

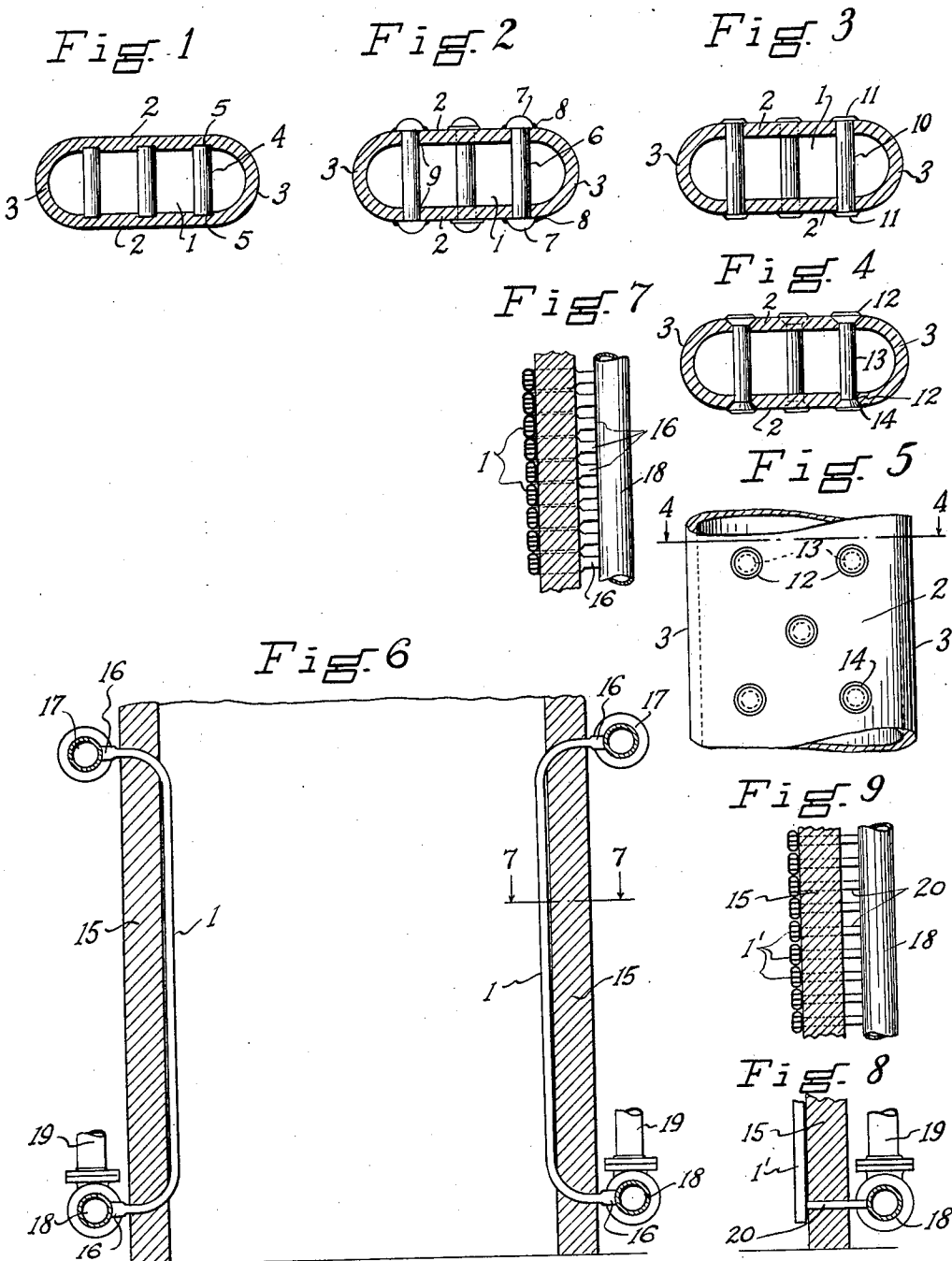
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TUBE

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TUBE

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5 Claims. (Cl. 122—481)

This invention relates to improvements in fluid heat exchange apparatus, and is exemplified herein as a radiantly heated steam superheater.

When steam under pressure is conducted through tubes exposed to high temperature heat radiantly transmitted from burning fuel, there is no gas film resistance comparable to the gas film resistance obtaining during the convection superheating of steam. In convection superheating it is important to keep the metal temperature down as the superheat goes up. This is accomplished by controlling the film resistance. This is done by providing a high velocity steam flow for the heating gases, this action decreasing the disparity between the outside and the inside resistances (the resistance of the metal to heat transfer being considered the inside resistance).

The above indicated conditions and problems do not apply to the functioning of radiantly heated superheaters. In the operation of the latter there is no gas film resistance. Most of the resistance to heat transfer is in the metal, the temperature of which is necessarily high. Again, in the functioning of radiantly heated superheaters there is a greater temperature differential across the metal. That part of the metal wall most remote from the burning fuel has a relatively low temperature, whereas the front portion of the wall has a relatively high temperature. The temperature of the film is, generally speaking, controlled by the steam temperature.

