Sept. 9, 1958 H. J. BLASKOWSKI 2,851,017

PANEL TYPE STEAM HEATERS

Filed Feb. 16, 1954 2 Sheets-Sheet 1

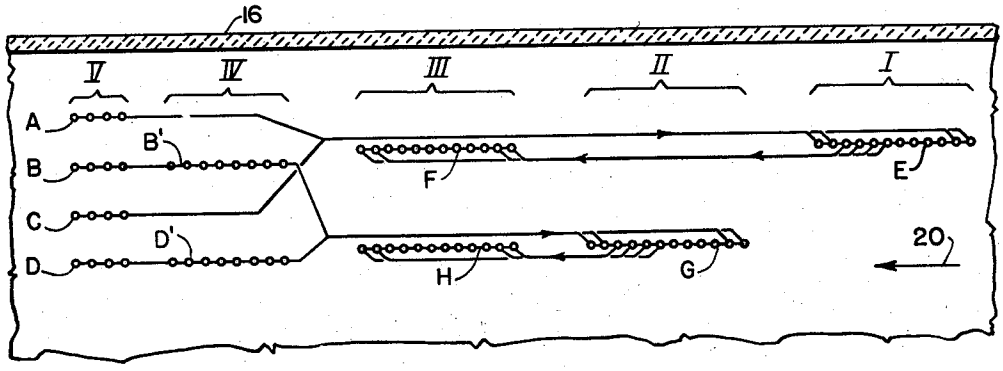


FIG. 2

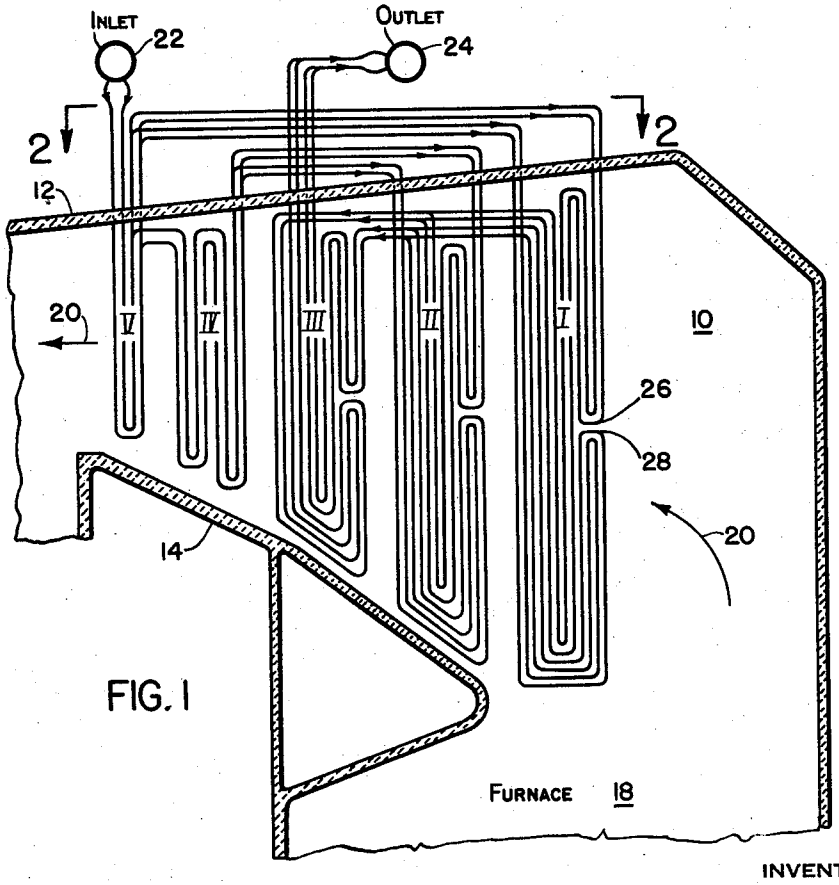


FIG. 1

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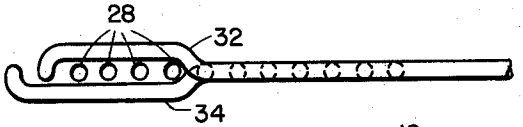


