

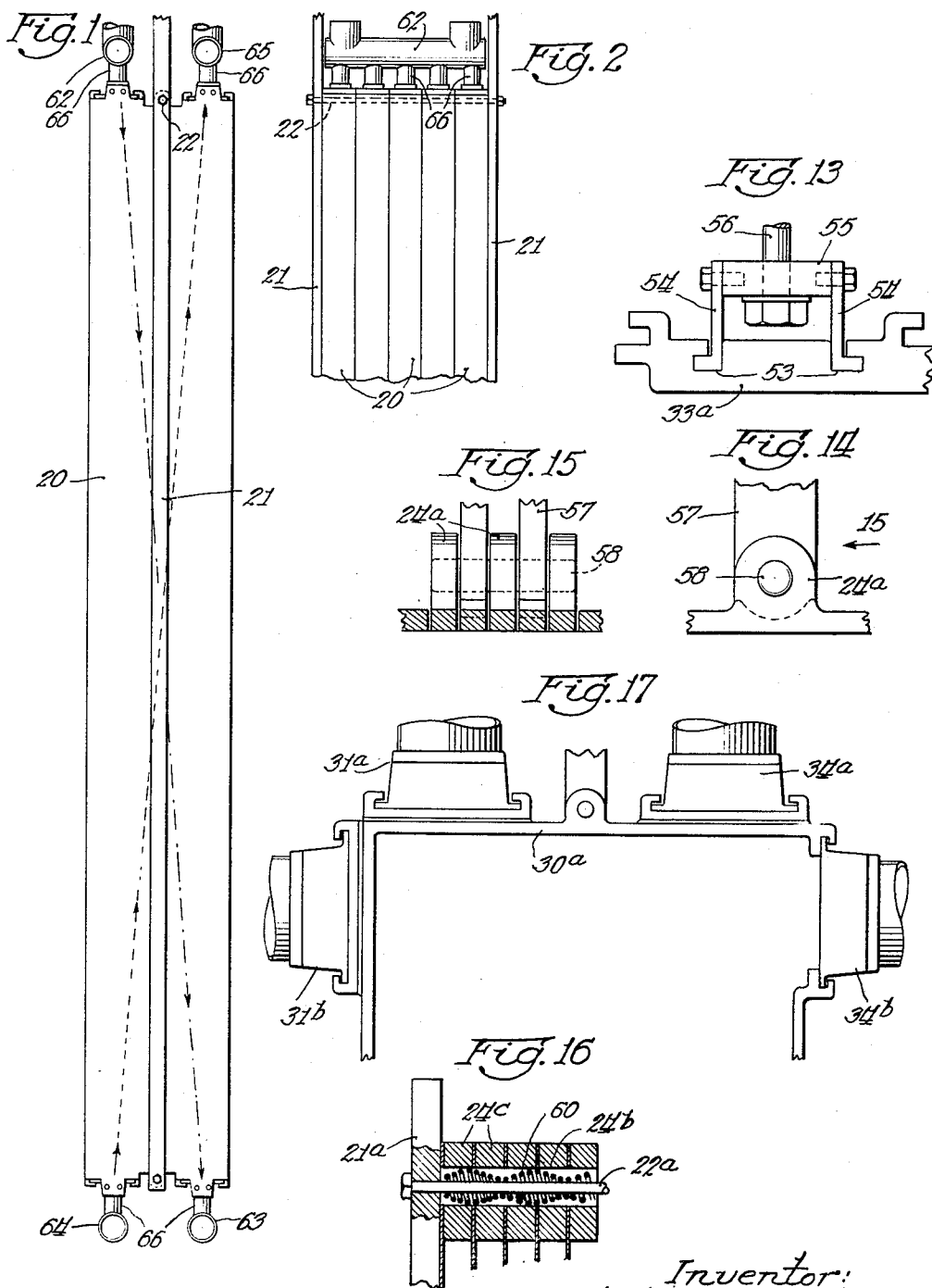
May 6, 1952

C. S. SIMPELAAR
GAS-TO-GAS HEAT EXCHANGER

2,595,308

Filed March 3, 1948

5 Sheets-Sheet 1



Inventor:
Clyde S. Simpelaar
By: *J. Lee & J. Lee*
Attys

May 6, 1952

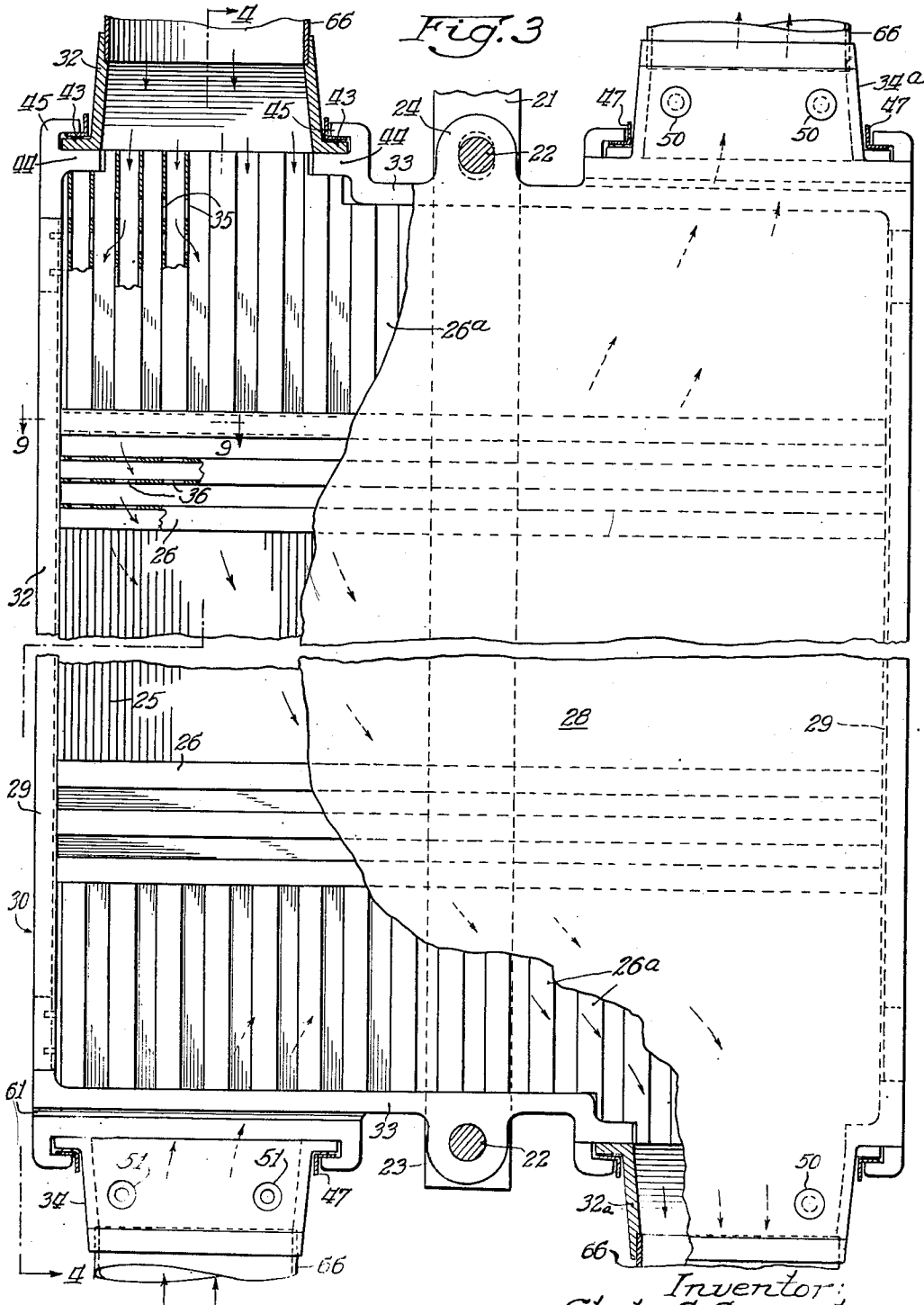
C. S. SIMPELAAR

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GAS-TO-GAS HEAT EXCHANGER

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5 Sheets-Sheet 2



