March 17, 1931. W. A. JONES 1,796,944

HEAT TRANSFER DEVICE

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Fig. 1.

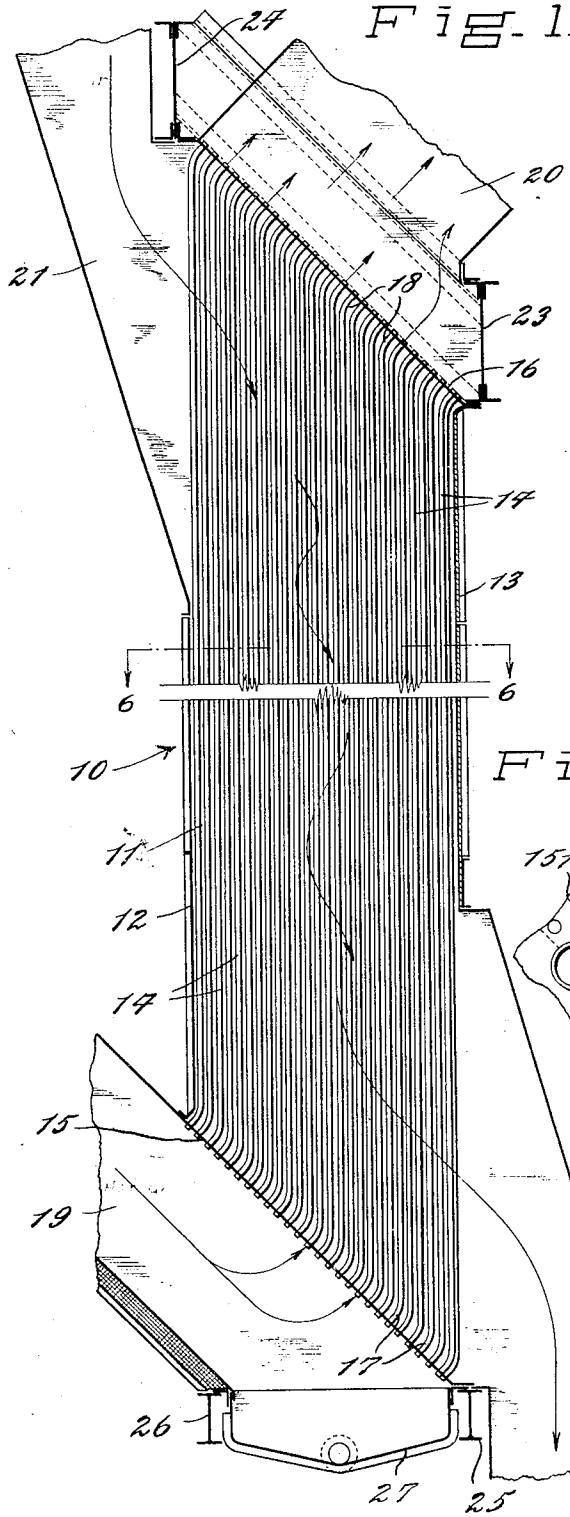


Fig. 3.

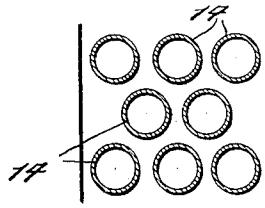


Fig. 2.

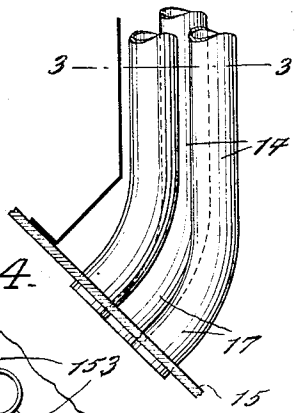


Fig. 4.

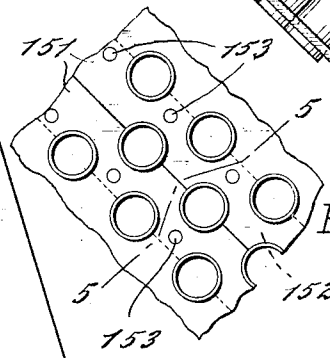
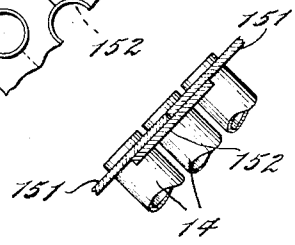


Fig. 5.