FIG. 4

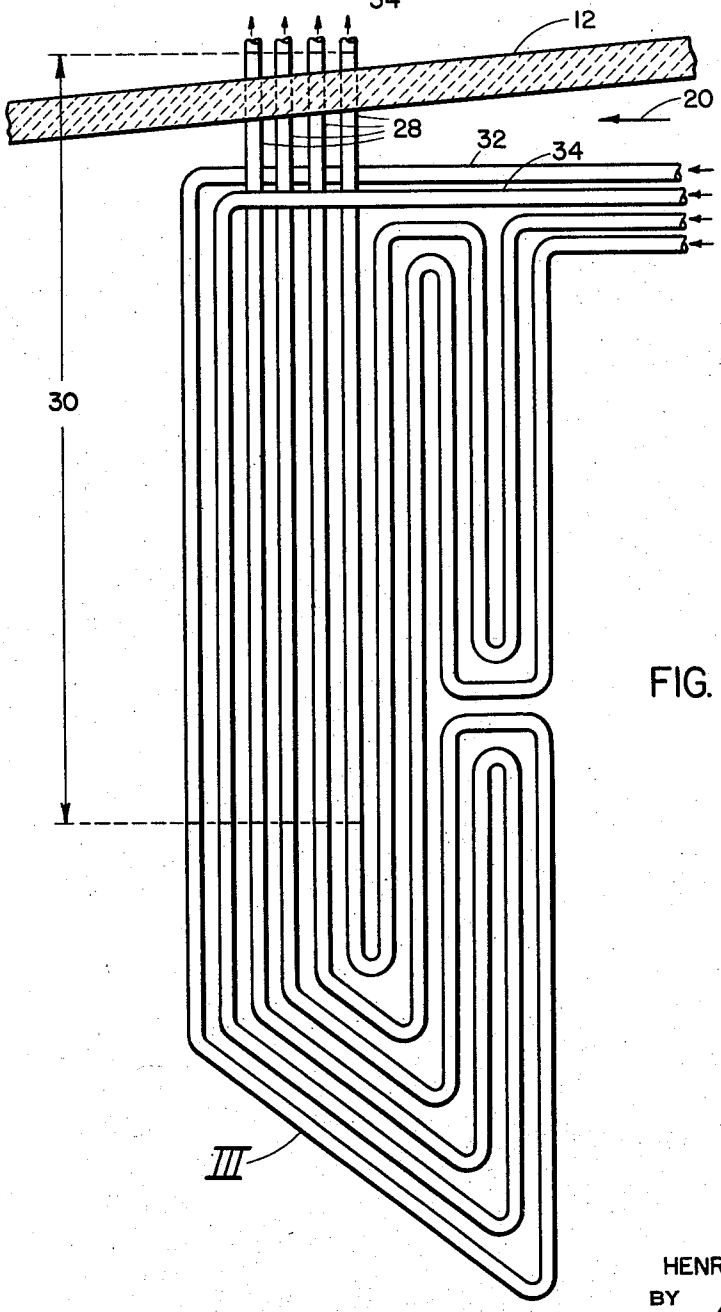


FIG. 3

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PANEL TYPE STEAM HEATERS

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Application February 16, 1954, Serial No. 410,540

10 Claims. (Cl. 122—476)

This invention relates to vapor heaters of the tubular panel type wherein the panels are disposed in and absorb heat from a stream of hot gases and particularly to an improved tubular arrangement of the panels so as to insure against excessive tube metal temperatures thereby reducing the cost and prolonging the life of the vapor heater and also so as to insure against setting up excessive stresses due to unequal thermal expansion.