Inventor:
Clyde S. Simpelaar
By: J. Lee & Lee *Attys.*

May 6, 1952

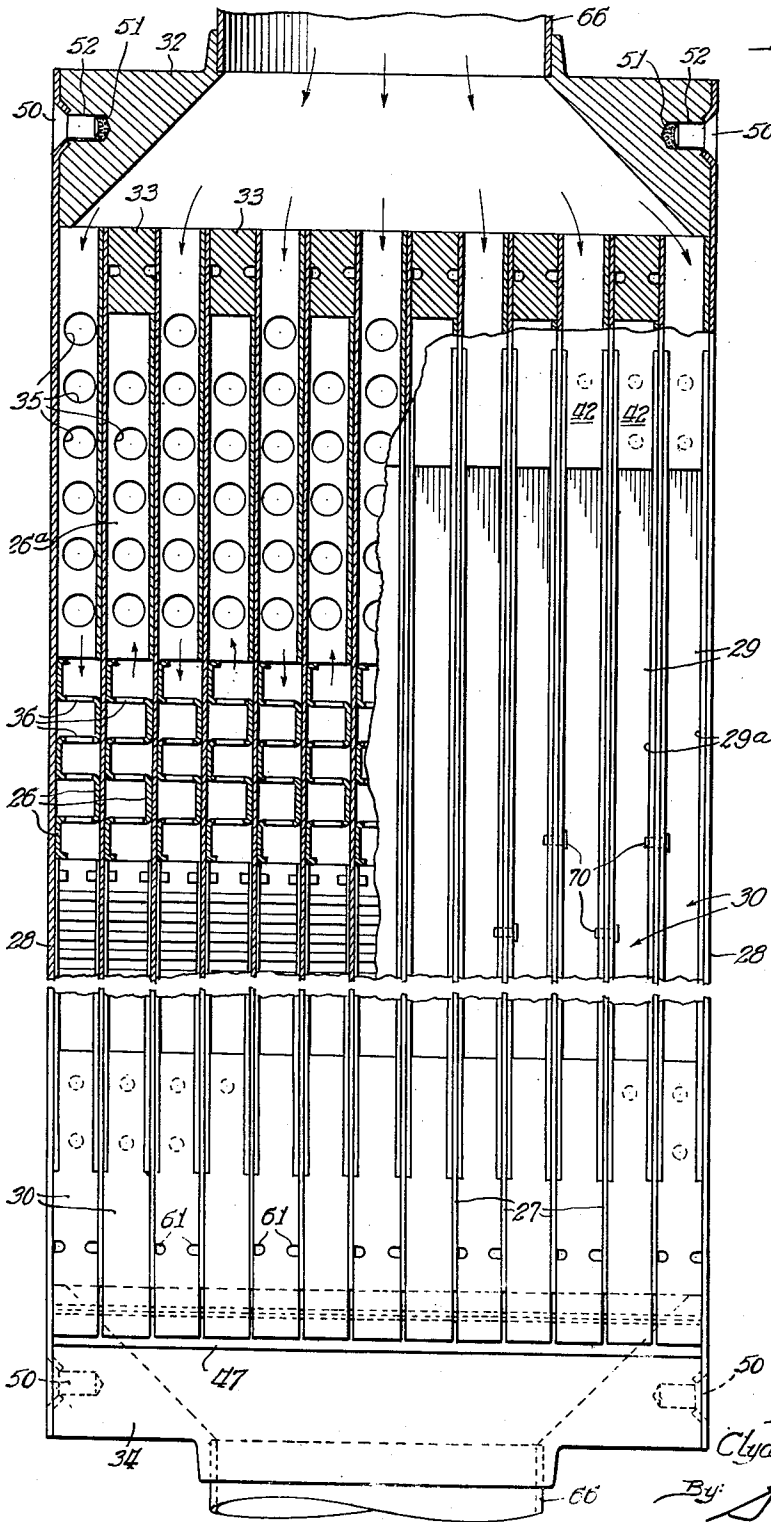
C. S. SIMPELAAR

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GAS-TO-GAS HEAT EXCHANGER

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5 Sheets-Sheet 3



Inventor:
Clyde S. Simpelaar
By: *J. Lee & S. Lee*
Attys.

May 6, 1952

C. S. SIMPELAAR