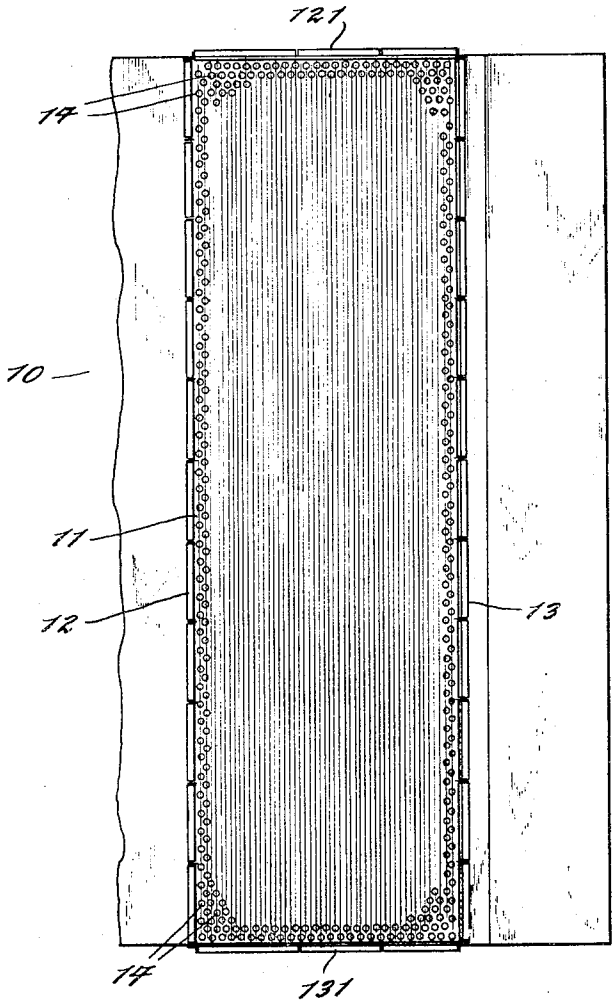
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Fig. 6.



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UNITED STATES PATENT OFFICE

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HEAT-TRANSFER DEVICE

Application filed March 5, 1927. Serial No. 172,998.

My invention will best be understood from the following description and the annexed drawings of an illustrative form of apparatus embodying my invention.

Referring to the drawings, Fig. 1 is a vertical section, partly in elevation, of an air heater embodying my invention; Fig. 2 is an enlarged view of a portion of a section of the lower end of the air heater through certain of the tubes, illustrating the staggered arrangement of the tubes; Fig. 3 is a section on line 3—3 of Fig. 2; Fig. 4 is a fragmentary view of a portion of the bottom plate taken at right-angles thereto; Fig. 5 is a section on line 5—5 of Fig. 4, and Fig. 6 is a section taken on the line 6—6 of Fig. 1.

Like reference characters indicate like parts in the various views.

In the drawing, 10 illustrates a heater generally, and 11 the flue in which the heater is located, side walls of the flue being indicated at 12 and 13, respectively, and the end walls thereof at 121 and 131 (Fig. 6). The heater comprises tubes 14 which are straight throughout the major portion of their length and extend parallel to the flue, as indicated in Fig. 1. The upper and lower ends of the tubes 14 are received in the openings in lower and upper parallel plates 15 and 16 which extend at an angle to the straight portions of the tubes and preferably at substantially 45° thereto and to the flue. As illustrated in Figs. 4 and 5, the lower plate 15 may be formed of separate sections 151 which may be secured together by butt straps 152 and rivets 153, or by welding, if desired. It will, of course, be understood that the upper plate 16 may, if desired, be similarly formed.

Preferably the tubes are bent at their upper and lower ends as at 17 and 18, so that they enter the tube plates 16 and 15 at substantially right-angles thereto. Preferably the tubes of one row are staggered with respect to the tubes of an adjacent row, as illustrated in Figs. 2, 3 and 4, the tubes preferably being staggered throughout both their straight and bent portions.