To attain the high steam temperatures often required in power plants today it is necessary to utilize costly high temperature steels in portions of the superheater and reheater elements usually including those portions that are exposed to furnace radiation. These conditions also frequently require, for safety reasons, the use of thicker wall tubes at these locations. All of these considerations lead to the increase in cost and weight of the superheater and/or reheater of the steam generator.

With the present invention excessive tube metal temperatures due to extremely high rates of heat absorption are reduced thereby reducing the amount of costly high temperature metal required in these modern steam heaters and prolonging the life of the same. This is accomplished by uniquely arranging the tubular elements in the various panels of the steam heater which have their upstream edges subjected to furnace radiation and/or direct impingement of the hot gases so that the steam flow along these upstream edges is twice that in conventional steam heaters. In general the invention comprises forming the upstream edge of these various tubular panels of independent tubes extending from each end of the panels to approximately the midpoint of the upstream edge and at said midpoint being reversely bent within the the plane of the panel.

With the high steam temperatures now being attained it is necessary to use expensive high temperature metal in fabricating at least a portion of the last leg of the finishing-off panel of the vapor heater. Since this portion will thus have a different coefficient of expansion from the remainder of the finishing-off panel it is necessary to provide for differential movement therebetween. This differential movement is accommodated in the present invention by arranging the tubular elements of this finishing-off panel so that the last legs thereof are free to expand longitudinally and independently with respect to the remainder of the panel but are guided so as to remain in the plane of the panel.

It is an object of this invention to provide an improved vapor heater of the tubular panel type having a novel tube arrangement whereby excessive tube metal temperatures are reduced and whereby excessive stresses due to differential expansion are not set up.

Other and further objects of the invention will become apparent to those skilled in the art as the description proceeds.

With the aforementioned objects in view, the invention comprises an arrangement, construction and combination of the elements of the steam heater in such a manner as to attain the results desired as hereinafter more particularly set forth in the following detailed description of an illustrative embodiment, said embodiment being shown by the accompanying drawing wherein:

Figure 1 is a schematic view of a steam heater disposed in a gas pass at the outlet of a furnace and constructed in accordance with the present invention;

Figure 2 is a diagrammatic plan view of a portion of the steam heater of Fig. 1;

Figure 3 is an enlarged view of the finishing-off panel of the steam heater;

Figure 4 is a top view of the panel of Fig. 3.

Referring now to the drawings wherein like reference characters are used throughout to designate like elements, gas pass **10**, within which the elements of the steam heater are disposed is bounded by upper and lower walls **12** and **14** respectively, and side walls **16**, one such side wall being shown in Fig. 2. This gas pass is in direct communication with the outlet of furnace **18** from which it receives hot combustion gases which flow through the gas pass and over the steam heater elements in the direction indicated by arrows **20**.

The steam heater is made up of five groups of panels designated on the drawing by Roman numerals I, II, III, IV and V with each group consisting of a number of vertically disposed panels spaced across the gas pass with the median plane of the panels being parallel with the gas flow through the pass.

As is evident from Fig. 2 the panels in the groups located downstream relative to the gas flow are much closer together than those located upstream for the reason that molten slag collects on the upstream panels and these panels must be spaced sufficiently so that the gas passages between them will not become unduly restricted or completely clogged by the bridging of slag between adjacent panels. Since the steam heater of this invention is made up of continuous tubes having their inlets connected to inlet header **22** and their outlets to outlet header **24** and being bent to form the panels in the several groups, the panel arrangement disclosed in Fig. 2 is achieved by combining the tubes of a number of the downstream panels into a single upstream panel with the steam flow through the tubes being as indicated by the arrows.

