April 22, 1941. A. E. STACEY, JR 2,238,952

NONFREEZING HEATER

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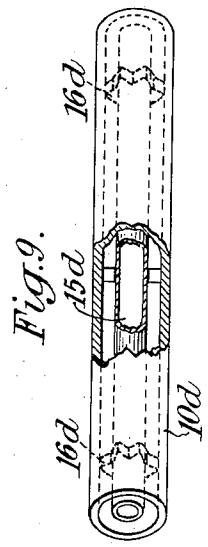


Fig. 9.

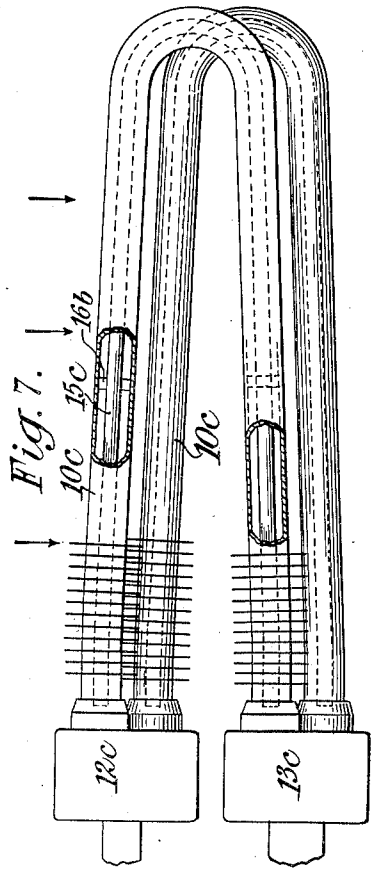


Fig. 7.

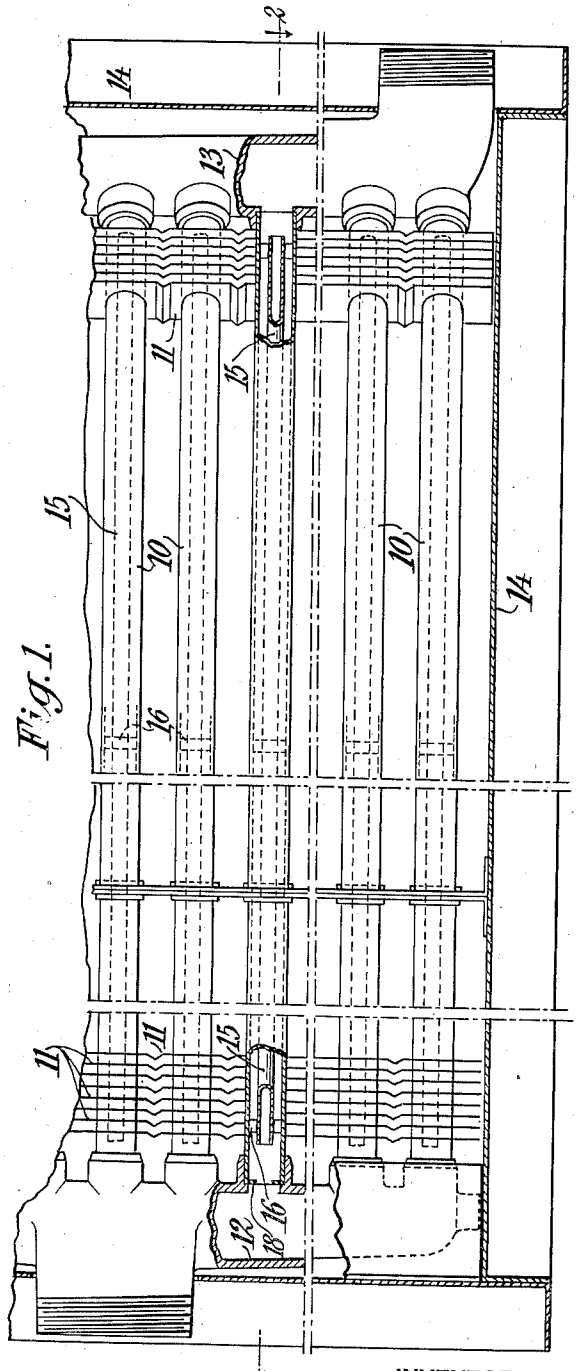


Fig. 1.