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GAS-TO-GAS HEAT EXCHANGER

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5 Sheets-Sheet 4

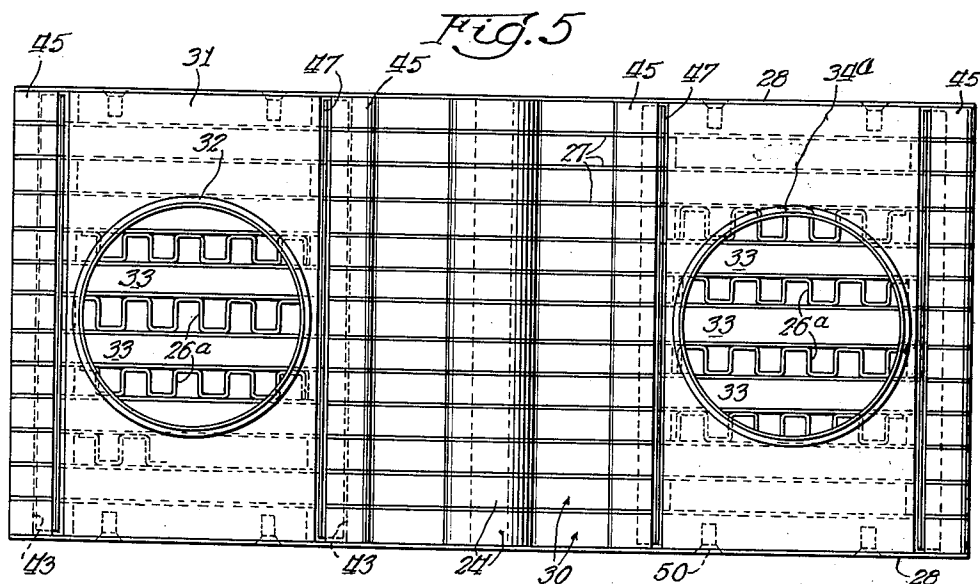


Fig. 9

Fig. 10

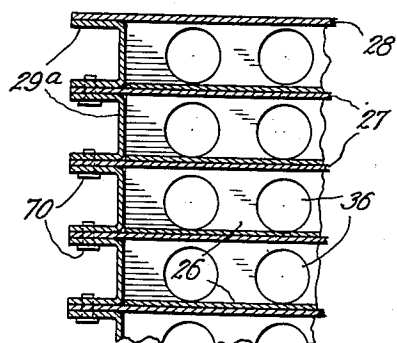


Fig. 11

Fig. 12

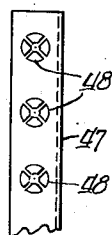


Fig. 12a

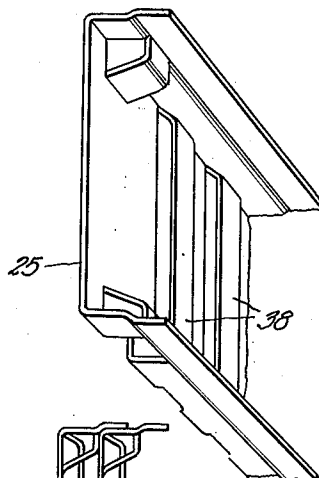
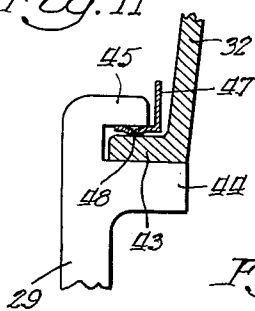