The four panels disclosed in Fig. 2 as making up group V and identified as A, B, C and D are each made up of a pair of tubes which are bent in the form of a U with the axes of the tubes making up each pair laying in a common plane parallel to the gas flow through pass **10**. The pair of tubes which form each of the panels A and C are laterally bent as disclosed and extend from these panels in an upstream direction relative to the gas flow to the location of group I, where they are bent to form the single panel E. In forming this upstream panel E, represented in Fig. 1 as the panel of group I, one of the pairs of tubes extends down the leading edge of the panel to approximately the midpoint of the edge where it is reversely bent at **26**, while the other pair of tubes extends down the entire trailing or downstream edge of the panel along the bottom of the panel and then up along the upstream edge of the panel to the location of this return bend **26**, where it is also provided with a return bend **28**. From these return bends each of the pair of tubes is bent in a serpentine manner to form the remainder of the panel and extends from panel E in a downstream direction to panel F in group III, this latter panel being formed in the same manner as panel E with the two pairs of tubes extending from this panel to outlet header **24**.

The pair of tubes forming panels B and D extend upstream a short distance and are then sinuously bent to form panels B′ and D′, respectively, after which they are laterally bent as shown in Fig. 2, and extend forward to the location of group II where they form the single panel

G. From panel G the tubes extend in a downstream direction to the location of group III where they form panel H with the tubes leading from this panel into outlet header **24**. Both of the panels G and H are formed in the same manner as the previously described panel E wherein the leading edge is composed of tubes extending downward from the top of the panel and upward from the bottom of the panel to approximately the midpoint of the leading edge where they are reversely bent. With this construction of the panels in groups I, II and III the stream flow along the upstream edge of these panels is twice that which is obtained by having the same tube or tubes extending along the entire lentgh of the upstream edge of the panel as has been done heretofore. Since the leading edge of the panels of groups I and II, and also to a less extent the panels of group III is subjected to intense furnace radiation and since the upstream edge of the panels of groups I and II is subjected to direct impingement of the combustion gases very high rates of heat transfer result causing high tube metal temperatures in the tubes making up these leading edges. By doubling the steam flow, however, this metal temperature is greatly reduced over that which would otherwise be obtained, resulting in greatly reducing the cost of the metal which may be used in fabricating these tubes as well as substantially prolonging the life of the tubes.

With the steam heater arrangement of this invention the steam temperature leaving each of the panels of group III is approximately the same, this being achieved by conveying the steam directly from panels A and C of group V to panel E of group I while the steam from panels B and D of group V is first conveyed to panels B' and D' of group IV and then to panel G of group II. Thus, while panel E is in a higher heat transfer rate zone than panel G the temperature of the steam entering panel E is substantially lower than that entering panel G so that the steam leaving these two panels and entering panels F and H, respectively, is approximately the same temperature. This arrangement in addition to equalizing steam temperatures has the advantageous result of providing panel E, which if farthest upstream, with a somewhat lower temperature of steam which results in lower tube metal temperatures in the panel.

For the purpose of simplifying the illustration and explanation of the invention, Fig. 2 discloses only the minimum number of panels in each of the groups which is commensurate with a full understanding of the invention. It is to be understood, however, that is an actual installation each group would be composed of many more panels than displosed in Fig. 2 with a typical installation having 52 panels in group V resulting in 26 panels in groups IV and III and 13 panels in groups II and I.

The panels making up group III are the finishing-off panels of the steam heater, i. e., the last panel through which the steam passes prior to entering outlet header **24** and the panel in which the desired steam temperature is attained. In a modern steam generator operating at a high pressure and a steam temperature of 1050° F. it is necessary to fabricate a portion of the final leg of the tubes making up this panel from expensive high temperature metal such as 18–8 chrome-nickel steel.

Figs. 3 and 4 disclose in detail one of the finishing-off panels of group III wherein the final legs of the four tubes making up this panel are identified as **28**, these legs extending upwardly through roof **12** of gas pass **10**. In a typical installation the portion **30** of legs **28** may be required to be fabricated from expensive high temperature steel wherefore these portions will have different coefficients of expansion than the remainder of the panel resulting in differential movement therebetween. In order to accommodate this differential movement, portions 30 of legs **28** are not rigidly welded into the tubular panel as is the case with the other portions of the tubes making up the panel but are independent of these other tube portions so that said portions **30** can expand independently thereof in an upward longitudinal direction. In order to insure that the portions **30** of legs **28** remain within the plane of the panel, the pair of tubes **32** and **34** that extend across the top of the panel and then down along the panel's trailing or downstream edge are laterally bent so as to snuggle but slidably receive legs **28** therebetween, as best seen in Fig. 4, thereby preventing lateral displacement of these legs while permitting independent longitudinal movement thereof.

