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RECUPERATOR STRUCTURES

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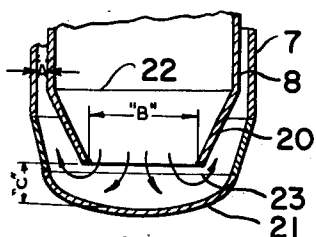
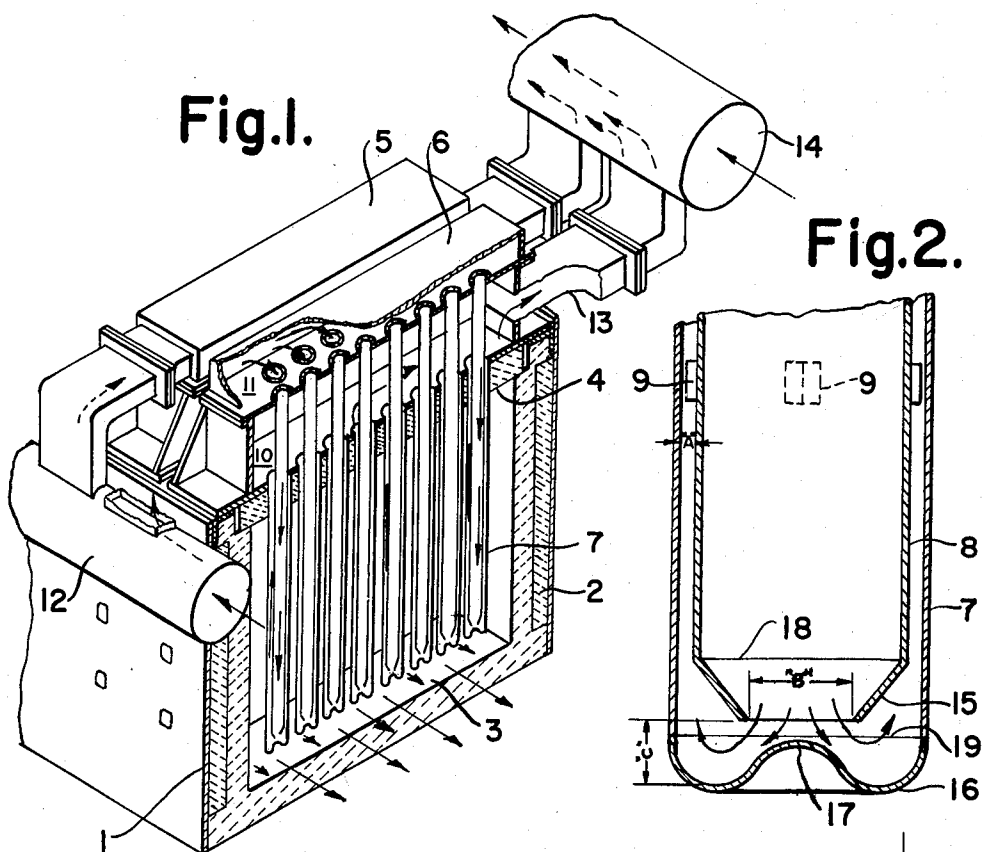


Fig. 3.

A	B	C
1/4"	3"	1 1/2"
5/16"	3 1/16"	1 9/16"
3/8"	3 3/8"	1 13/16"
7/16"	3 9/16"	2 3/32"
1/2"	3 3/4"	2 3/8"
9/16"	3 7/8"	2 5/8"
5/8"	4"	2 7/8"

Fig. 4.

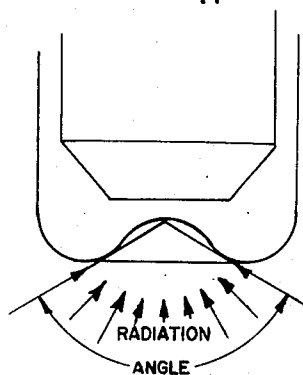


Fig. 5.

