inlet and outlet ducts connected said flue to receive dust from the flue gases. respectively to opposite end portions of each of said heat-exchange ducts, said main gas

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