While I have described and illustrated a preferred embodiment of my novel steam heater it is to be understood that such is merely illustrative and not restrictive and that variations and modifications may be made therein without departing from the spirit and scope of the invention. I therefore do not wish to be limited to the precise details set forth but desire to avail myself of such changes as fall within the purview of my invention.

What I claim is:

1. In a steam generator, the combination of a gas pass through which hot combustion gases are conveyed, superheater means disposed in said gas pass, said superheater means comprising, a plurality of independent tubes connected in parallel and formed into a rectilinear panel the surfaces of which are parallel to the gas flow through the pass, with the tubes disposed in the median plane of the panel, at least one of said tubes extending directly from one end of the panel along the upstream edge of the panel to approximately the midpoint of said edge whereat it is reversely bent within the plane of the panel and in the downstream direction, another of said tubes extending from said one end along the downstream edge of the panel, along the other end and then from said other end along the upstream edge to approximately said midpoint whereat it is reversely bent within the plane of the panel and in the downstream direction.

2. In a steam generator the combination of a furnace, a gas pass leading from the furnace, a steam superheater comprising a plurality of individual tubes having their inlets connected with a common inlet header and their outlets connected with a common outlet header, said tubes having portions thereof formed into a number of panels spaced across the gas pass, the tubes of these panels having portions forming a first single panel upstream of said spaced panels and a second single panel intermediate said spaced panels and said first panel with the tube portions forming these panels being disposed in the median plane of the panels and with the median plane of all the panels being parallel with the gas flow through the gas pass, the upstream panel being located so its leading edge is subjected to radiant heat from the furnace, said tubes being arranged so that the steam flows therethrough from said spaced panels to said first panel and thence to said intermediate panel, the upstream edge of the upstream panel having a different one of said individual tubes extending from opposite ends toward the midpoint of said edge and being reversely bent at approximately said midpoint and in the plane of said panel.

3. In an organization of the type described the combination of a gas pass through which hot combustion gases are conveyed, a tubular superheater disposed in said gas pass for superheating a vapor and including a number of panels composed of a number of individual juxtaposed tubes connected in parallel, said panels being parallel with the gas flow and spaced in the direction of gas flow and being interconnected for serial vapor flow therethrough, the tubes in the several panels being disposed in the median plane of the panel, the upstream edge of the upstream panel having a plurality of said tubes contiguously disposed and extending therealong from each end of the panel to substantially the midpoint of said edge and there being reversely bent in the plane of said panel with said plurality of tubes that extend from one end to approximately said midpoint being different tubes than those extending from said other end to said midpoint.

4. A vapor heater of the tubular panel type comprising

a gas pas sadapted to have hot combustion gases flow therethrough, a plurality of continuous tubes having their inlets connected with an inlet header and their outlets connected with an outlet header, said tubes forming a plurality of panels disposed in and extending transversely of said gas pass, said panels being parallel with the gas flow and spaced longitudinally of said gas flow, said tubes forming the panels in a manner so that the panels are interconnected for serial vapor flow therethrough with the last panel through which the vapor flows including a pair of tubes extending along one end thereof and then being bent to form a portion of said last panel, the tube portions that make up said last panel having generally straight final portions juxtaposed to one another and extending a substantial distance within the panel and projecting from the panel at the end thereof having said pair of tubes extending therealong, a portion of said final tube portions being fabricated of a metal having a coefficient of expansion different from that of the remainder of said panel, said last named portions being independent of the remainder of said panel and free to move relative thereto in a longitudinal direction, said pair of tubes extending along the end of the panel having said final tube portions snugly but slidably disposed therebetween thereby retaining said tube portions within the plane of the panel but allowing them to expand relative to the remainder of the panel.

