Feb. 13, 1968 E. C. LEWIS ET AL 3,368,532

HIGH TEMPERATURE STEAM HEATERS AND TUBE ARRANGEMENT THEREFOR

Filed Dec. 16, 1965 2 Sheets-Sheet 1

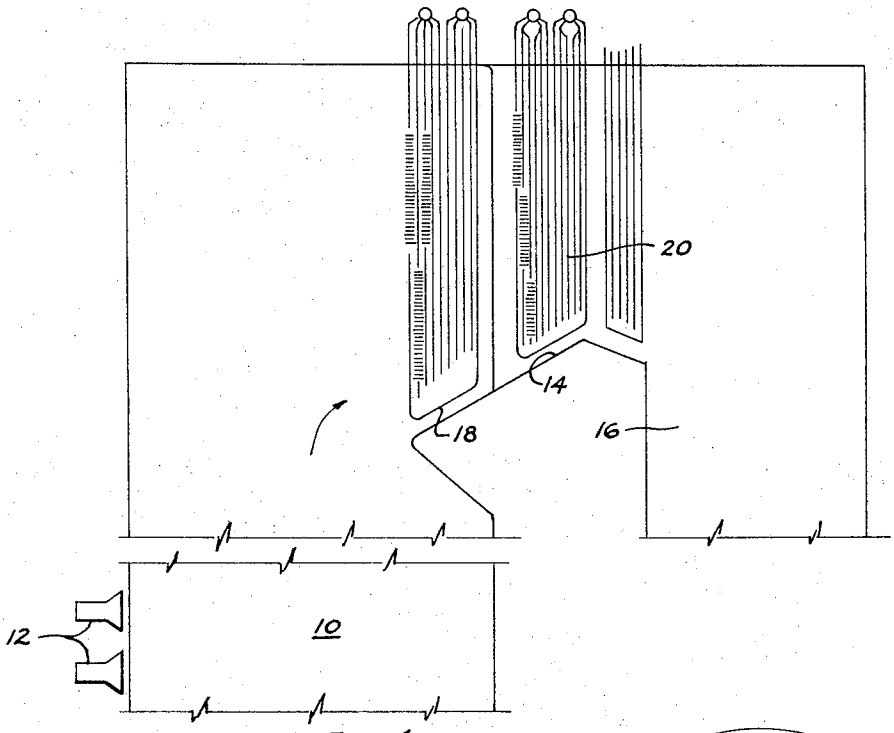


FIG. 1

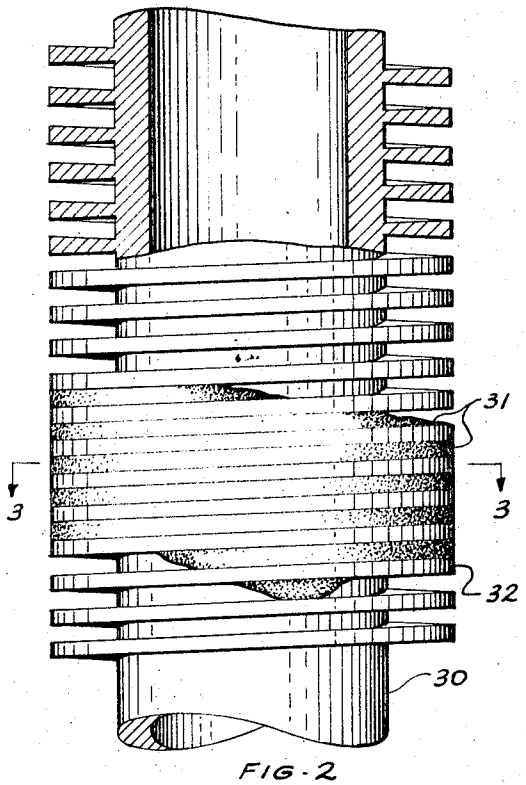


FIG. 2

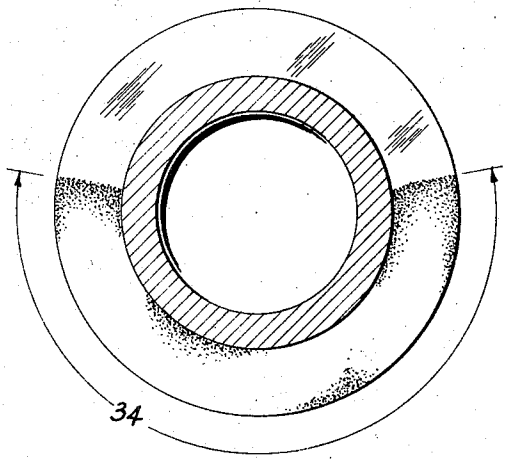


FIG. 3

INVENTORS
EVERETT C. LEWIS
JAMES JONAKIN
BY
Elden H. Luther
ATTORNEY

Feb. 13, 1968 E. C. LEWIS ET AL 3,368,532

HIGH TEMPERATURE STEAM HEATERS AND TUBE ARRANGEMENT THEREFOR

Filed Dec. 16, 1965 2 Sheets-Sheet 2

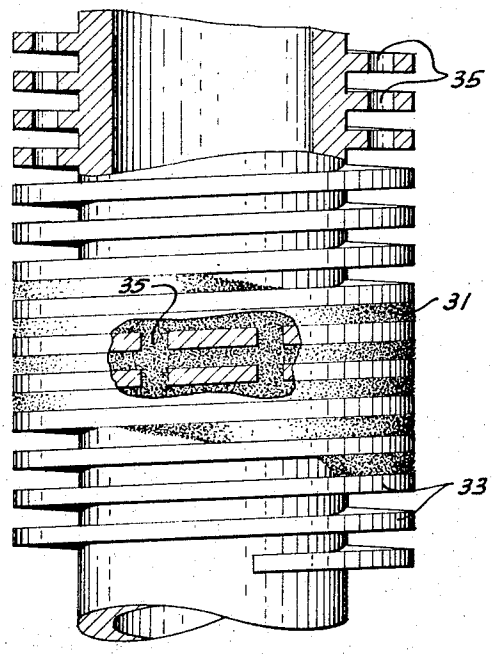


FIG. 4

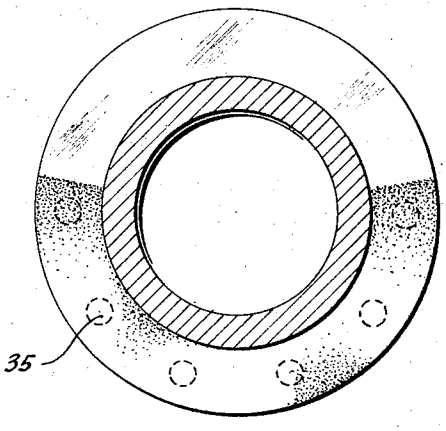


FIG. 5

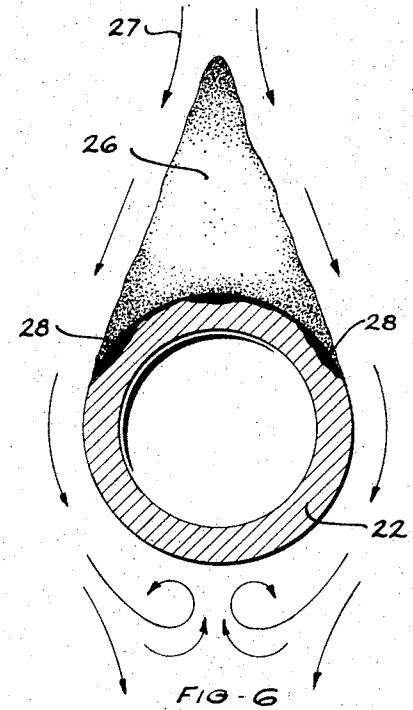


FIG. 6

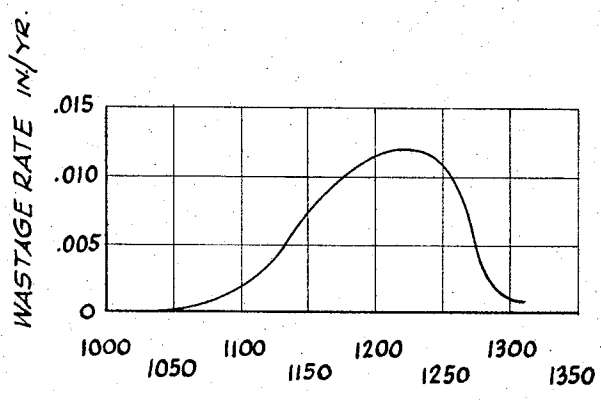


FIG. 7

INVENTORS
EVERETT C. LEWIS
JAMES JONAKIN
BY
Eldon H. Luther
ATTORNEY

United States Patent Office

3,368,532

Patented Feb. 13, 1968

3,368,532

HIGH TEMPERATURE STEAM HEATERS AND TUBE ARRANGEMENT THEREFOR

Everett C. Lewis, Avon, and James Jonakin, Simsbury, Conn., assignors to Combustion Engineering, Inc., Windsor, Conn., a corporation of Delaware

Filed Dec. 16, 1965, Ser. No. 514,299
5 Claims. (Cl. 122—367)

ABSTRACT OF THE DISCLOSURE

A steam heating surface positioned in the combustion gas stream of a coal fired vapor generator. This surface is so disposed that the tube wall temperature would normally be between 1050 and 1300° F. This surface is comprised of tubular members which have radially extending fins and intermediate the fins on the upstream side of the tubes there is disposed a high temperature refractory. The construction of the fins is such as to effectively retain this refractory in place.

This invention relates generally to steam heaters, i.e., reheaters and superheaters as employed with coal fired high temperature steam generating units and has particular relation to an improved steam heater and a tubular construction for use with such steam generators.