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1

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RECUPERATOR STRUCTURES

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This invention relates to new and useful improvements in recuperator structures, more particularly to the shaping and spacing of the ends of the heat exchange tubes of metallic recuperators. The present invention is a continuation-in-part of application Serial No. 444,514 filed July 20, 1954, now abandoned.

In the former application there is disclosed metallic tube structures made of stainless steel in which the ends of the tubes are shaped to eliminate dead spots at the center thereof. Also the tubes are designed to prevent the collection of dust or flakes of scale in the dead air space at the ends of the tubes by eliminating such space and utilizing the full sweeping action of the air velocity passing through said tubes.

The present application deals with the spacing of the walls of an inner and outer tube and the shaping and spacing of the ends of the tubes in such proportion that the cold air passing from the inner tube at the end into the end of the outer tube and up along the space between said tubes maintains the tube ends below the melting temperature of the metal and has a uniform velocity flow whereby there is no interruption of the air stream that would cause stagnation or that would effect clogging by precipitation of any particles entrained in said air.

The invention and its objects will appear more clearly from a description of the accompanying drawing which constitutes a part hereof in which like reference characters designate like parts and in which:

Figure 1 is a view in perspective of a recuperator structure with banks of metal tubes embodying the principles of this invention.

Figure 2, a cross-sectional view of the lower end of the assembled inner and outer tubes;

Figure 3, a cross-section of the lower end of a modified form of inner and outer recuperator tube shapes.

Figure 4, a table giving the relative spacing of the inner and outer tubes and the dimensions of the flow passages from the inner tube and between the tubes; and

Figure 5, a diagrammatic illustration of the radiation angle of the tube shown in Figure 2.

In the drawing the numerals 1 and 2 designate the side walls of a recuperator chamber, 3 the floor thereof and 4 the ceiling. Supported on the walls 1 and 2, which are suitably reinforced by buckstays and other structural steel members, are a plurality of headers 5 and 6, each of which supports banks of metallic tubes 7 that are made of stainless steel, there being the outer tubes 7 and inner tubes 8 separated by spacers 9 as shown in Figure 2, the outer tubes being in open communication with a chamber 10 and the inner tubes extending upward to a chamber 11. The chamber 11 is connected to manifold 12 from which cold air is blown into the chamber and downwardly through the tubes 8 and the chamber 10 is connected by ducts 13 to a manifold 14 which collects the preheated air passing upward from the outer tubes

2

into chamber 10 and delivers the same to the burners (not shown) of an industrial heating furnace such as a continuous billet heating furnace, also not shown.

The construction of the recuperator and the manner of mounting the tubes is not novel and is no part of the present invention. It has been described for illustrative purposes only. The invention deals with the shape and spacing of the inner and outer tube ends, as shown in Figures 2 to 5 of the drawings.

In the form of tube ends shown in Figure 2, the inner tube end 15 is of inverted frusto-conical shape open at the end, the opening being designated by the reference character "B." The outer tube end 16 is of concavo convex shape having a reentrant bottom 17. Both the inner tube end 15 and outer tube end 16 may be cast of stainless steel or they may be pressed to shape and welded to the cylindrical end of the tubes on the lines 18 and 19 which are the joints.

In Figure 3, the end 20 of inner tube 8 is of inverted frusto conical shape the same as in Figure 2, but the nose or end 21 of outer tube 7 is cup or dish shaped, as shown. The embodiment of Figure 3 also serves to uniformly deflect the flow of air in substantially the same manner as illustrated in the embodiment of Figure 2 when the spacing of the cylinder walls and tube ends is carried out as hereinafter stated. The ends may be cast or pressed and welded at the joints 22 and 23.

In addition to the shaping of the ends of the tubes, as shown, to eliminate dead or heat spots, an important feature is the spacing and sizing of the air flow passages from the inner tube and between the tubes to keep the metal temperature below melting or burning.

