Aug. 11, 1931. M. S. SMITH 1,817,948

HEAT EXCHANGE DEVICE

Filed Nov. 16, 1929 3 Sheets-Sheet 1

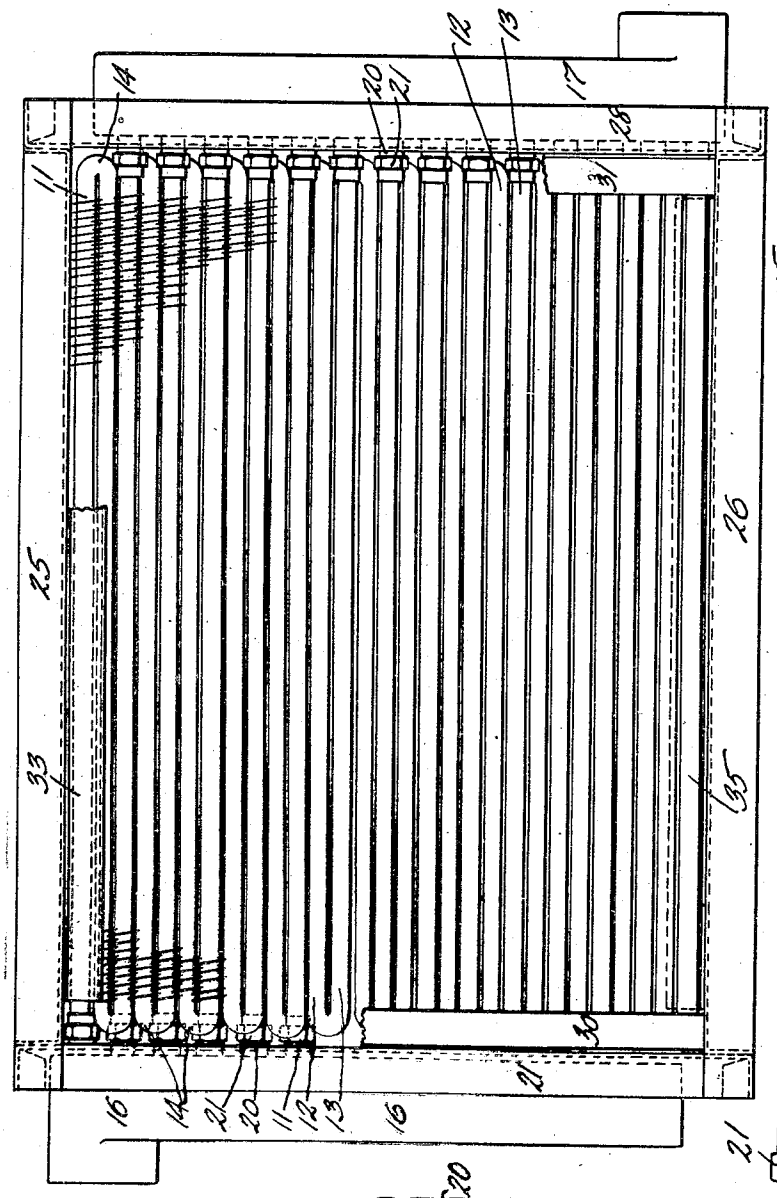


Fig. 1.

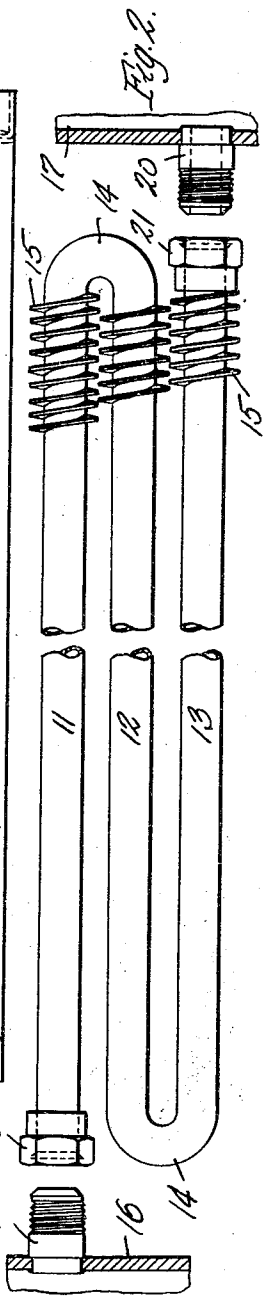


Fig. 2.