When the device is used as an air heater, for which use my invention is particularly applicable, although not necessarily limited thereto, the hot gases enter through the inlet 19 and pass through the tubes 14 to the outlet 20. The air enters at the upper portion of the heater through the inlet 21 and flows between the tubes and then parallel thereto and over the straight portions thereof and to the outlet 22 at the lower end, thereby securing a counterflow of the air with respect to the gases. While the directions of flow of the air and gases just described are in the preferred manner, it will be understood that the flow of either the gas or the air, or both, may be the reverse of that described, if desired. Arranging the tube plates or heads at an angle to the flue and to the straight portions of the tubes, as illustrated, increases the center to center distance of the tube holes in the plates, so that the ligaments between the tube openings are of sufficient strength without the necessity of increasing the air flow area between the tubes. Staggering the tubes of one row with respect to those of the adjacent row also increases the ligament strength in the tube sheet without increasing the air flow area parallel to the tubes. Furthermore, bending the tubes, particularly when the tubes are round, as illustrated, increases the spaces between the bent ends of the tubes as compared with the spaces between the straight portions of the tubes, so that when the air inlet is opposite the facing side of the inclined upper plate and the air outlet is opposite the facing side of the inclined lower plate, the air is permitted more freely to enter between the tubes at their upper ends and to be discharged more freely from the lower ends than would be the case if the tubes were not bent at their ends.

The upper tube sheet or plate 16 is supported by I-beams 23 and 24, the plate preferably being bent at its ends, as indicated, and may be bolted or otherwise secured at each edge to one of the flanges of the I-beams. Similarly, one edge of the lower tube plate 15, which is here shown as forming one wall of the flue 19, is bent, as indicated, and may be secured to the upper side of the I-beam 25, a second I-beam 26 being preferably pro-

vided which, with the I-beam 25, form supports for the ash collecting basin 27.

The tubes are preferably secured to the upper plate which may be done by expanding hard into the openings thereof, while they are slidable through the openings of the lower plate. Such an arrangement is described in an application of David S. Jacobus and William A. Jones, Serial No. 103,443, which was filed in the Patent Office on or about April 21, 1926. By securing the tubes at their upper ends to the upper plate, but permitting them freely to slide through the openings of the lower plate there is no tendency to bend the plates under the expansion and contraction of the tubes. At the same time, the tubes which are secured to the upper plate serve to maintain the same in its true inclined position. The upper plate may be made comparatively thin and when so formed there is, of course, a tendency for the plate to sag at its inner portion due to the weight of the parts. Any sagging of the top plate, however, would necessarily throw the tubes secured thereto out of alignment, but since the tubes are held in alignment through their slidable connection in the lower plate, the upper plate cannot sag. It is to be understood, however, that the tubes could be secured at both ends to the tube sheets, or they could be secured to the lower plate and permitted to slide through the openings in the upper plate.

By employing the tube plates in the manner illustrated, it is possible to secure a practically uniform flow of the air over the outer surfaces of the tubes with the tubes brought close enough together for that part of the air heater where the air flows parallel to the tubes to secure a good heat transfer rate.

An air heater built in accordance with my invention requires a relatively small amount of floor space. Furthermore, the cost of the heater for a given performance is relatively low. It will be noted that all of the tubes of the air heater are of the same length, a feature that, of course, lends itself to economy; at the same time, no baffles are required for directing the gases back and forth across the tubes which would increase the draft loss. Furthermore, by inclining the plates in the manner illustrated, any water which may accumulate on the upper plate, due to condensation, will drain away from the tubes.

I claim:

1. In combination, a flue, a heater for transferring heat from one gas to another located therein and comprising tubes having their major portions extending parallel to the flue, end plates inclined at less than 90° to the tubes and provided with openings in which the respective ends of the tubes are received, a gas inlet in the flue wall at one end of the heater and opposite the inclined face of the associated end plate for directing air between the tubes, a gas outlet in the flue wall at the opposite end of the heater and located opposite the inclined face of the opposite plate, whereby hot gases may be passed through said tubes in a direction generally opposite to the flow of gas over the tubes.