Fig. 18

Inventor:
Clyde S. Simpelaar
By: *[Signature]* Attys

May 6, 1952

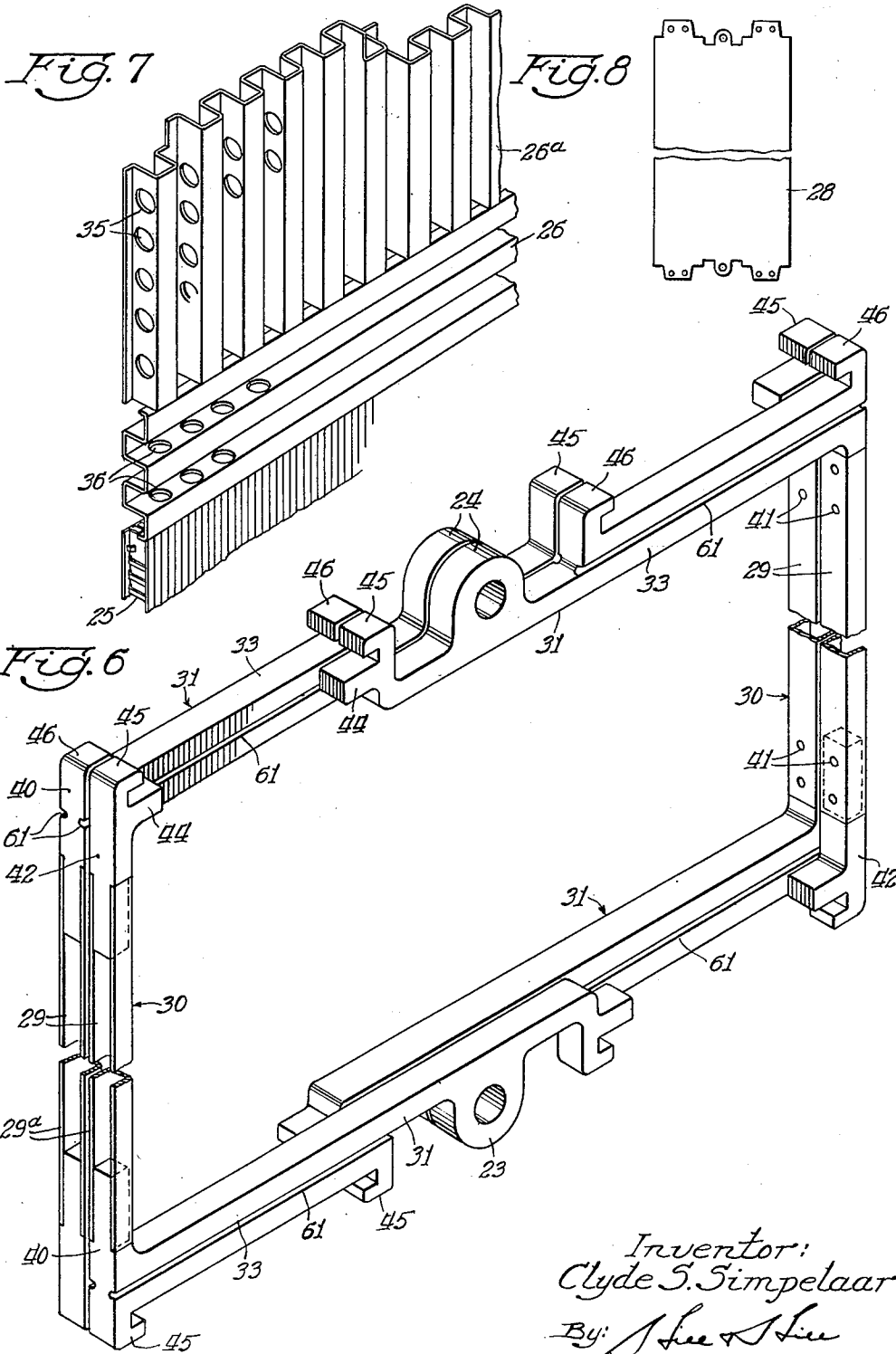
C. S. SIMPELAAR

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GAS-TO-GAS HEAT EXCHANGER

Filed March 3, 1948.

5 Sheets-Sheet 5



Inventor:
Clyde S. Simpelaar
By: *[Signature]*

[Initials]

UNITED STATES PATENT OFFICE

2,595,308

GAS-TO-GAS HEAT EXCHANGER

Clyde S. Simpelaar, Racine, Wis., assignor to
Modine Manufacturing Company, Racine, Wis.,
a corporation of Wisconsin

Application March 3, 1948, Serial No. 12,865

10 Claims. (Cl. 257-245)

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This invention relates to gas to gas heat exchangers and is in the nature of an improvement on the heat exchanger disclosed in my pending application Serial No. 780,251, filed October 16, 1947.

As in the heat exchanger of my said prior application, this heat exchanger is employed for heat exchange between two or more gases of different temperatures, and the principal object is to increase the efficiency in heat exchangers of this character.

Another object is to produce a heat exchanger suitable for high pressure operation and in which there is a true counterflow of gases and having a high heat transfer capacity and low pressure drop.

Another object is to provide improved means to vent any leakage of gas to the outer atmosphere.

Another object is to provide improved means to urge the gas connections against the border frame members during the bonding operation.

Another object is to tie the gas connections to the side sheets of the heat exchanger by means which allow for relative movement between the gas connections and side sheets during the bonding operation.

Another object is to provide a novel and improved means to support a heat exchanger unit or several of them arranged in a bank.

Another object is to provide a simple mechanical assembly of relatively few individual self-locating and supporting parts in which the baking of the assembled unit completes the fabrication thereof in a single bonding operation.