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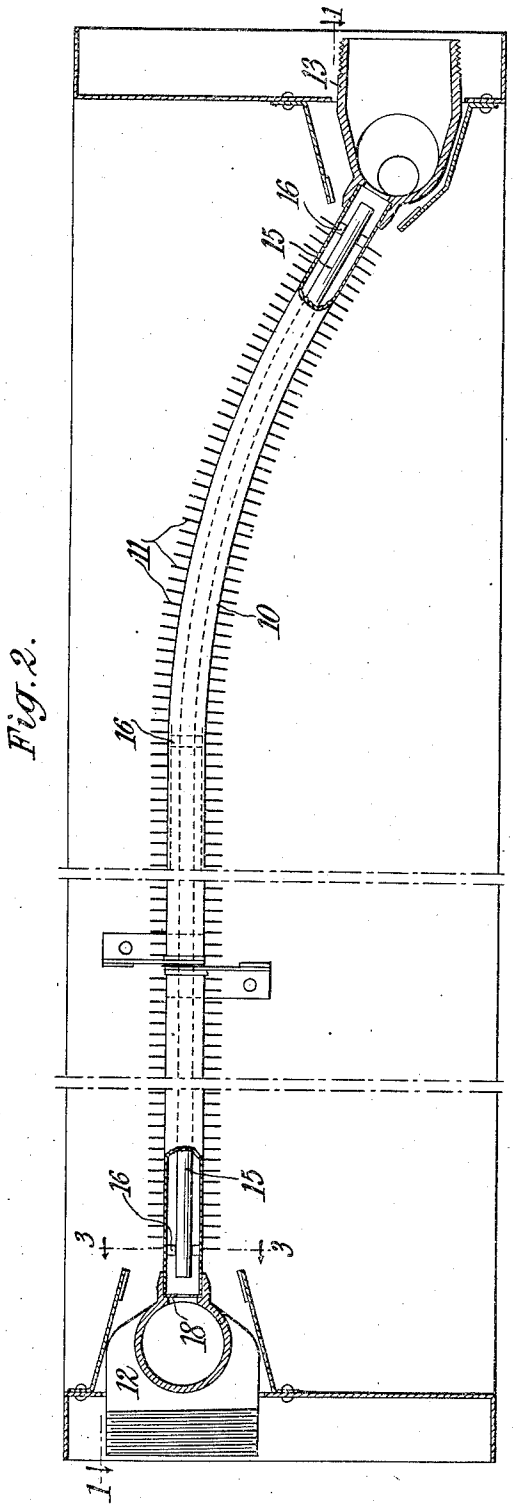


Fig. 2.

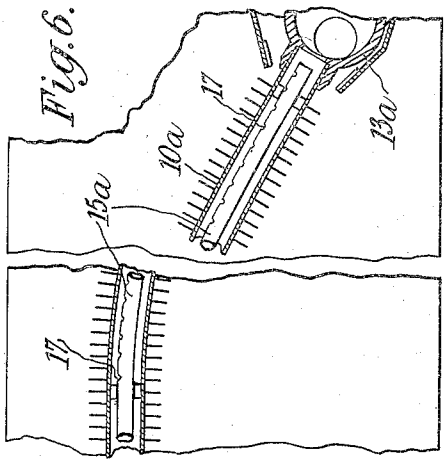


Fig. 6.

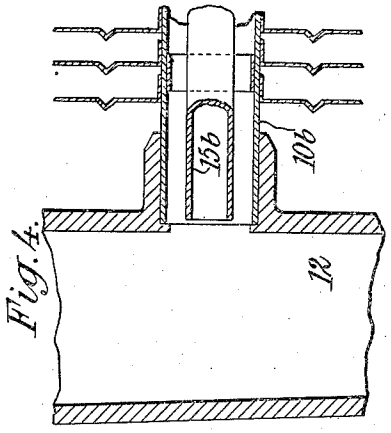


Fig. 4.