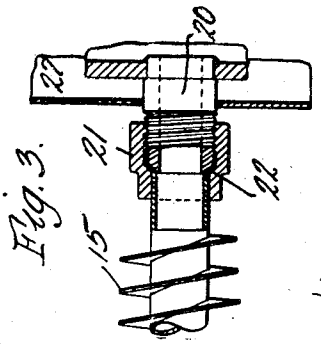


Fig. 3.

INVENTOR.
Milton S. Smith
By Parker & Prochnow.
ATTORNEYS.

Aug. 11, 1931. M. S. SMITH 1,817,948

HEAT EXCHANGE DEVICE

Filed Nov. 16, 1929 3 Sheets-Sheet 2

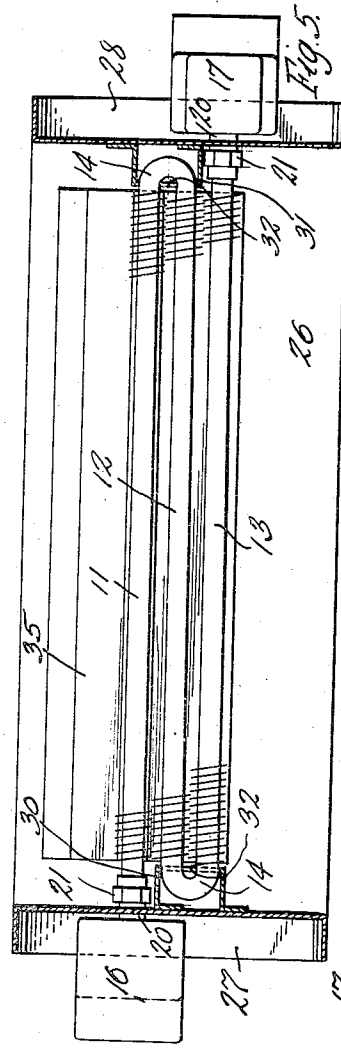


Fig. 5.

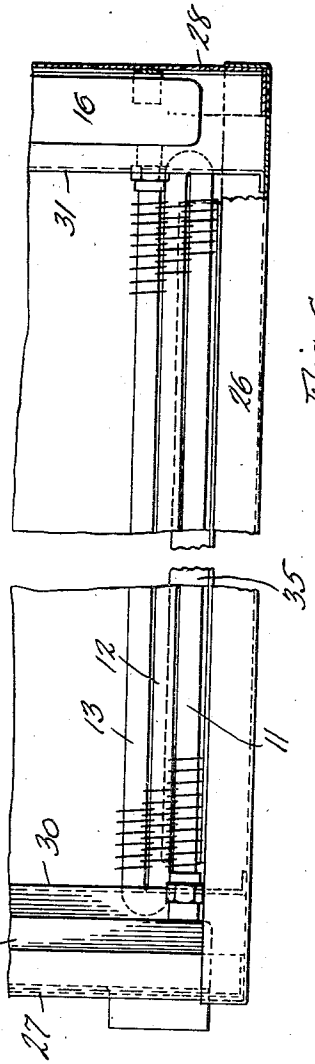


Fig. 6.