In the consideration of conditions obtaining during the superheating of steam in a radiantly heated superheater, the internal resistance to heat transfer may be considered as all such resistance other than resistance externally of the outside surfaces of the tubes. When this is the case, the internal resistance is naturally high by reason of the nature of the fluid inside of the tubes. This internal resistance is measured in temperature differences, the metal temperature in the present instance being always higher than the temperature of the receiving fluid. This condition in conjunction with the high temperature of the fluid brings the metal temperature so high that it may be dangerous from the standpoint of oxidation and strength.

In modern superheating practice exceedingly high temperatures are required. They are in excess of 800° F. at the present time. When such superheating temperatures obtain, and when it is considered that the temperature of the outside portion of the metal is probably above this superheat temperature, there is at least one apparent reason for the fact that current published engi-

neering reports indicate that the operation of radiantly heated superheaters with plain tubes is still causing many difficulties from the standpoint of satisfactory superheater life and safety in operation.

The present invention solves the above indicated problem by providing for the production of high temperature superheated steam while keeping the metal temperatures at safe values when the tubes are exposed to the intense radiant heat of modern furnaces.

A subsidiary problem arising in the development of radiant steam superheaters relates to the fact that the tubes of these superheaters are not equally heated on all sides. This is especially true when the tubes are arranged near a furnace wall as shown in this case. The wall sides of the tubes receive less radiant heat, and they will therefore be cooler than the opposite sides of the tubes. This condition results in a tendency to cause tube distortion and attendant damage to the superheater.

The present invention solves this problem by providing means for accomplishing two simultaneous and cooperating results. One is the equalization of the temperatures of the cooler face and hotter face of the tube wall. A second is the reduction of the temperature of the hottest portion of such superheaters to safe values, that is, to values which are lower than those possible where the invention is not used. These results make it practicable to safely deliver fluids at temperatures which are higher than those which would otherwise be possible.

It is recognized that water heating devices using stay-bolts to resist pressure are known in the art, but, in such devices, the stay-bolts merely perform a staying function. They perform none of the functions which must pertain in a solution of the problems which were before the inventor. In such water heating devices as in the water legs of locomotive boilers, the metal temperature is usually only a few degrees above the water temperature. This condition is just the reverse of the condition pertaining in the operation of devices improved by the applicant.

In such prior art devices the resistance at the water surface is insignificant compared to the resistance at the gas or steam surface pertaining in radiantly heated superheaters with which this invention is concerned. The maximum temperature to which water can be raised is about 706° F., and this temperature is only possible at the critical pressure 3226 pounds per square inch. In modern superheater practice much higher tem-

peratures are required. They are in excess of 800° F. at the present time. Thus, as compared to the conditions pertaining to the prior art devices, the inventor deals with hotter fluids, and he deals with devices in which there is a much greater temperature difference between the metal and the fluid in contact with the metal and heated therethrough. These conditions are entirely different, and they cause entirely different problems.

In some prior art devices flattened cast iron tubes are employed to heat water passing through the tubes. Pins or other devices in the nature of stay-bolts pass through the walls of these tubes and through the contained water, but the applicant has no knowledge of any such devices which accomplish the results obtained by the present invention. The fact that the tubes of such prior devices are of cast iron itself indicates that the pressure conditions of applicant's device do not obtain. Furthermore, the manufacture of such prior art devices by soldering the parts together indicates that the high temperatures of radiantly heated superheaters do not obtain. Such high temperatures would render such soldered structures manifestly inoperative. In such prior devices the pins performed merely the duty of ordinary fins providing an extended interior surface.

This application is a continuation of application bearing Serial Number 247,932, and filed on January 19, 1928 by the same applicant.

It is an object of this invention to provide, in radiantly heated steam superheaters improvements whereby the heat exchange is materially enhanced, the resistance to the type of heat transfer pertaining to such devices being minimized.

The invention will be understood from the description in connection with the accompanying drawing in which:

Fig. 1 is a section through an illustrative embodiment of the invention;

Fig. 2 is a section through a modification;

Fig. 3 is a section through a modification;

Fig. 4 is a section through a modification;

Fig. 5 is a plan view partly broken away of the tube shown in section in Fig. 4;

Fig. 6 is a vertical section through a furnace showing the tubes in place;

Fig. 7 is a section along the line 7—7 of Fig. 6;

Fig. 8 is a vertical section similar to Fig. 6 through a furnace partly broken away showing a modification; and

Fig. 9 is a section through the modification similar to the section 7—7 of Fig. 6.

In the drawing reference character 1 indicates a tube that is flattened so as to have two parallel sides 2, 2 which are joined by wall portions 3, 3. One or more rows of pins 4 are located inside of the tube perpendicular to the walls 2, 2 and the ends of the pins or conductors 4 are welded to the inside faces of the walls 2, 2. The tubes can be made by first flattening a round tube to the form shown in Fig. 1, then introducing the pins 4 into the inside of the tube and holding them in place by wooden strips or in any other convenient manner. The walls 2, 2 may be heated, for example, by applying an electric current from the outside of the tube, while the tube is being compressed to force the ends of the pins into the fused metal of the tube, the tubes thereby becoming somewhat more flat after the pins are welded in place than they were before the pins were introduced. The ends of the tubes may be left circular for convenience in anchoring them into

headers, and the pins 4 may be of circular or any other convenient shape. If they are made flat, their longest cross sectional dimensions should preferably extend longitudinally of the tube.