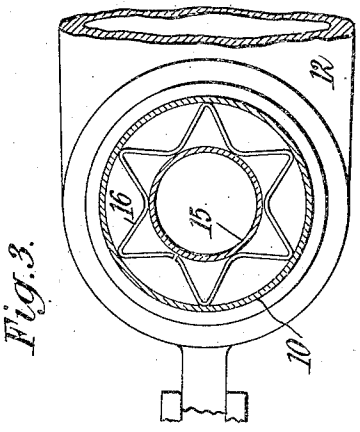


Fig. 3.

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Fig. 5.

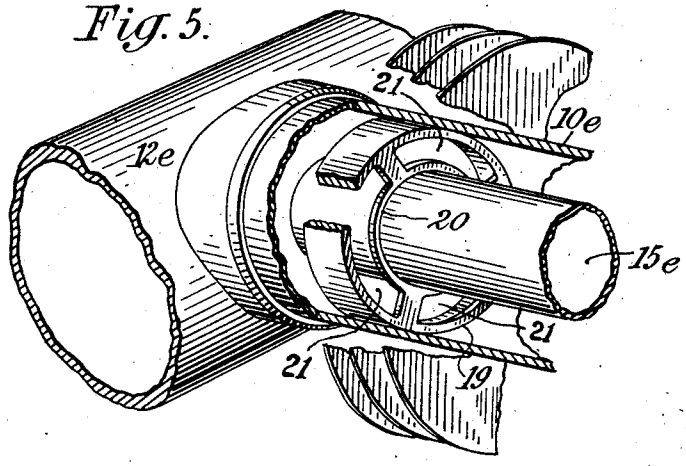
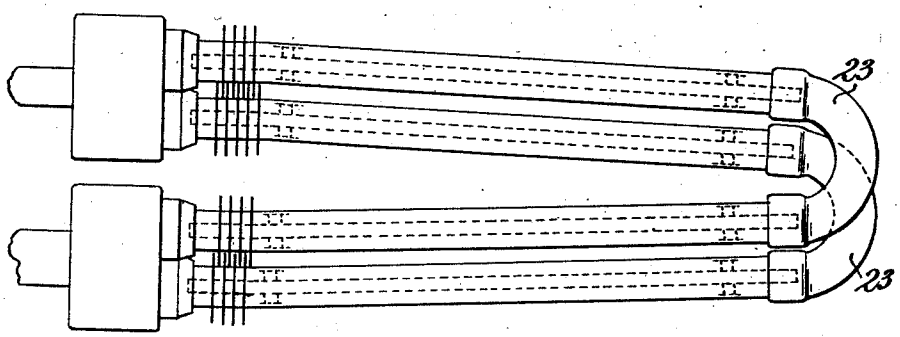


Fig. 8.



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2,238,952

UNITED STATES PATENT OFFICE

2,238,952

NONFREEZING HEATER

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Application May 11, 1939, Serial No. 272,983

18 Claims. (Cl. 257—46)

This invention relates to heat exchange apparatus, and is primarily directed to the improvement of those devices of this general class wherein steam is condensed to heat a volume of air or other gas passing over and in contact with its outer surfaces.