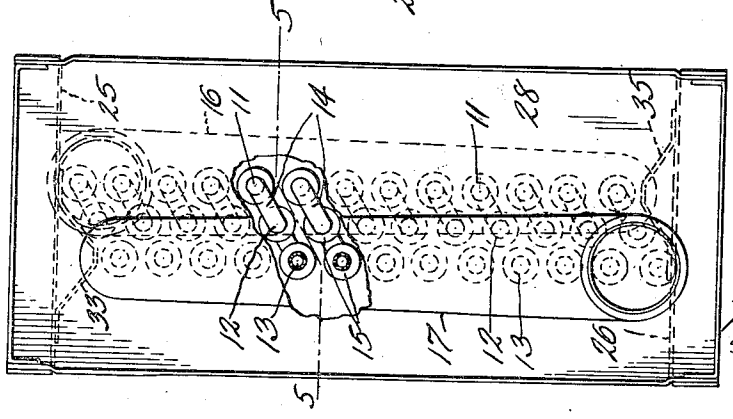


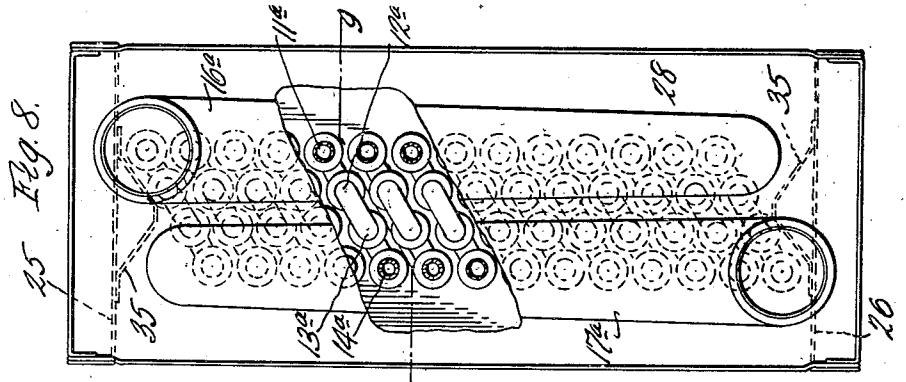
Fig. 4.

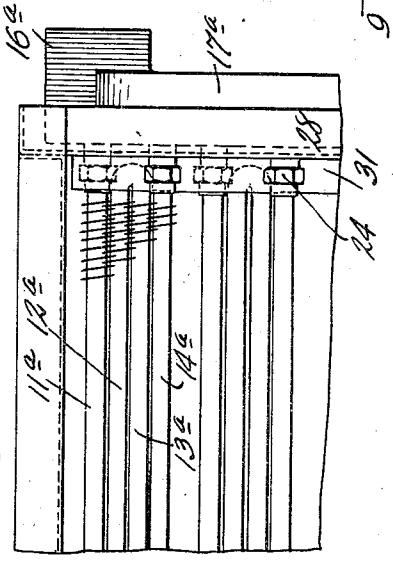
INVENTOR.
Milton S. Smith
by Parker & Nichols.
ATTORNEYS.