Another object is to provide a heat exchanger of which the component parts; except the inlet and outlet gas connections and border frame members, are fabricated from relatively inexpensive metal sheet or strip stock.

Another object is to improve the construction of the border frame members as well as the method of assembling the border frame members with the inlet and outlet gas connections.

Another object is to obtain a more efficient flow distribution through the heat exchanger unit.

Another object is to provide a heat exchanger assembly constructed of a plurality of similar units capable of efficient usage in gas separation plants such as oxygen and nitrogen plants.

With these and other objects and advantages in view, this invention consists in the several novel features of construction, arrangement and combination of parts hereinafter fully set forth and more definitely pointed out in the appended claims.

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The invention is clearly illustrated in the drawings accompanying this specification, in which:

Fig. 1 is an end elevation of a bank of heat exchanger units;

Fig. 2 is a side elevation thereof partly broken away;

Fig. 3 is a view of one of the units partly in side elevation and partly in vertical section and with the middle portion thereof broken away and part of one of the side sheets broken away;

Fig. 4 is a view partly in end elevation and partly in vertical section of the unit seen in Fig. 3 taken substantially on the line 4-4 of Fig. 3;

Fig. 5 is a plan of the unit seen in Fig. 3;

Fig. 6 is a perspective view partly broken away of two border frame members of the unit;

Fig. 7 is a perspective view partly broken away of certain plenum sections or filler and distribution strips and fin elements that comprise one of the passes of the unit;

Fig. 8 is a side elevation of one of the side sheets of the unit;

Fig. 9 is a horizontal section through several of the separation sheets and several channel members of some of the border frame members taken substantially on the line 9-9 of Fig. 3;

Fig. 10 is a detail fragmental perspective view upon an enlarged scale of one of the fin elements;

Fig. 11 is a detail fragmental view partly in side elevation and partly in vertical section illustrating one of the spring strips that are located between the gas connections and the border frame members;

Fig. 12 is a detail fragmental plan of the spring strip seen in Fig. 11;

Fig. 12a is an end view of the spring strip seen in Fig. 12;

Fig. 13 is a detail fragmental side view of a modified form of hanger connection;

Fig. 14 is a detail fragmental side view of a second modified form of hanger connection;

Fig. 15 is a view of the hanger connection seen in Fig. 14 looking in the direction of the arrow 15 therein;

Fig. 16 is a detail vertical section through a third modified form of hanger connection;

Fig. 17 is a diagrammatic view in side elevation of a modified form of heat exchanger unit partly broken away; and

Fig. 18 is an end elevation of two fin elements showing them in nested together condition.

Referring to said drawings and first to Figs. 1 and 2, the reference character 20 designates several of the heat exchanger units with their broad sides placed side by side and provided at

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their ends with inlet and outlet manifolds as will hereinafter be described.

While the heat exchanger may be laid on its side, it is here shown as suspended vertically by hanger bars 21 secured to the upper and lower ends of the units by rods 22 which extend through the hanger bars and through lugs 23, 24 (see Figs. 3 and 6) formed on the border frame members. The upper holes in the hanger bars may be elongated vertically to allow for unequal expansion and contraction between the units and hanger bars.

The heat exchanger units are substantially identical in construction and each comprises a fabricated elongated unit composed of alternate and intermediate passes, each consisting of nested together fin elements 25 (see also Fig. 10) and plenum sections or filler and distribution sections 26, 26a. Gas of one temperature flows through alternate passes, and gas of a higher or lower temperature flows through the intermediate passes but in the opposite direction. The slabs of fin elements extend lengthwise of the unit and are arranged in heat exchange relation with respect to each other and are spaced apart by separation sheets 27 (see Fig. 4). Side sheets 28 enclose two of the sides of the unit while arms 29 of the border frame members 30 (see Figs. 3, 4 and 6) enclose the other two sides of the unit.

The border frame members 30 are similar in construction, and a description of one will suffice for all of them. Each border frame member contains two similar L-shaped bars 31, each of which comprises the relatively long arm 29 and a relatively short arm 33, the long arms 29 extend the full length of the unit, but the short arms stop short of the opposite long arms to leave gaps which serve as ports to the interior of the pass bounded by the border frame member.

The long arms of the L-shaped bars in the main are composed of channel shaped members 29a, each temporarily fastened at one end to a right angle extension 40 of the short arm of the L-shaped bar as by screws 41 (see Fig. 6), and temporarily fastened at its other end to an extension 42 as by screws 41. The ends of the extensions 40, 42 are let into the channels of the channel bars so that their side faces may be flush.

The channel shaped members 29a of the border frame members are tied to the separation sheets 27 as by drive screws 70 to temporarily secure them together prior to the bonding operation.

The adjacent border frame members are reversed, with respect to each other, so that the short arm 33 of each L-shaped bar extends along the gap at the end of the adjacent short arms. Thus, gas may enter and discharge from alternate passes, but the intermediate passes are blocked off at these gaps so that gas cannot enter or discharge through the blocked off places.

Referring now to Fig. 3, it will be seen that a gap is left between the upper short arm 33 and the long arm at the left, and that a gap is left between the lower short arm 33 and the long arm at the right. Gas enters the pass shown and through the alternate passes from the gas inlet connection 32 and flows through the pass and discharges through the gas outlet connection 32a. The intermediate passes are blocked off at the top and bottom (see Fig. 4), but gas of a different temperature enters the intermediate passes through the gas inlet con-

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nection 34 and flows through the intermediate passes to the gas outlet connection 34a. Thus, it will be seen that a true counter-flow for gases is provided.