The development of the heating art within the past few years has centered very largely about the extended surface heat exchanger and its application to fan blast heating systems. The advantages of heaters of this general type, in the matter of large transfer capacity for a unit of small over-all dimensions and light weight, are well known to those skilled in the art. So, too, are its disadvantages in certain classes of installations. In order to illustrate the latter, consider the use of such a heater unit for the tempering of air drawn into a building from the outside thereof. It will be understood, of course, that the heater is necessarily designed to carry the maximum estimated load in the coldest weather which may normally be expected. When those conditions exist then the supply of steam to the unit at full pressure will result in the heating of air passing through the unit to a desired degree. Should the temperature of the outside air drop below the expected minimum, there is a great likelihood that the condensate in the tubes may freeze. The problem arises more frequently, however, as a result of a falling off of the load within the building. Under such conditions the continued supply of steam at full pressure will necessarily produce uncomfortable and wasteful overheating of the building. Any attempt to modulate the heat output of the unit, however, is fraught wtih danger. If, for example, the steam supply is throttled, then it is immediately evident that the heat radiating surfaces of the unit are excessive. Consequently, the reduced quantity of steam supplied will all be condensed within the first foot or two of its tubes. The remaining portions will contain only condensate, and air passing thereover at less than 32° F. will very quickly freeze that condensate, stop the heating action, and, most important of all, probably result in the bursting of the tubes.

The principal object of the invention is to provide an exchanger, and particularly one of the lightweight extended surface type, which may be used to heat air or other gas passing over its outer surfaces from an initial temperature of 32° F. or less to some desired final temperature without running the risk of freezing condensate therein.

It is another object of the invention to provide an extended surface heater embodying means adapted to prevent the freezing of condensate therein, and this, even under the drastic conditions imposed by a modulation of its heat output capacity through a throttling of the steam supplied thereto.

It is yet another object of the invention to provide for the even and uniform distribution of steam throughout the radiating tubes of a heater of the foregoing character in order that all parts thereof may be maintained at substantially the same temperature—in order that all portions of a stream of air discharged thereover may be heated to the same degree.

It is a further object of the invention to provide a heater adapted to carry out the foregoing objects, and yet one having substantially the same heat transfer capacity as any prior art heater of the same area and general dimensions—and, specifically, one in which the means included to prevent the freezing of condensate therein do not materially reduce its steam condensing capacity.

The full nature of the invention, along with other objects and features making for efficiency and economy of manufacture, will be more apparent from a consideration of the following description in the light of the accompanying drawings, in which

Figure 1 is a fragmentary plan view of an extended surface heater embodying the invention, certain parts thereof being broken away better to show the interior construction;

Fig. 2 is a sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a sectional view taken on the line 3—3 of Fig. 2 but on an enlarged scale;

Fig. 4 is a fragmentary view in section and on an enlarged scale of a supply header and a heat transfer tube of a device similar to that of Figs. 1 and 2 embodying the invention in modified form;

Fig. 5 is a perspective view, on an enlarged scale, of a fragment of a supply header and a heat transfer tube of a device similar to that of Figs. 1 and 2, and embodying the invention in yet another way;

Fig. 6 is a fragmentary view illustrating a portion of a heat radiating tube and a discharge header of a heater similar to that of Figs. 1 and 2 embodying the invention in still another modified form;

Figs. 7 and 8 are side elevational views illustrating other forms of extended surface heater

units to which the invention is fully applicable, and

Fig. 9 is a perspective view illustrating the invention in its simplest form.

The invention is illustrated in Figs. 1 and 2 embodied in a single row heater unit comprising a series of thin walled copper tubes 10 having their outer heat transfer surfaces greatly extended by the application of closely spaced metal fins 11 and their opposite ends connected to oppositely disposed steam supply and condensate headers 12 and 13, respectively, and a casing 14 supporting these various parts and serving to direct a stream of air over the finned portions of the tubes and to prevent the by-passing of that air around the headers. The tubes 10 will vary in length in different units depending, of course, upon their rated heat transfer capacities. It is not at all unusual, for example, for them to be 6, 8 or even 12 feet long, but their exact length is of no importance to the present invention.

In order to prevent the freezing of condensate within the heater under circumstances such as those heretofore mentioned, each of the main tubes 10 has disposed therein a smaller open-ended tube 15 which extends lengthwise thereof from a point fairly close to the discharge header 13 toward the supply header 12. The smaller tubes are preferably made of the same metal as the larger ones, in this instance copper, although it may in certain cases be desirable to make them of some other metal having a lesser heat transfer coefficient.