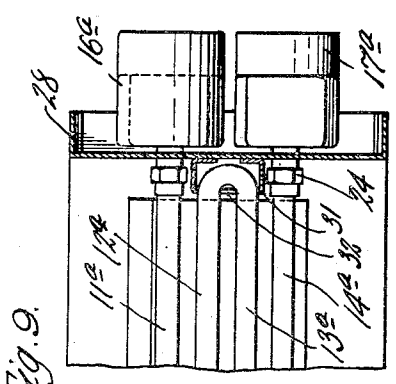
Aug. 11, 1931. M. S. SMITH 1,817,948

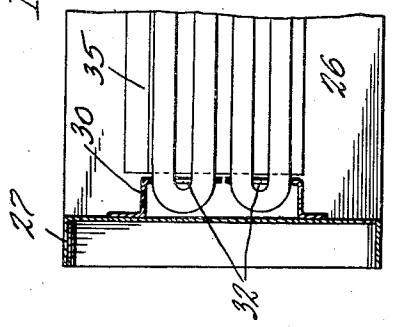
HEAT EXCHANGE DEVICE

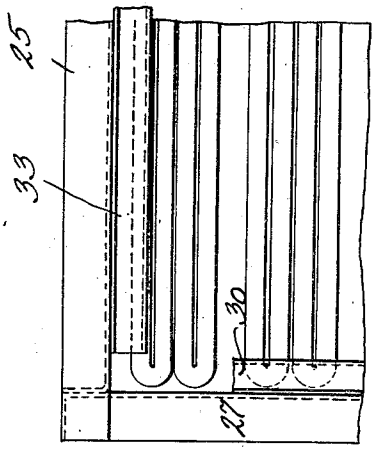
Filed Nov. 16, 1929 3 Sheets-Sheet 3



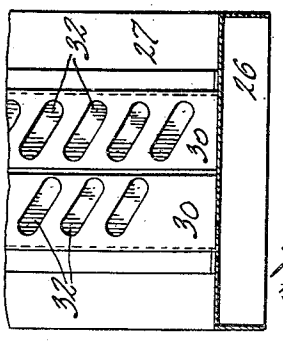




Fig. 10.

INVENTOR.
Milton S. Smith
By Parker & Prochnow.
ATTORNEYS.

Patented Aug. 11, 1931

1,817,948

# UNITED STATES PATENT OFFICE

MILTON S. SMITH, OF MAPLEWOOD, NEW JERSEY, ASSIGNOR TO CARRIER CONSTRUCTION COMPANY, INC., OF NEWARK, NEW JERSEY

## HEAT EXCHANGE DEVICE

Application filed November 16, 1929. Serial No. 407,758.

This invention relates to improvements in heat exchange devices such as radiators, steam heaters, coolers and the like, which comprise a plurality of hollow radiating elements or tubes through which a fluid medium may be circulated for exchange of heat with another medium, such as air, which passes over the exterior surfaces of the hollow elements or tubes. While the present improvements are herein disclosed in connection with heaters of this sort having tubes provided with external radiating fins to increase their radiating surface, nevertheless the improvements are applicable also to other types of radiators and heaters.

Heaters of this sort are used, for instance, in air heating and ventilating systems for buildings, the radiator or heater being arranged in an air duct for heating the air which passes between the tubes of the heater. The radiating tubes of such heaters are commonly arranged in a plurality of banks, rows or groups, one behind another in the direction of flow of the air past the heater, the number of rows or groups depending upon the required heating capacity, and as ordinarily constructed, all of the tubes are connected at one end to a steam supply or inlet header and at the opposite end with an outlet or discharge header, so that the heating medium passes simultaneously through the tubes in the several rows or groups. In such an arrangement, each and every tube in a multiple row or group heater would be supplied with substantially the same amount of steam, and if the supply were insufficient to adequately heat the air passing over the tubes, the tubes would be heated only for a part of their length, and if the air were sufficiently cold, the condensate might freeze before reaching the outlet header and burst the heater.

One object of this invention is to provide a heat exchange device of improved construction which overcomes this objection.

Other objects of the invention are to provide a heat exchange device comprising radiating tubes or elements arranged in a plurality of groups one behind another, and connected so that the medium which circulates through the radiating tubes will pass through the different groups or rows in succession; also to provide a heat exchange device having radiating tubes or elements arranged in a plurality of groups one behind another, and connections whereby a medium may be circulated first in multiple through the radiating tubes or elements in one group, and then in multiple through the radiating tubes or elements in another group; also to provide a heat exchange device having radiating tubes or elements arranged in a plurality of groups one behind another and connected so that a fluid medium may be circulated in multiple through the different groups in succession, and so that the radiating tubes or elements of one group will be disposed opposite the spaces between the radiating tubes or elements of the next adjacent group; also to provide a heat exchange device comprising a plurality of spaced radiating tubes, each bent to provide substantially parallel, straight stretches or tubes connected so that a fluid medium may be circulated in multiple through the different stretches of the tubes in succession; also to improve heat exchange devices in the other respects hereinafter described and set forth in the claims.

In the accompanying drawings:

Fig. 1 is a front elevation of a 3-row heater embodying my invention.

Fig. 2 is an elevation, on an enlarged scale, showing one of the bent tubes of the heater disconnected from the nipples by which the opposite ends of the bent tube are joined to the inlet and outlet headers.

Fig. 3 is a fragmentary, sectional elevation, enlarged, showing one of the unions for connecting the tubes to the headers.

