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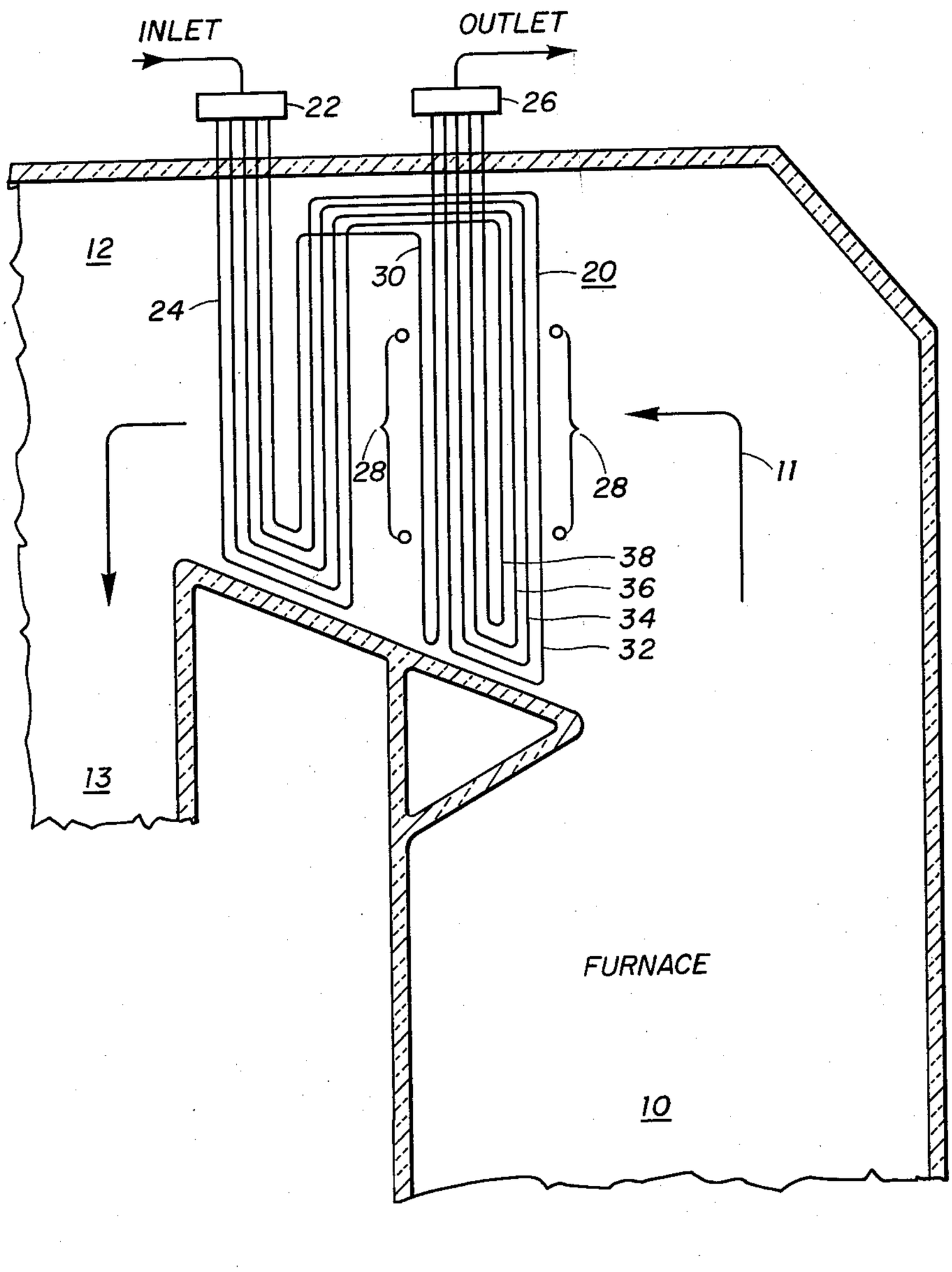

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VAPOR HEATER ARRANGEMENT WHICH PROTECTS THE TUBES FROM OVERHEATING AND SOOTBLOWER EROSION

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This invention relates to vapor heaters of the tubular panel type wherein the panels are positioned in and absorb heat from a stream of hot combustion gases and particularly to an improved arrangement of the tubes within the panel so as to give the utmost protection against overheating and sootblower erosion damage.