The plenum sections are preferably composed of corrugated metal sheets of which the plenum sections 26a have perforations 35 in their side walls, whereby the gas may flow laterally as well as longitudinally. The plenum sections 26 extend at right angles to the plenum sections 26a and the top and bottom walls thereof have perforations 36 therein, through which gas may flow in a vertical direction as well as laterally of the unit.

The fin elements 25 extend longitudinally of the unit between the plenum sections 26, and the cross walls 38 of the fin elements are slit and offset to provide slots through which the gas may flow laterally therefrom and longitudinally thereof as in my prior application above referred to.

The fin elements are nested together as seen in Fig. 18 and may be constructed in accordance with the disclosure of my prior application above referred to. In Figs. 3 and 4, the major portion of the fin elements has been broken away and others omitted to permit the view to be made upon as large a scale as possible.

The gas connections extend between the side plates 28 at the top and bottom of the unit. Each gas connection is generally of rectangular form and has two solid side flanges 43 by which it is secured to the L-shaped bars of the border frame members. At the gaps, the L-shaped bars are formed with ledges 44, against which the flanges 43 contact. Hooks 45 project outward from these ledges, and other hooks 46 are formed on the parts of the short arms 33 that block off the entrance to the interior of the unit. The hooks 46 are aligned with the hooks 45, so that the flanges 43 of the gas connections may enter the grooves between the hooks 45 and ledges 44, and between the hooks 46 and short arms 33 of the L-shaped bars.

For urging the gas connections against the ledges 44 and against adjacent parts of the short arms 33, prior to the bonding operation, spring strips 47 (see Figs. 11, 12 and 12a) are employed between the hooks 45, 46 and flanges 43 of the gas connections. These spring strips are struck up with suitable dies to provide groups of spring fingers 48 with the groups spaced apart the same distance, center to center, as are the hooks 45, 46, so that when the spring strips have been driven into place there will be a group of spring fingers between each hook 45 and 46 and the flanges of the gas connections. When the spring strips have been driven into place, the spring fingers have been placed under compression and function to urge the flanges 43 against the ledges 44 and the short arms 33, so as to hold them in intimate contact during the bonding operation to insure a perfect bond between the gas connections and adjacent parts of the border frame members.

The gas connections are respectively tied to the side sheets 28 by rivets 50 (see Fig. 4), which may have tapered heads that extend through counter-sunk holes in the side sheets with their stems entering oversize sockets 51 in the gas connections. The walls of the sockets are lined with bonding material 52 so as to make the cavity in the sockets of the same diameter as that of the rivets, whereby the latter, when driven into the cavities, will be securely held therein. The purpose of lining the sockets with bonding material

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is to permit of any unequal expansion between the side sheets and gas connections, and to allow for movement of the gas connections toward the border frame members as the bonding material on the adjacent faces of the flanges of the gas connections and the border frame members melts and as the spring fingers urge the gas connections toward the border frame members. As the bonding material around the rivets melts, the gas connections may move relative to the rivets.

To prevent any possibility of leakage between passes at the gas connections, grooves 61 (see Fig. 6) are formed in the arms 33 of the border frame members at places adjacent the gaps. These grooves extend lengthwise of the arms and the separation sheets 27 extend past the grooves, thus providing ducts that open at their ends to the outer atmosphere. The grooves prevent the passage of gas from the gas connections to the blocked off passes and likewise from the blocked off passes to the gas connections, any leakage in either direction is vented to the atmosphere.

When several units are used in a heat exchanger as shown in Figs. 1 and 2, gas inlet manifolds 62, 64 and gas outlet manifolds 63, 65 may be used in connection with the several units. The manifolds may be connected to the respective gas inlet and outlet connections by pipe connections 66 soldered or otherwise joined thereto.

A heat exchange unit embodying the present invention may be assembled as follows:

First, one of the side sheets 28 is laid upon a bench, table or other support with the rivets 50 projecting up through holes in the sheet. The gas inlet and outlet connections may then be set in place on the side sheet, and two L-shaped bars of the border frame member are laid in place upon the sheet, the flanges 43 of the connections serving as guides for the short arms of the L-shaped bars. Other suitable guides may also be provided for properly locating the border frame member on the side sheet. The plenum sections are then laid on the side sheet and a slab of fin elements laid on the sheet in the space between the innermost plenum sections. A separation sheet 27 is then laid upon the assembled parts and another course or pass, similar to the first one, is laid upon the separation sheet except that the border frame member is reversed with respect to the one of the first course or pass, so that the short top and bottom arms of the L-shaped bars block off the entrance and exit to and from the next adjacent passes. In this manner, the several courses or passes are assembled, after which the spring strips are hammered into place with the spring fingers pressing against the flanges and urging them into intimate contact with the border frame members.

The other side sheet is then laid on the assembled parts and rivets 50 are driven through the holes in the side sheet and into the lined sockets in the gas connection, after which the entire structure is placed in an oven and heated to the fusing temperature of the bonding material. It is to be understood that the surfaces of the contacting members of the unit are coated with a suitable bonding material or thin sheets of bonding material may be used between such members when that is more convenient or preferable.