Fig. 4 is an end elevation of the heater, partly in section.

Fig. 5 is a sectional plan view thereof on line 5—5, Fig. 4.

Fig. 6 is a front elevation, partly in section, of a slightly modified form of a 3-row heater, in which the headers are arranged inside of the protecting frame of the heater.

Fig. 7 is a fragmentary front elevation of a 4-row heater embodying the invention.

Fig. 8 is an end elevation thereof, partly in section.

Fig. 9 is a sectional plan view thereof on line 9—9, Fig. 8.

Fig. 10 is an inside elevation of one end of the protecting frame and supports for the bent ends of the radiating tubes.

Referring first to Figs. 1–6, the heater comprises a plurality of spaced, substantially parallel radiating tubes or elements 11, 12 and 13, arranged in three rows or groups one behind another, with each tube in one row joined to the corresponding tube in the next row so that the three connected tubes form continuous S-like passages through which steam or other medium may flow for effecting an exchange of heat between the same and the air or other medium which passes over the exterior surfaces of the tubes. As shown, a single long tube is bent at 14 between its ends, see Fig. 2, to form each three connected tubes 11, 12 and 13, but manifestly the tubes 11, 12 and 13 could be made separate and joined together in other ways so as to form a continuous passage. Except where the context clearly expresses a different meaning, it will be understood that in the following description and claims, where tubes and radiating elements arranged in different rows or groups are mentioned, it is intended to embrace either separate tubes or elements suitably connected so as to form a continuous passage, or a single, continuous bent tube. The radiating tubes may be provided with exterior helical radiating fins 15 for increasing their radiating surface. The tubes 11 are connected at their ends to a supply header or connection 16, and the tubes 13, or opposite ends of the several bent tubes are connected to an outlet header or connection 17 so that the steam or other medium can pass from the header 16 first in multiple through the several tubes 11 in the first row, and then in multiple through the tubes 12 and 13, in the other rows in succession to the outlet header. The different rows or groups of tubes are disposed one behind another in the direction of flow of the air through the heater, and preferably the tubes are arranged in stepped order fore and aft of the heater in the direction of flow of the air so that the tubes in one row or group will be located opposite the spaces between the corresponding tubes in the next adjacent row or group of the heater, see Fig. 4. By this arrangement, the air passing through the spaces between the tubes in one row will strike directly against the tubes in the next row, and a more uniform and even distribution of the air against the surfaces of the tubes in the different rows or groups will be insured.

As shown in the drawings, the tubes are detachably joined to the headers by unions each comprising a screw-threaded nipple 20 rigidly secured to the header and a screw-threaded sleeve or nut 21 which surrounds the end of the tube and is adapted to screw onto the nipple and clamp the outwardly flanged end of the tube between the end of the nipple and an internal shoulder 22 on the sleeve or nut 21. The tubes, however, can be connected to the headers in any other suitable way, but preferably detachable connections are employed so that the tubes may be individually secured to and disconnected from the headers.

In the construction thus far described, in which the tubes are arranged in three rows one behind another, the continuous passages each formed by the three connected tubes have their opposite or inlet and outlet ends disposed at opposite ends of the heater, and the inlet and outlet headers or connections are therefore located at opposite ends of the heater. The same would be true of any other odd number of rows of tubes, for instance, five or seven, and obviously this construction could be employed for any odd number of rows. In the case of an even number of rows, for instance, two, four or six, the inlet and outlet ends of the continuous passages formed by the connected tubes in the different rows would be disposed at the same end of the heater.

Figs. 7 to 10 show a heater having an even number of rows of tubes, there being shown in these figures tubes disposed in four rows, one behind the other and connected, as before, to form continuous passages. 11*a*, 12*a*, 13*a* and 14*a* represent the four tubes or four stretches of the bent tubes. The inlet ends of the tubes 11*a* are connected to an inlet header or connection 16*a* and the outlet ends of the tubes 14*a* are connected to an outlet header or connection 17*a*, these two headers or connections being arranged one in front of the other at the same end of the heater. The tubes may be removably secured to the headers by clamping unions 24 such as before described, or in any other suitable manner.