In the preferred form the smaller tubes are mounted in spaced relation to the main tubes 10, preferably concentric therewith, being supported at several points along their lengths by spiders 16. The supporting spiders may take any desired form, it being important only that they occupy as little of the cross sectional area of the main tube as is practical—that they present a minimum resistance to the flow of steam through the main tube. A suitable and convenient one, as illustrated in Figs. 2 and 3, consists of nothing more than a narrow strip of metal bent to star shape so that the outer ends of its legs may engage the inner surface of the main tube 10 while the inner ends thereof engage and support the smaller tube 15.

The new heater operates under full load conditions in a perfectly normal way. Thus steam supplied to its inlet header 12 at the full design pressure passes directly into and forces its way completely through the main tubes 10. In such circumstances condensate can drain directly from the main tube into the discharge header 13 without any possibility of freezing. The smaller tubes and their spiders do not materially interfere with this operation. They merely occupy small sections of the main tubes, and accordingly reduce the full load capacity of the heater to some extent. Steam will be present in the smaller tubes, of course, but it will be surrounded by the steam, at substantially the same temperature and pressure in the main tubes. Accordingly, under full load operating conditions there will be little or no condensation in the smaller tubes, and there will be little or no flow of steam through them.

The primary function of the smaller tubes is to maintain clear passageways through which steam can flow whenever it is needed to warm and thereby prevent the freezing of condensate in the surrounding main tubes. Their action can best be understood by contrast with the operation of a prior art heater. Assume, for example, that a prior art unit (an exchanger of the type illustrated in Figs. 1 and 2 but not equipped with the small inner tubes) is being used to temper air having an initial temperature of less than 32°, and to illustrate more fully, that the supply of steam has been throttled because of a decreased demand for heat. Under these conditions it is evident that the transfer surface of the tubes far exceeds that needed to condense the reduced quantity of steam supplied to them. That being so, all of that steam must necessarily condense in the first few feet of the tubes. Frequently under throttling conditions it fails to penetrate beyond the first third of the length of the heater. Consequently, condensate must flow through the remaining two-thirds of the tubes to the discharge header in heat exchange relation with air at sub-freezing temperatures. Quite naturally, that condensate will be greatly overcooled, and begins to freeze, first forming a slush and then creating a stoppage at a point adjacent the discharge header—the coldest point in the heater. In a matter of a minute or two after a stoppage occurs, the condensate backs up and freezes solid, splitting the tubes and destroying the heater.

In the new heater that can not happen. Under comparable conditions, the cooling of condensate in the main tubes destroys the temperature balance, and steam begins to condense in the smaller tubes. A flow of steam will thus be established through the smaller tubes to assure a warming of the condensate in the surrounding larger ones and thereby prevent any possibility of freezing up of the latter.

Assume further, however, that the condition is so drastic as to cause formation of ice in the main tubes despite the presence of steam in the smaller ones. The freezing does not take place instantaneously. Ice first forms on the inner surface of the main tubes and gradually builds up from that point. That ice obviously acts as a splendid insulator thereby cutting down the transfer of heat from the main tubes to the air passing thereover. Any heat supplied by the smaller tubes will then be effectively confined to a mere warming of the condensate in the larger ones. Little or none of it can escape through the main tubes to the surrounding air. The smaller tubes may thus attain their maximum effectiveness in combating further ice formation. At the same time it will be evident that the presence of ice in the main tubes restricts their cross sectional areas and tends to raise the velocity of flow therethrough. This increased velocity further impedes the formation of ice, and lessens the chance of freezing.

It might be thought that the formation of ice in a prior art heater would equally act to reduce the transfer of heat from the condensate to the air, and allow steam to penetrate farther into the tubes. The art, however, is familiar with the fact that it does not. Ice formation starts near the discharge header and doubtless its presence tends to reduce transfer, and to increase the rate of flow at that point. But that ice is far removed from the parts of the tubes which contain steam. No heat is available to combat the formation, and it proceeds, eventually blocking the tubes and stopping all flow through them. In the present device, however, as has been pointed out, steam is present in the smaller tubes adjacent the point where ice would normally form, and it is effective to avoid for-

mation entirely, or in any event to prevent accumulation of ice and complete blockage of the main tubes.