In most present day boiler installations, use is made of vapor heating or steam heating sections in the form of panels, for example superheater or reheater panels, which extend downwardly either from the upper portion of the furnace or the gas pass, which extends horizontally from the upper portion of the furnace. These panels absorb heat from the hot combustion gases which flow from the furnace on through the gas pass. The panels, being positioned in such close proximity to the source of burning fuel, are exposed to combustion gases of extremely high temperatures. Such location presents some problems.

One problem encountered is the overheating of the outermost tubes, both on the upstream and downstream edges of the panel, which absorb heat by radiation from the furnace and the cavity downstream of the panel, as well as by convection, whereas the tubes in the central portion of the panel absorb substantially less heat by radiation. For this reason, the outermost tubes on occasion are overheated and fail. In some boilers, for example those utilizing oil or coal as a fuel, ash deposits form on the tubes within the vapor heating panels, and these deposits must be periodically removed. For this reason, sootblowers are usually inserted into the furnace or gas pass both upstream and downstream of the panel to remove these deposits from the tube surfaces.

It has been found that the jet action of the steam or air streams from the sootblowers also removes films of oxide deposits which form on the surface of the tubes. These oxide deposits, once formed, are desirable since they protect the metal of the tubes from further corrosion or oxidation. It has further been discovered that the thickness of oxide film that is formed on the tube surface at high temperatures is considerably greater than the thickness of the film of oxide scale formed on the tube surfaces of the tubes at lower temperatures. A thin film of oxide clings to the surface of the tube and receives support therefrom to a greater extent than a heavy or thick coating of oxide scale as formed on a tube at high temperature. Thus, sootblower action will more readily remove the heavy oxide coating from the tubes at high temperatures than when such sootblower action is directed against a thin film of oxide as formed on the surface of a tube at lower temperatures.

It is an object of this invention to provide a compact, economical arrangement of tubes within a vapor or steam heating section whereby the outermost tubes of the panel or section which are exposed both to radiant heat and sootblower action are maintained relatively cool, to prevent damage or failure thereof due to overheating or sootblower erosion.

Other objects and advantages will become apparent from the following description taken in conjunction with the accompanying drawing wherein the FIGURE is a schematic elevational view of a steam heater arranged in a gas pass at the outlet of a furnace in accordance with my invention.

Referring now to the figure, numeral **10** denotes the furnace of a steam generator wherein fuel is burned. The hot combustion gases rise and flow through the gas pass **12**, the direction of gas flow being indicated by arrow **11**. Positioned within the gas pass are reheater sections or panels **20** and **24**. Steam to be reheated enters inlet header **22** from a high pressure turbine (not shown) then flows through panels **24** and **20**, where the steam is superheated by absorbing heat from the hot combustion gases flowing through the gas pass, and then flows from outlet header **26** to an intermediate or low pressure turbine (not shown).

In most utility steam generator installations it is desirable to have the superheated steam leaving the reheater section at a very high temperature, for example 1050° F. To reach this temperature, it is beneficial to place the reheater in the upper portion of the furnace, or in the gas pass directly adjacent the furnace as illustrated, where the combustion gases are still at extremely high temperatures. When a fuel is burned in the furnace which produces fly ash or dust particles, for example coal or oil, the fly ash or dust particles in the combustion gases will be separated out as the gases flow through the reheater panels or sections, forming deposits on the tubes within the panels. These deposits cause corrosion of the tubes and also prevent proper transfer of heat from the hot combustion gases to the steam flowing within the reheater tubes, and thus the deposits must be periodically removed from the tube surfaces by means of sootblowers **28**. These sootblowers are inserted into the gas pass through openings in the side walls thereof, and direct streams of high pressure steam or air at the panels.

As mentioned previously, thin films of protective oxide scale are present on the tube surfaces, which protect the tubes from further corrosion and oxidation. The hotter the tubes, the thicker the coating of oxide scale, and the more easily it is removed by the jets of steam or air issuing from the sootblowers which impinges on the tube surfaces. The outermost tubes in the panel receive the most direct impingement from the sootblowers, and thus are most likely to have their film of oxide scale removed. Also, the outermost tubes absorb the most heat from the hot combustion gases, since these tubes are subject to radiant heat transfer from the furnace and the cavity between panels **20** and **24**, which radiant heat transfer is greater than that of the tubes in the central portion of the panel. Since the steam leaving the last reheater panel **20** is at approximately 1050° F., it is possible to damage or rupture these tubes by overheating, if for some reason the temperature increases only slightly above what they were designed for. This is especially true of the outermost tubes, which receive the most heat.