By using continuous bent tubes detachably connected at their opposite ends to the headers, any tube can be readily disconnected in case it is injured or leaks and be replaced by a new tube without disturbing the other tubes.

The heater, in either of the forms described, is preferably mounted in or provided with a rectangular frame which surrounds and protects the tubes, the walls and radiating fins of which are usually made of relatively thin copper and are comparatively frail and easily bent. The frame may be, as shown, composed of flanged sheet metal top and bottom members 25 and 26 rigidly secured by riveting, welding or otherwise to flanged, sheet metal end members 27 and 28 respectively. As shown in Figs. 1, 4 and 5, the end members have flanges on all four edges

thereof extending outwardly, and the top and bottom ends of the end members extend and are secured between the extensions of the front and back flanges of the top and bottom members, which flanges also extend outwardly respectively upwardly and downwardly.

In the heater shown in Figs. 1, 4 and 5, employing this form of frame, the headers are located outside of, or outwardly beyond the end members of the frame, and the unions by which the tubes are joined to the headers project through holes in the webs of the end members 27 and 28.

If preferred, however, the headers can be disposed within the frame or between the end members, as shown in Fig. 6. In the latter construction the frame may be similarly composed of flanged sheet metal members, but the members are preferably arranged with their flanges extending inwardly as shown in Fig. 6, thus giving the frame smooth, flat exterior bounding faces free from outwardly projecting flanges or sharp edges. This frame with the inturned flanges is shown in the drawings in connection with a 3-row heater, but it will be manifest that this frame as well as the other frame shown with the out-turned flanges could be employed, regardless of whether the heater is provided with an odd or even number of rows of tubes.

When the tubes in the different rows are joined by bends or connections to form a continuous tube, as illustrated, the protecting frame is preferably provided at one or both ends, as may be necessary, with supports for the tubes adjacent the bends. As shown, these supports 30 and 31 are made of sheet metal plates secured to the end members of the frame in any convenient way, and have offset parts provided with inclined slots 32, see Fig. 10, through which the bent parts of the tubes extend, and in which they are loosely seated or supported. These supports 30 and 31 also serve as closures to close the space between the bent ends of the tubes and the end members 27 and 28 of the frame. The air is thus prevented from passing through these spaces and is forced to pass through the spaces between the tubes or straight stretches of the tubes.

Because of the stepped arrangement of the tubes before explained, the bottom tube in the rear row and the top tube in the front row are spaced farther away from the adjacent frame members 26 and 25 than the corresponding tubes in the other rows. These spaces, if not obstructed, would leave a path of lower resistance for the passage of the air than is afforded by the body of the heater, and in order to obstruct these spaces and resist the passage of air therethrough, upper and lower baffles 33 and 35 are provided. These baffles, as shown, consist of trough-shaped, sheet metal plates which are suitably secured on the inner faces of the top and bottom frame members and project therefrom into the spaces between the frame members and the bottom and top tubes.

A heater constructed as described, embodies the use of radiating fins or surfaces arranged in two or more rows in a manner that exposes only one-half of the length of the fluid passages in a two-row heater, one third in a three-row heater and one-fourth in a four-row heater to the incoming cold air. This means that all the steam supplied to the heater passes first through the tubes which are first exposed to the cold air, and that the heat will be sufficient under normal conditions to raise the temperature of the air above freezing even when an insufficient supply of steam is provided. In other words, if a three-row heater, for instance, is supplied with steam in sufficient quantity to give only one-half of the normal condensation, the steam would be largely condensed in the first row of tubes, and any excess would partially heat the tubes in the other rows and add to the heat of the air as it passed over the second and third rows of tubes. This result is very different from that which would occur in a heater in which the steam is supplied simultaneously to the several rows of tubes. In such case, in a heater of the same radiating surface, every tube in the heater would be supplied with the same amount of steam, and if the supply were insufficient, the tubes would be heated only part way across, and if the air were sufficiently cold, the condensation would freeze before reaching the outlet header and might burst the heater.