In order further to illustrate the efficacy of the device, consider the worst possible case. Assume, for example, that at the time the steam is turned on, the main tubes are completely blocked with solid ice. Even so, the smaller tubes must necessarily be open. They, as may be seen in the drawings and as will later appear, have their discharge ends located at the discharge header so that they can drain directly into the latter. At no time can condensate drain from the small tubes into the larger ones, and by the same token, at no time can condensate back up from the large tubes into the small ones. Accordingly, while steam cannot pass through the main tubes, it can always find clear paths through the smaller ones. Obviously, most of it will be condensed before it can reach the discharge header. There is little likelihood of this condensate freezing, however, first, because the velocity of the steam tends to carry it through the smaller tubes before it can freeze, and, secondly, because the surrounding ice prevents the falling of the temperature of this condensate below 32° F. In a very few minutes enough heat will be supplied to melt some of the ice and clear at least a small passage through each of the main tubes. Thereafter steam can flow through the larger as well as the smaller tubes, and its presence in the larger ones will very quickly dissipate the ice.

The exact extent of the smaller tubes and their location within the larger ones cannot be defined with precision because these factors will vary in heaters of different design and possibly will change in accordance with the character of the installation. It is only necessary, to achieve the aims of the present invention, that the smaller tubes shall provide clear paths through those portions of the larger ones wherein freezing is liable to occur. In a heater such as is shown in Figs. 1 and 2, the smaller tubes should have their inlet ends within portions of the larger ones which are always filled with steam, say within the first quarter or third of the main tubes. It is preferred that condensate shall drain from the small tubes directly into the discharge header, not into the main tubes which may be already fairly well filled with cool condensate. Accordingly the small tubes should terminate at a point which is fairly close to the discharge headers. This is particularly true when the heater is to be mounted in a horizontal position, as illustrated.

The small tubes serve a further function in improving steam distribution. When, for example, all of the steam passing into the main tubes condenses before it reaches the discharge header, then the pressure in the discharge ends of the main tubes will be somewhat lower than that in their inlet ends. Accordingly, steam flowing through the smaller tubes to the discharge header, can back up into the discharge ends of the main tubes, and tend to keep them completely filled. Distribution can be further improved, as shown in Fig. 6, by providing each of the smaller tubes **15***a* with a series of small openings **17** which extend through the last one-half or one-third of its length. In this modification, steam can escape directly from the smaller tubes into the larger ones at any point at which the pressure may be unbalanced. As a result the main tubes will be kept at a fairly uniform temperature and air passing over their discharge ends will be heated to just about the same degree as that passing over the inlet ends. The improved distribution, of course, combats any tendency on the part of the condensate to freeze. If, under very drastic conditions, ice formation begins, then the presence of steam in the smaller tube will be sufficient to prevent solid freezing—will supply enough heat to keep the freezing under control.

It is evident that in the device of Fig. 6 condensate can drain from the small tubes through the distributing openings **17** into the larger ones. This is particularly true when the heater is to be mounted in a horizontal position, as illustrated. The addition of this condensate is not desirable. It necessarily occurs when the larger tubes are already fairly well filled with cool condensate, and the excess merely tends further to clog the main tubes and increase the possibility of freezing. While the danger is not very great, it may be offset to some extent by forming the distributing openings **17** in those parts of the smaller tubes which will be uppermost when the heater is mounted in a horizontal position. If that is done then condensate can only escape from the smaller tubes when they are completely filled—a condition which rarely occurs.