In the modification shown in Fig. 2, the pins or conductors 6 extend entirely through holes in the walls 2, 2 and the ends are upset to form rivet heads 7 that may be in turn welded to the tubes if desired, as indicated at 8.

In the modification shown in Fig. 3, the pins or conductors 10 are of sufficient length to be substantially flush with the outside surfaces of the walls 2, 2 and the ends are welded, as indicated at 11, to the walls of the tubes.

In the modification shown in Fig. 4, the outside portions of the holes through the walls 2, 2 are made conically shaped, as indicated at 12, and the ends of the pins 13 are expanded so as to be seated in these conical portions and may be welded to the walls as indicated at 14.

Any of the tubes illustrated in Figs. 1 to 5 may have their ends bent to extend through the walls of the furnace and rows of such tubes may be installed along the sides of the furnace, as indicated in Fig. 6, with the bent portions extending through the walls of the furnace and the flat portions lying along the inside walls of the furnace with the rounded wall portions of adjacent tubes in contact with each other or nearly so, so that they will receive a large part or nearly all of the radiant heat that would otherwise impinge directly upon the walls of the furnace. The round end portions 16 of the tubes 1 are expanded into upper and lower headers 17 and 18. The lower headers 18 may be connected by the pipe 19 to a source of steam, such as the steam space of the steam and water drum and the headers 17 may be connected to the steam main.

In the modification shown in Figs. 8 and 9, the tube 1' is made straight and is flattened for its entire length, and the ends of the flat tubes are connected by means of nipples 20 that extend through the walls of the furnace to the superheater headers.

In the modifications indicated in the drawing, there are metallic members extending from the hotter wall portions of the tubes across the interior tube spaces to the opposite walls of the tubes. These members are to have adequate cross section with reference to their duty which is to conduct heat from the hottest tube face to transmit it to the fluid and to the opposite tube face to equalize the temperature of the faces. These members may be materially thicker relative to the wall and to the space between them than they are shown. It is also to be understood that the tubes may be placed in the furnace in such a way that opposite faces of each tube may receive radiant heat. In this case, heat is conducted both ways by the cross members employed.

Some of the heat conducting elements 13 which extend across the tube interiors permit the tube to have a flattened section, or stated more broadly, they permit the tube to have a section which is other than a circular section. In this case, these members act as stays and the tube flatness contributes to the objective because it increases the surface exposed to heat and also because it increases the ratio of metal heating surface to the surface of gas heated. This arrangement also permits the use of relatively short

cross members, thereby increasing the value of such members as heat conductors.

I claim:

1. In fluid heat exchange apparatus, a furnace, means for burning fuel in the furnace, a row of tubes exposed to radiant heat in the furnace and conducting steam past a zone in which the tubes have their front and rear wall portions heated unequally, and metallic conductors in heat exchange relation with the metal of the tubes and extending from the front wall portions to the rear wall portions of the tubes, said conductors being distributed over the wall portions of the tubes exposed to heat radiantly transmitted from the burning fuel.

2. In fluid heat exchange apparatus, a furnace, means for burning fuel in the furnace, a row of flat faced tubes exposed to heat radiantly transmitted from the burning fuel and conducting steam past a zone in which the tubes have their front and rear wall portions unequally heated, and metallic conductors in heat exchange relation to the metal of the tubes and extending across the steam currents from the front wall portions to the rear wall portions of the tubes, said conductors being distributed over the wall portions of the tubes exposed to heat radiantly transmitted from the burning fuel.

3. In fluid heat exchange apparatus, a furnace having a gas directing wall, means for burning fuel in the furnace, a row of tubes disposed along

the side of the wall towards the burning fuel and conducting steam past a zone in which the tubes have their front wall portions and their rear wall portions unequally heated, the opposing portions of the front and rear wall portions having aligned openings therein and metallic conductors in heat exchange relation with the metal of the tubes and extending from the front wall portions to the rear wall portions of the tubes as well as through the openings formed in those wall portions, said conductors being distributed over the wall portions of the tubes exposed to heat radiantly transmitted from the burning fuel.

4. In a device of the class described, a superheater tube subjected to the action of radiant heat and adapted to conduct a fluid therethrough, and a plurality of pins extending transversely across the interior of the tube and having at least one end welded to the inner wall of the tube, the wall at that point being continuous.

5. In a device of the class described, a tube subjected to the action of radiant heat and adapted to conduct a fluid therethrough, said tube having oppositely disposed flattened sides, and a plurality of pins extending across the interior of the tube and having their opposite ends secured to said flattened sides, said sides being closed at the points where the pin ends are secured thereto, the ends of said tubes being unflattened and secured to headers.

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