I claim as my invention:

1. A heat exchange device comprising spaced radiating tubes arranged in a plurality of rows one behind another and with the tubes in one row communicating end to end with the tubes in another row, and a fluid supply connection communicating with the several tubes in one row so that the fluid from said supply connection flows in multiple first through the tubes in one row and then through the tubes in another row, said rows of tubes being disposed with reference to the direction of flow of a medium externally over the tubes so that said medium contacts in succession with the first and following rows of tubes.

2. A heat exchange device comprising spaced radiating tubes arranged in a plurality of rows one behind another and with the tubes in one row communicating end to end with the tubes in another row, and a fluid supply connection communicating with the several tubes in one row so that the fluid from said supply connection flows in multiple first through the tubes in one row and then through the tubes in another row, and the tubes in one row being located opposite

the spaces between the tubes of the next adjacent row, said rows of tubes being disposed with reference to the direction of flow of a medium externally over the tubes so that said medium contacts in succession with the first and following rows of tubes.

3. A heat exchange device comprising spaced radiating tubes arranged in a plurality of rows one behind another and with the tubes in one row communicating end to end with the tubes in another row, a fluid supply header connecting with corresponding ends of the several tubes in one row only, and a fluid discharge header connecting with corresponding ends of the several tubes in another row only, whereby fluid can flow from said supply header in multiple through the tubes in each row and in succession through the tubes in said different rows to the discharger header, said rows of tubes being disposed with reference to the direction of flow of a medium externally over the tubes so that said medium contacts in succession with the first and following rows of tubes.

4. A heat exchange device comprising spaced radiating tubes arranged in a plurality of groups one behind another and with the tubes in one group communicating end to end with the tubes in another group, and a fluid supply header connected in multiple with the several tubes in one group only, whereby fluid can flow from said supply header first through the several tubes in one group and then through the several tubes in another group, said groups of tubes being disposed with reference to the direction of flow of a medium externally over the tubes so that said medium contacts in succession with the first and following groups of tubes.

5. A heat exchange device comprising spaced radiating tubes arranged in a plurality of groups one behind another and with the tubes in one group communicating end to end with the tubes in another group, a fluid supply header connected in multiple with the several tubes in one group only, and a fluid discharge header connected in multiple with the tubes in another group only, whereby fluid can flow from said supply header first through the several tubes in one group and then through the several tubes in another group, said groups of tubes being disposed with reference to the direction of flow of a medium externally over the tubes so that said medium contacts in succession with the first and following groups of tubes.

6. A heat exchange device comprising spaced radiating tubes arranged in a plurality of groups one behind another and with the tubes in one group communicating end to end with the tubes in another group, a fluid supply header connected in multiple with the several tubes in one group only, and a fluid discharge header connected in multiple with the tubes in another group only, whereby fluid can flow from said supply header first through the several tubes in one group and then through the several tubes in another group, and the tubes in one group being located opposite the spaces between the tubes in the next adjacent group, said groups of tubes being disposed with reference to the direction of flow of a medium externally over the tubes so that said medium contacts in succession with the first and following groups of tubes.

7. A heat exchange device comprising spaced radiating tubes each bent to form a plurality of substantially parallel connected stretches forming a continuous passage, and a fluid supply connection joined in multiple to the corresponding stretches of said tubes, whereby fluid from said supply connection can flow in multiple through the different stretches of said tubes in succession, the successive stretches of the tubes being disposed with reference to the direction of flow of a medium externally over the tubes so that said medium contacts in succession with the first and following stretches of the tubes.

8. A heat exchange device comprising spaced radiating tubes each bent to form a plurality of substantially parallel connected stretches forming a continuous passage, and a fluid supply connection joined in multiple to the corresponding stretches of said tubes, whereby fluid from said supply connection can flow in multiple through the different stretches of said tubes in succession, and the different stretches of the tubes being disposed in different groups with the stretches of one group opposite the spaces between the stretches of the next adjacent group, the successive stretches of the tubes being disposed with reference to the direction of flow of a medium externally over the tubes so that said medium contacts in succession with the first and following stretches of the tubes.