In the modified form of hanger connection illustrated in Fig. 13, the upper short arms 33a of the border frame members are formed with L-shaped slots 53, extending down from their upper faces, and L-shaped bars 54 have their lower edge portions inserted into said slots with

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their upper edge portions bolted to a hanger block 55 suspended on a bolt or other headed rod 56.

In the modified form of connection shown in Figs. 14 and 15, the upper intermediate lugs between the lugs 24a are omitted from the border frame members, and the lower ends of the hanger bars 57 are placed between the lugs 24a and secured thereto as by a pin 58.

In the modified form of hanger connection illustrated in Fig. 16, the upper rod or bolt 22a extends through the hanger bars, one of which is seen at 21a and extends through oversized holes 24b in the lugs 24c, which lugs correspond with the lugs 24 in Fig. 3. A coiled spring 60 of hour glass form having coils that engage the walls of the holes in the lugs, and other coils that engage the rod or bolt 22a permit unequal expansion between the units and hanger bars. The lower ends of the hanger bars may be connected to the units by a rod or bolt in the same manner as is illustrated in Fig. 3.

In the modified form of heat exchanger unit illustrated fragmentarily in Fig. 17, in addition to the inlet and outlet gas connections at the ends of the unit, other inlet and outlet gas connections are provided at the sides of the unit; an inlet gas connection 31a and an outlet gas connection 34a are illustrated at the upper end of the unit; similar gas connections are provided at the lower end as illustrated in connection with the preferred form of the invention. Another gas inlet connection 31b is shown at one side of the unit adjacent its upper end, and an outlet connection 34b is shown at the opposite side of the unit. Gas inlet and outlet connections are also provided on the opposite sides of the unit adjacent the lower end thereof except that the gas inlet connection will be at the right hand side and the gas outlet connection will be at the left hand side.

This modified construction provides for handling four different gases of different temperatures; the border frame members 39a are constructed so as to block off all of the passes except those communicating with a gas inlet connection and a corresponding outlet connection. As an example, the border frame member shown has a gap at the gas outlet connection 34b, consequently, said border frame member has a gap at the corresponding inlet connection.

The passes are constructed substantially in the same manner as those of the preferred form, and those passes which handle the same gas open to one of the gas inlet connections and a corresponding gas outlet connection.

In the operation of the heat exchanger of the preferred form, gas of one temperature flows through the alternate passes and gas of a higher or lower temperature flows through the intermediate passes in the opposite direction. The heat of the hotter gas is conducted to the gas of lower temperature by the separation sheets, fin elements and plenum sections.

Having thus described my invention, it is obvious that various immaterial modifications may be made in the same without departing from the spirit of my invention; hence, I do not wish to be understood as limiting myself to the exact form, construction, arrangement and combination of parts herein shown and described or uses mentioned.

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

1. In a gas to gas heat exchanger, the combination of border frame members having inlet

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and outlet openings, inlet and outlet gas connections secured to said border frame members at said inlet and outlet openings, separation sheets overlapping the side edges of the border frame members and providing narrow spaces, corrugated and perforated plenum sections in said spaces extending longitudinally from the ends of the border frame members, other corrugated and perforated plenum sections in said spaces extending from said longitudinal plenum sections, and crosswise of the spaces, and nested together slotted fin elements in said spaces extending between the horizontal plenum sections, all of the contacting parts being bonded together, the size and number of perforations in the respective plenum sections being such that a desired distribution of gas flow is achieved between the respective openings and the finned space between the horizontal plenum sections.

2. A gas to gas heat exchanger comprising in combination, border frame members each having gaps therein, said gaps providing ports between the exterior and interior of the border frame members, the ports at each end comprising inlet and outlet ports, separating sheets between adjacent border frame members, inlet and outlet gas connections disposed at the inlet and outlet ports, apertured plenum sections adjacent the ends of the border frame members, some extending at right angles to the others, and fin elements occupying the space between and extending between the plenum sections, all adjacent parts being bonded together, the size and number of apertures in the respective plenum sections being such that a desired distribution of gas flow is achieved between the respective ports and the finned space between the horizontal plenum sections.

3. A gas to gas heat exchanger comprising in combination, border frame members each having gaps therein, said gaps providing ports between the exterior and interior of the border frame members, the ports at each end comprising inlet and outlet ports, separating sheets between adjacent border frame members, gas inlet and gas outlet connections disposed at the inlet and outlet ports, apertured plenum sections adjacent the ends of the border frame members, some extending at right angles to the others, and slotted fin elements occupying the space between and extending between the plenum sections, all of the contacting parts being bonded together, the size and number of apertures in the respective plenum sections being such that a desired distribution of gas flow is achieved between the respective ports and the finned space between the horizontal plenum sections.

4. In a gas to gas heat exchanger, the combination of side sheets, separation sheets therebetween, heat exchanger elements including border frame members disposed between said sheets, gas connections disposed at the ends of said heat exchange elements and extending between said side sheets, certain of said border frame members having openings therein operatively connecting said connections with the heat exchanger elements associated with such frame members locating rivets extending through said side sheets and into oversized holes in the gas connections to maintain the latter and said sheets in assembled relation, and fusible bonding material disposed between the walls of the holes and the rivets, said fusible bonding material, when fused, permitting limited relative adjusting movement between the gas connections and

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border frame members during the bonding operation, said rivets providing in the bonded structure interlocked connections between the side plates and the gas connections.