The heater illustrated in Figs. 1 and 2 includes a plurality of orifice plates **18** which serve the conventional function of metering an equal quantity of steam from the supply header to each of the main tubes **10**. The same thing may be accomplished, as shown in Fig. 4, by extending the smaller tubes **15***b* to the inlet ends of main tubes **10***b*. Each smaller tube will then define an orifice between itself and its main tube which serves to limit the inflow of steam. In an even better arrangement, as shown in Fig. 5, an element of special design serves the dual function of supporting the smaller tubes and of metering the quantity of steam admitted to the larger ones. A satisfactory one for this purpose may consist of nothing more than a metal cup **19** adapted to fit within a main tube **10***e* and having a central opening **20** in its disc portion to receive a smaller tube **15***e*, and a series of other openings **21** in its disc portion which serve to restrict the flow of steam from the header **12***e*. Only a single one of these special spiders need be used in each main tube. At other points the smaller tubes may be supported by the simpler form of spider illustrated in Fig. 3 or in any other desired way. This arrangement does away with the necessity for providing separate orifice plates; it simplifies assembly to some extent for it is no more difficult to insert the disc cup **19** than the spider **16**, and it is otherwise advantageous.

In the foregoing the invention has been illustrated and described in its application to a single row heater of the straight line type. It is fully applicable, however, to multi-row heaters of this or other types. If, for example, the heater consists of two or more rows of tubes connected to supply and discharge headers arranged similarly to those of Fig. 2, then the smaller tubes may be included with the larger tubes of each row, and they may be either imperforate or perforated, as desired. With this form of heater, however, it may be found that the inclusion of the smaller tubes within the larger ones of the first row, the row over which incoming air first passes, will be sufficient.

The invention is illustrated as applied to yet

another form of heater in Fig. 7. There the main transfer tubes 10c are of hairpin form, arranged in side by side relation with their ends connected to adjacently disposed supply and discharge headers 12c and 13c, and adapted to be mounted within any appropriate casing (not shown). In this modification the smaller tubes 15c are imperforate, and are substantially coextensive with the main ones being supported at several points by spiders 16b. They may, however, be of lesser extent, and may be provided with series of distributing openings comparable to those illustrated at 17 in Fig. 6.

Some difficulty may arise in the manufacture of the device of Fig. 7, particularly in connection with the installation of the inner tubes. In can readily be avoided by constructing the device as illustrated in Fig. 8. In that embodiment separate sections of small tubing are first installed in the straight sections of the main tubes, and the main tubes are then interconnected by the application of return bends 23. If continuous, smaller tubes are desired, then it will still be found simpler to set such tubes in place in the return bends 23 before applying them to the straight sections of the main tubes.

While the invention has its greatest utility in the lightweight extended surface type of heater, it may of course be embodied in a cast iron heater or in an ordinary plain pipe coil. The simplest form which the device may take is illustrated in Fig. 9. There it consists of nothing more than a tube 10d which may or may not be provided with heat radiating fins, having its opposite ends open for direct communication with a source of steam and a condensate drain line, and a small inner tube 15d supported concentrically therein upon spiders 16d, and extending through the larger tube for such distance as may be found necessary to prevent freezing of condensate in the latter. Again, the tube 15d may be imperforate in accordance with the disclosure of Figs. 1 and 2, or it may be provided with a series of spaced openings in accordance with the modification of Fig. 5.

Since certain changes may be made in the embodiment of the invention, all within the skill of the worker in the art, it is intended that the foregoing shall be construed in a descriptive rather than in a limiting sense.

What I claim is:

1. A heat exchange device comprising a main heat transfer conduit over which a medium to be heated may be passed, such main conduit being adapted for open communication at one of its ends with a source of steam and at its other end with a condensate drain; and a smaller conduit disposed within the larger one, such smaller conduit being open at both of its ends, and being adapted to provide a substantially unrestricted path for steam through that part of the main tube wherein freezing of condensate is liable to occur.

2. A heat exchange device according to claim 1 further characterized in that the smaller conduit extends from a point adjacent the discharge end of the main tube towards the steam inlet end thereof, and has its open discharge end so located that condensate may flow therefrom directly into the condensate drain.