9. A heat exchange device comprising supply and discharge connections, and a plurality of spaced radiating tubes all connected at one end to said supply connection and all connected at the opposite end to said discharge connection, whereby fluid can pass from said supply connection to said discharge connection in multiple through the several tubes, said tubes being bent between their ends to provide a plurality of connected stretches arranged in different groups one behind another, the successive stretches of the tubes being disposed with reference to the direction of flow of a medium externally over the tubes so that said medium contacts in succession with the first and following stretches of the tubes.

10. A heat exchange device comprising supply and discharge connections, and a plurality of spaced radiating tubes all connected at one end to said supply connection and all connected at the opposite end to said dis-

charge connection, whereby fluid can pass from said supply connection to said discharge connection in multiple through the several tubes, said tubes being bent between their ends to provide a plurality of connected stretches arranged in different groups one behind another, and the stretches in one group being arranged opposite the spaces between the stretches of the next adjacent group, the successive stretches of the tubes being disposed with reference to the direction of flow of a medium externally over the tubes so that said medium contacts in succession with the first and following stretches of the tubes.

11. A heat exchange device comprising two headers, a plurality of spaced tubes all connected at one end to one header and all connected at the opposite end to the other header, said tubes being bent between their ends to provide a plurality of connected stretches arranged in different rows one behind another, and means for loosely supporting the tubes at the bends so as to permit free expansion and contraction of the tubes, said rows of stretches being disposed with reference to the direction of flow of a medium externally over the tubes so that said medium contacts in succession with the first and following rows of stretches.

12. A heat exchange device comprising two headers, a plurality of spaced tubes all connected at one end to one header and all connected at the opposite end to the other header, said tubes being bent between their ends to provide a plurality of connected stretches arranged in different rows one behind another, a frame for said tubes which defines a passage for the flow of a medium externally over said tubes, said rows of stretches being disposed with reference to the direction of flow of said medium through said passage so that said medium contacts in succession with the first and following rows of stretches.

13. A heat exchange device comprising two headers, a plurality of spaced tubes all connected at one end to one header and all connected at the opposite end to the other header, said tubes being bent between their ends to provide a plurality of connected stretches arranged in different rows one behind another, a protecting frame for said tubes, which defines a passage for the flow of a medium externally of said tubes, said rows of stretches being disposed with reference to the direction of flow of said medium through said passage so that said medium contacts in succession with the first and following rows of stretches, said stretches of the tubes extending substantially from one end to the other of said frame, and supports at the opposite ends of said frame on which the bends of the tubes loosely rest.

14. A heat exchange device comprising substantially horizontal spaced radiating tubes arranged in a plurality of vertical rows one behind another, hollow connections joining the tubes in one row end to end with the tubes in another row, to form continuous fluid passages, an upright fluid supply header communicating with the several tubes in one row so that the fluid from said supply header flows in multiple first through the tubes in one row and then through the tubes in another row, said rows of tubes being disposed with reference to the direction of flow of a medium externally over the tubes so that said medium contacts in succession with the first and following rows of tubes and means for loosely supporting the tubes adjacent said hollow connections so that the tubes are free to expand and contract.

15. A heat exchange device comprising spaced radiating tubes arranged in a plurality of rows one behind another, hollow connections joining the tubes in one row end to end with the tubes in another row to form continuous fluid passages, a fluid supply connection communicating with the several tubes in the first row, a frame surrounding the rows of tubes, and defining a passage for the flow of a medium externally over said tubes, said rows of tubes being disposed with reference to the direction of flow of said medium through said passage so that said medium contacts in succession with the first and following rows of tubes and supports at the ends of the frame on which the tubes loosely rest adjacent said hollow connections so that the tubes are left free to expand and contract.

16. A heat exchange device comprising spaced radiating tubes arranged in a plurality of rows one behind another and in stepped order with the tubes of one row opposite the spaces between the tubes in the next adjacent row, a frame surrounding the tubes, and members for obstructing the passage of air through the spaces between the frame and the tubes at the adjacent ends of the rows.

MILTON S. SMITH.