5. A vapor heater of the tubular type comprising a gas pass adapted to have hot combustion gases flow therethrough, a plurality of tubes having their inlets connected with an inlet header and their outlets connetced with an outlet header, said tubes forming a plurality of panels disposed in and extending transversely of said gas pass, said panels being parallel with the gas flow and spaced longitudinally of the gas flow, the tubes forming the panels so that the panels are interconnected for serial vapor flow therethrough with the last panel through which the vapor flows having a panel spaced upstream thereof and a panel spaced downstream thereof relative to gas flow, the upstream edge of the upstream panel having independent tubes extending therealong from each end of the panel and being reversely bent in the plane of said panel at approximately the midpoint of the said upstream edge, the last panel through which the vapor flows including a pair of tubes extending along one end thereof and then being bent to form a portion of said last panel, the tube portions that make up said last panel having generally straight final portions juxtaposed to one another and extending a substantial distance within the panel and projecting from the panel at the end thereof having said pair of tubes extending therealong, a portion of said final tube portions being fabricated of a material having a coefficient of expansion different from that of the remainder of said panel, said last named portions being independent of the remainder of said panel and free to move relative thereto in a longitudinal direction, said pair of tubes extending along the end of the panel having said final tube portions snugly but slidably disposed therebetween thereby retaining said tube portions within the plane but allowing them to expand relative to the remainder of the panels.

6. A vapor generator including a furnace, a vapor heater disposed to have the stream of hot combustion gases generated in the furnace flow thereover and effective to heat the vapor generated by the vapor generator, said

heater comprising several independent tubes connected in parallel and formed into a panel extending into said gas stream with the median plane of the panel being generally parallel to the direction of flow of said gas stream and with said tubes lying in said median plane, said panel being disposed so the upstream edge thereof is subjected to intense radiant heat from the furnace, said upstream edge of the panel including a different one of said tubes extending therealong from opposite ends thereof to approximately the midpoint of said edge and there being reversely bent in the plane of said panel.

7. A superheater as defined in claim 6 wherein there are a plurality of said panels spaced across the gas pass.

8. A superheater as defined in claim 6 wherein there are also a plurality of said panels spaced longitudinally of the gas pass.

9. A vapor generator including a furnace, a vapor heater disposed to have the stream of hot combustion gases generated in the furnace flow thereover and effective to heat the vapor generated by the vapor generator, said heater comprising several independent tubes connected in parallel and formed into a panel extending into said stream with the median plane of the panel being generally parallel to the direction of flow of said gas stream and with the panel being disposed so the upstream edge thereof is subjected to intense radiant heat from the furnace, said tubes lying in the median plane of the panel, said upstream edge of the panel including a pair of said tubes extending therealong from opposite ends thereof to approximately the midpoint of said edge and there being reversely bent in the plane of said panel, another pair of said tubes immediately behind said first pair with respect to the flow of combustion gases and extending from said opposite ends to approximately said midpoint and likewise being reversely bent and internested with said first mentioned pair.

10. A vapor generator including a furnace, a vapor heater disposed to have the stream of hot combustion gases generated in the furnace flow thereover, said heater comprising several independent tubes connected in parallel for parallel flow therethrough of the vapor generated by the vapor generator and formed into a panel extending into said gas stream with the median plane of the panel being generally parallel to the direction of flow of said gas stream and with the tubes making up the panel lying in said median plane, said panel being disposed so the upstream edge thereof is subjected to intense radiant heat from the furnace, the upstream edge of said panel being made up of a pair of said tubes one of which extends from one end of said edge to approximately the midpoint of said edge and is there bent in the plane of the panel and away from said edge with the other extending from said other end to approximately said midpoint and there is also bent in the plane of the panel and away from said edge.

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