In Figures 2 and 3 the space between the inner and outer tube is designated "A," the end opening of the inner tube "B" and the distance of the end of the inner tube from the end of the outer tube by the reference character "C."

The spacing of the cylindrical walls of the tubes and the ends of the tubes is given in the table shown in Figure 4 of the drawing. If the space "A" between the tubes 7 and 8 is $\frac{1}{4}$ inch, the distance "C" is $1\frac{1}{2}$ inches to provide the same volume and velocity flow at all points from the opening "B" down to the inner wall of the ends 16 and 17 of the outer tube and up the space "A." These figures are derived from calculations to determine the flow areas of the space between the end of the inner tube and the end of the outer tube to be the same as the area of the annular space "A" between the tubes. As shown in the table of Figure 4, the dimensions of "B" and "C" vary with "A."

I have found that by so proportioning the spacing of "A" and "C" and the dimension of "B," the cold air flowing from the inner tube 8 will strike the center of the nose of the outer tube and wipe the inner wall as it passes upward through space "A" between the tubes.

The cold air entering the header chamber 11 is of course somewhat preheated by the warm air flow upward around the space "A" to the outlet header chamber 10. However, by maintaining the velocity and volume of the air flow constant in accordance with the proportioning of the flow passages, as shown in the table of Figure 4, dead air space is avoided at the end of the tube which is of the hottest area of the suspended banks of tubes. The wiping action of the air passing from the opening "B" into the space "C" and "A" keeps the temperature of the tubes to below the melting point and the heated air delivered to the header box chamber 10 is such as to be useful for use in hot blast furnaces or for supporting combustion as in continuous or soaking pit furnaces.

Although several embodiments of the invention have been herein illustrated and described, it will be evident

to those skilled in the art that various modifications may be made in the details of construction without departing from the principles herein set forth. Notice is given of my application Serial Number 293,091 filed June 12, 1952, now abandoned, of which earlier application the application for these Letters Patent comprises a continuation-in-part.

I claim:

1. A metal recuperator for industrial heating furnaces including a heat exchange structure comprising banks of tubular heat exchange members suspended in a hot gas flow passage, said members consisting of outer tubes and inner tubes spaced from each other to provide an air flow passage therebetween, said inner tubes being open at both ends and said outer tubes each having a closure at one end constituting a central deformed deflecting portion deformed in the direction of the outlets of the inner tubes having a curved surface for directing the flow of cold air from the open end of the inner tubes to the air flow passage between said tubes in wiping contact with the curved surface of the closure end of the outer tubes, and the end of the inner tubes adjacent the closure of the outer tubes being of inverted frusto-conical shape to direct the air flow to strike the center of the curved surface of the closure, the open end of the inner tubes being spaced from said curved surface a distance in such proportion to the diameter of the inner tube openings that the flow area corresponds to the flow area of the annular space between the inner and outer tube walls so that the cold air passes from the open ends of the inner tubes against the curved surfaces of the closure and along the air flow passage between said tubes at uniform velocity and volume to maintain said tube ends and outer tube walls below the melting temperature of the metal of which the tubes are made.

2. A metal recuperator for industrial heating furnaces

including a heat exchange structure comprising banks of tubular heat exchange members suspended in a hot gas flow passage, said members consisting of outer tubes and inner tubes spaced from each other to provide an air flow passage therebetween, said inner tubes being open at both ends and said outer tubes having a reentrant closure at one end of concavo-convex shape to provide curved air flow surfaces for directing the flow of cold air from the inner tubes to the air flow passage between said tubes in wiping contact with said curved air flow surfaces, the open end of the inner tubes being spaced from said curved air flow surfaces a distance in such proportion to the diameter of the inner tube openings that the flow area corresponds to the flow area of the annular space between the inner and outer tube walls so that the cold air passes from the open ends of the inner tubes against the curved surfaces of the closure and along the air flow passage between said tubes at uniform velocity and volume to maintain said tube ends and outer tube walls below the melting temperature of the metal of which the tubes are made.

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