3. A heat exchange device according to claim 1 further characterized in that the smaller conduit is imperforate throughout its length, extends from a point adjacent the discharge end of the main tube towards the steam inlet end thereof, and has its discharge end so located that condensate may flow therefrom into a drain without mixing with condensate in any part of the main transfer conduit which might normally freeze up.

4. A heat exchange device according to claim 1 further characterized in that the smaller conduit extends from a point adjacent the discharge end of the main tube towards the steam inlet end thereof, and is provided with a series of openings formed at intervals beginning adjacent the discharge end and terminating at a point between its ends.

5. A heat exchange device according to claim 1 further characterized in that said smaller conduit extends substantially the full length of the main one, and by the provision of means for supporting said smaller conduit in spaced relation to said main one.

6. A heat exchange device comprising steam supply and condensate discharge headers, a plurality of main heat transfer tubes disposed in spaced relation one to another, said main tubes having their opposite ends joined to and in direct communication with said supply and discharge headers, a plurality of smaller open ended tubes each disposed within and extending lengthwise of one of said main tubes and providing a substantially unrestricted path for steam through that part of such main tube wherein freezing of condensate is liable to occur, and means for supporting said smaller tubes in spaced relation to said larger ones.

7. A heat exchange device according to claim 6 further characterized in that the means for supporting said smaller tubes are also adapted to meter the flow of steam from the supply header to said main tubes whereby to assure even distribution of steam to all of said main tubes.

8. A heat exchange device according to claim 6 further characterized in that each of said smaller tubes is imperforate throughout its length and has its discharge end so located that condensate may drain therefrom directly into said discharge header without mixing with condensate in the surrounding main tubes.

9. A heat exchange device according to claim 6 further characterized in that each of said smaller tubes extends from a point adjacent said discharge header towards said supply header, and is provided with a series of distributing openings beginning near its discharge end and terminating short of its inlet end.

10. A heat exchange device according to claim 6 further characterized in that said smaller tubes are substantially coextensive with said main transfer ones, and are imperforate throughout their lengths.

11. A heat exchange device according to claim 6 further characterized in that said smaller tubes are substantially coextensive with said main transfer ones and each is provided with a series of distributing openings beginning at a point substantially removed from its inlet end and terminating at a point adjacent said discharge header.

12. A heat transfer device according to claim 6 further characterized in that each of said smaller tubes extends from a point adjacent said discharge header towards said supply header and terminates short of said supply header.

13. A heat exchange device comprising steam supply and condensate discharge headers, a plurality of main heat transfer tubes disposed in

spaced relation to each other with their opposite ends connected to and in direct communication with said headers, said main transfer tubes having finned outer surfaces to increase their heat transfer capacity, a single smaller tube disposed within and extending substantially the full length of each main transfer tube, each such smaller tube being open at both of its ends and providing a substantially unrestricted path between said headers, and means for supporting each smaller tube substantially concentric with its main transfer tube.

14. A heat transfer device according to claim 13 further characterized in that said smaller tubes are imperforate throughout their lengths.

15. A heat transfer device according to claim 13 further characterized in that each of said smaller tubes is provided with a series of spaced openings, such series beginning at a point substantially removed from the inlet end of the tube and extending to a point adjacent said discharge header.

16. A heat transfer device according to claim 13 further characterized in that each smaller tube is supported within its main tube upon a plurality of spiders each having several legs engaging the inner surface of the main tube and the outer surface of the smaller tube, but not blocking the path through the main tube.

17. A heat exchange device according to claim 13 further characterized in that the means for supporting each smaller tube comprises a disc disposed within the main tube adjacent its inlet end, such disc having a central opening for receiving the smaller tube and another opening which is of larger area than the inlet end of said smaller tube and is adapted to restrict the flow of steam from said supply header into such main tube.

18. A heat exchange device according to claim 1, further characterized in that said smaller conduit extends from a point adjacent the discharge end of said main tube towards the inlet end thereof, and by the provision of means for supporting said smaller conduit in spaced relation to said main one.

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