2. In combination, a flue, a heater for transferring heat from one gas to another located therein and comprising tubes having their major portions extending parallel to the flue, end plates inclined at less than 90° to the tubes and provided with openings in which the respective ends of the tubes are received, means for delivering hot gases to the lower end of said tubes whence the said gases pass upwardly through said tubes, a gas inlet in the flue wall at the upper end of the heater and opposite the inclined face of the associated end plate for directing air between the tubes, and a gas outlet in the flue wall at the lower end of the heater and located opposite the inclined face of the lower end plate.

3. In combination, a flue, a heater for transferring heat from one gas to another located therein and comprising tubes for conveying gas through said heater extending parallel to the flue, end plates inclined at less than 90° to the straight portions of the tubes and provided with openings in which the respective ends of the tubes are received, the tubes being bent at their ends to enter the respective openings of the respective tube plates at substantially right angles thereto, a gas inlet in the flue wall at one end of the heater and opposite the inclined face of the associated end plate for directing gas between the tubes, and a gas outlet in the flue wall at the opposite end of the heater and located opposite the inclined face of the opposite plate.

4. In combination, a flue, a fluid heater located therein and comprising tubes extending parallel to the flue, end plates inclined at less than 90° to the straight portions of the tubes and provided with openings in which the respective ends of the tubes are received, the tubes being bent at their ends to enter the respective openings of the respective tube plates at substantially right angles thereto, means for conducting heating gases to said tubes, a gas inlet for gases to be heated at one end of the heater and opposite the associated end plate for directing a gas between the tubes, and a gas outlet at the opposite end of the heater and located opposite the inclined face of the opposite plate.

5. In an air heater, a plurality of parallel tubes straight throughout the major portions of their lengths, end plates inclined at less than 90° to the straight portions of said tubes and provided with openings, the ends of said tubes being bent to enter the openings of said end plates, and means whereby the gases flow over opposite surfaces of said tubes in opposite directions.

6. In an air heater, a plurality of parallel tubes straight throughout the major portions of their lengths and all of substantially the same length and form, end plates inclined at less than 90° to the straight portions of said tubes and provided with openings, the ends of said tubes being bent to enter the openings of said end plates, and means whereby the gases flow over opposite surfaces of said tubes in opposite directions.

7. In an air heater, a plurality of parallel tubes straight throughout the major portions of their lengths, end plates inclined at less than 90° to the straight portions of said tubes and provided with openings, the ends of said tubes being bent and entering the openings of said end plates at substantially right angles thereto, and means whereby the gases flow over opposite surfaces of said tubes in opposite directions.

8. In an air heater, a plurality of parallel tubes straight throughout the major portions of their lengths, end plates inclined at substantially 45° to the straight portions of said tubes and provided with openings, the ends of said tubes being bent to enter the openings of said end plates, and means whereby the gases flow over opposite surfaces of said tubes in opposite directions.

9. In an air heater, a plurality of parallel tubes straight throughout the major portions of their lengths, the straight portions being substantially vertical, end plates inclined at less than 90° to the straight portions of said tubes and provided with openings, the ends of said tubes being bent to enter the openings of said end plates, and means whereby the gases flow over opposite surfaces of said tubes in opposite directions.

10. A vertically disposed heat exchanger supported from the top, vertically disposed tubes and inclined tube plates at opposite ends of said tubes, said tubes being supported from the upper tube plate.

11. A vertically disposed heat exchanger supported from the top, vertically disposed tubes and inclined tube plates at opposite ends of said tubes, said tubes being supported from the upper tube plate, the supports for said exchanger being disposed along the edges of said upper tube plate.

12. In a heat exchanger, tube plates at opposite ends thereof at an angle of about 45° to the central axis of said exchanger, and tubes extending through both of said plates and attached to one only of them.

13. In combination, a flue, a heater for transferring heat from one gas to another located therein and comprising tubes having their major portions thereof extending parallel to the flue, end plates provided with openings in which the respective ends of the tubes are received, at least one of said plates being inclined at less than 90° to the said major portions of the tubes, the tubes being bent to enter the openings of said inclined plate, a gas inlet in the flue wall at one end of the heater and opposite the inclined face of the said inclined end plate for directing the air between the tubes, and a gas outlet flue in the flue wall at the opposite end of the heater.

WILLIAM A. JONES.