In order to prevent damage caused by sootblower erosion or overheating, I have designed a reheater panel whereby the outermost tubes of such panel are both inlet legs, where the steam flowing therethrough is at a lower temperature than that flowing through the outlet leg.

Looking at the figure, reheater panel or section **20** is made up of substantially U-shaped tubes **30**, **32**, **34**, **36**, and **38**. As shown, the inlet leg, or cool leg, of tube **30** is the one that is exposed to radiant heat from the space or cavity between panels **20** and **24**, and is also subject to the greater sootblower action. On the other side or edge of the panel, the inlet leg, or cool leg of tube **32** is the one that is exposed to radiant heat from furnace **10**, and is also subject to the greatest sootblower action.

The temperature of the steam entering tubes **30**, **32**, **34**, **36**, and **38** within panel **20** is probably between 965–1000° F., with the outlet temperatures being approximately 1050° F. Thus it can be seen that the temperature of the inlet portions or legs of tubes **30** and **32**, which are exposed to sootblower erosion and the greatest radiant heat,

are 50–75° cooler than would be the hot end, or outlet portions of the same tubes.

It would be possible to have the hot end, or outlet portion of tube 30 extend down along the bottom edge of the panel, having it bend up somewhere in the central portion of the panel, and still gain the benefit of my invention; namely, to provide a relatively cold tube on both the front and back edges of the panel. However, the preferred design is as illustrated, with the tube 30 bent directly back upon itself. With this construction the tube need not be offset out of the plane of the panel, which would be necessary if the outlet leg were positioned in the central portion of the panel. Also, with the outlet leg of tube 30 doubled back so that it is directly adjacent the inlet leg, it is easy to change the overall length of the tube. Thus, if desired, the tube could be made shorter by merely making the two legs shorter, with the bend being further from the gas pass floor. This would then expose a small portion of tube 32, in the lower left hand corner of the panel, to radiant heat and sootblower action. In some circumstances it might be desirable to bend two tubes instead of one along the back edge of the panel, such as tube 30, the tubes being nested as tubes 32, 34, 36, and 38 are illustrated. Also, it should be readily understood that superheaters, which are subject to the same problems as reheaters, could also be constructed in accordance with my invention.

While I have shown and described the preferred embodiment of my invention it is to be understood that the invention is not limited thereto but may be otherwise variously embodied and practiced within the scope of the following claims.

What I claim is:

1. In a steam generator the combination of a furnace which acts as a source of hot combustion gases, wall means forming a passage through which the hot combustion gases flow, steam heating means comprising a plurality of independent tubes formed into a rectilinear panel which is parallel to the flow of the hot combustion gases, each of the tubes having a plurality of vertical portions, each of the vertical portions being parallel with one another, and substantially equally spaced from the next adjacent vertical portion, some of the vertical portions being inlets and some being outlets, by means of

which steam enters and leaves the steam heating means, respectively, said panel having a first edge closest to the source of hot combustion gases, and a second edge farthest from the source of hot combustion gases, the tubes being positioned in the rectilinear panel such that the vertical portion closest to the source of hot combustion gases and the vertical portion farthest from the source of hot combustion gases are both inlets, and extend along the entire first and second edges of the panel, respectively, and sootblowers positioned downstream and upstream of the rectilinear panel.

2. In a steam generator the combination of a furnace which acts as a source of hot combustion gases, wall means forming a passage through which the hot combustion gases flow, steam heating means comprising a plurality of independent tubes formed into a rectilinear panel which is parallel to the flow of hot combustion gases, said panel having a first edge closest to the source of hot combustion gases, and a second edge farthest from the source of hot combustion gases, each tube consisting solely of a single substantially U-shaped configuration having two vertical portions, each and every vertical portion of all of the tubes being parallel with and substantially equally spaced from the next adjacent vertical portion throughout the width of the panel, one vertical portion of each tube being an inlet and the other vertical portion of each tube being an outlet, by means of which steam enters and leaves the steam heating means, respectively, the tubes being positioned in the rectilinear panel such that the vertical portion closest to the source of hot combustion gases and the vertical portion farthest from the source of hot combustion gases are both inlets, and extend along the entire first and second edges of the panel, respectively, and sootblowers positioned downstream and upstream of the rectilinear panel.

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