5. In a gas to gas heat exchanger, the combination of side sheets, separating sheets therebetween, heat exchanger elements including border frame members disposed between said sheets, gas connections disposed at the ends of said heat exchange elements and extending between said side sheets, certain of said border frame members having openings therein operatively connecting said connections with the heat exchanger elements associated with such frame members, taper headed locating rivets extending through counter-sunk holes in said side sheets and into oversized holes in the gas connections to maintain the latter and said side sheets in assembled relation, the walls of said holes being lined with fusible bonding material disposed between the walls of the holes and the rivets, said fusible bonding material, when fused, permitting limited relative adjusting movement between the gas connections and border frame members during the bonding operation, said rivets providing in the bonded structure interlocked connections between the side plates and the gas connections.

6. In a heat exchanger, the combination of a multipass heat exchange structure, including a plurality of pairs of L-shaped border frame members, each pair forming the side walls of a respective pass, the pairs of border frame members of corresponding passes carrying the same fluid being similarly positioned with gaps between the adjacent ends of each pair of frame members to form inlet and outlet openings therein similarly located in the respective passes to form a group of inlet openings and a group of outlet openings, inlet and outlet connections respectively located at and operatively enclosing the respective groups of inlet and outlet openings, with the connections abutting the end portions of border frame members adjacent said openings, said connections each having a pair of oppositely disposed, parallel flanges extending transversely across the adjacent border frame members, the ends of the latter each extending outwardly therefrom with hooks at opposite sides of each gap terminating in opposed portions, each overlying an adjacent flange of the connection thereat, and resilient means interposed between the overlying portions of the hooks and such flanges operative to urge the abutting surfaces of such connection and members toward one another, said members and connections being bonded into a unitary structure with said resilient means operative to maintain the connections and members in close engagement during the bonding thereof.

7. In a heat exchanger, the combination of a multipass heat exchange structure, including a plurality of border frame members forming the side walls of such passes, the border frame members of corresponding passes carrying the same fluid having openings therein similarly located in the respective passes to form a group of openings, a connection located at and operatively enclosing the group openings, with the connection abutting the portions of border frame members adjacent said openings, said border frame members having pairs of hooks extending outwardly from the frame with their free ends terminating on opposed portions overlying peripheral portions of the connection, and resilient means interposed between the overlying portions of the

hooks and said connection operative to urge the abutting surfaces of said connection and members toward one another, said members and connection being bonded into a unitary structure with said resilient means operative to maintain the connection and members in close engagement during the bonding thereof.

8. In a heat exchanger, the combination of a multipass heat exchange structure, including a plurality of border frame members forming the side walls of such passes, the border frame members of corresponding passes carrying the same fluid having inlet and outlet openings therein similarly located in the respective passes to form a group of openings, a connection located at and operatively enclosing the group of openings, with the connection abutting the portions of border frame members adjacent such openings, said connection having oppositely disposed flanges extending across the adjacent ends of the respective passes, said border frame members having grooves therein disposed in opposed relation on opposite sides of each of the respective openings, said grooves extending transversely to their respective frame members and aligned with corresponding grooves in the other frame members, the flanges on said connection being positioned in respective opposed grooves, and resilient means positioned between the outer faces of the flanges and the adjacent side walls of the grooves operative to urge the abutting surfaces of said connection and members toward one another, said members and connection being bonded into a unitary structure with said resilient means operative to maintain the connection and members in close engagement during the bonding thereof.

9. In a heat exchanger, the combination of a multipass heat exchange structure, including a plurality of border frame members forming the side walls of such passes, the border frame members of corresponding passes carrying the same fluid having openings therein similarly located in the respective passes to form a group of openings, a connection located at and operatively enclosing the group of openings, with the connection abutting the portions of border frame members adjacent such openings, said connections having oppositely disposed flanges extending across the adjacent ends of the respective passes, said border frame members having portions integrally formed therewith overlying the opposed flanges of the connection, and resilient means interposed between the overlying portions of the border frame members and said flanges operative to urge the abutting surfaces of said connection and members toward one another, said members and connection being bonded into a unitary structure with said resilient means operative to maintain the connection and members in close engagement during the bonding thereof.

10. In a fluid pass for heat exchangers, the combination of a pair of spaced, relatively thin, rectangular metal sheets, the latter being positioned in parallel planes and substantially co-extensive in size, closure means at the peripheral edges of said sheets for operatively sealing the space between said sheets at said edges to form a closed chamber, a plurality of elongated, relatively closely spaced fin elements positioned in said chamber, all of said elements extending in the same direction, with their corresponding ends spaced from the closure means at a pair of opposite edges of said sheets, said elements substantially filling the transverse space between the closure means at the other pair of opposite edges of said sheets, with said fin elements extending from one sheet to the other, respective plenum structures positioned between the respective ends of the fin elements and adjacent closure means, said structures each comprising a pair of corrugated sheets, with the height of the corrugations being substantially equal to the distance between said first-mentioned spaced sheets, with the corrugations of one sheet of each pair extending at right angles to the corrugations of the other sheet of such pair, said structures providing reinforcing means between said spaced sheets, said pass having a pair of openings therein each located at and communicating with a respective plenum structure to form fluid ports for the pass, the transverse walls of the corrugated plenum structures having a plurality of spaced openings therein arranged to provide a desired distribution of fluid flow between each fluid port and the adjacent corresponding ends of the finned elements, all adjacent parts of said fluid pass being bonded together into a unitary structure.

CLYDE S. SIMPELAAR.

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