In coal fired steam generators producing superheated and reheated steam at high temperatures such as 1000° F. or higher via tubular heat exchangers extending transversely of the combustion gas stream there is experienced corrosion, or more correctly metal wastage, of the tubes or certain portions of the tubes that make up these superheaters and reheaters. The problem is specifically encountered wherein the tube metal temperature is in a range between approximately 1050 and 1300° F., and the problem is confined to the upstream face or region of the tube with relation to gas flow. It is on this portion that ash deposit builds up and it is believed that this metal wastage is caused by molten alkali-iron-sulphur compounds in this deposit with the compounds being molten generally in the previously mentioned 1050 to 1300° F. range. Thus if the metal temperature can be maintained above or below this range, this metal wastage due to ash deposits can be eliminated.

One solution to this problem that has been utilized in the past is to provide these particular regions of the superheater tubes affected by this corrosion with stainless steel shields. These shields cover the particular region of the tube subjected to this metal wastage (i.e. the upstream region) and are held in place by bands that extend around the rear portion of the tube. These stainless steel shields are not subject to the metal wastage problem because they are in relatively poor heat exchange relation with the tube so that they operate at a temperature substantially higher than that of the tube and thus are above the critical 1300° F. limit. This has proved to be a troublesome and costly solution however, since it is difficult to maintain these shields in place and the shields themselves are relatively expensive.

The present invention provides an improved solution to this problem and in accordance with the invention there is provided a tubular heat exchange construction for use in the portions of the superheaters and reheaters subjected to this metal wastage with the tubular construction having laterally extending fins in closely spaced relation. The upstream portion of the tube with relation to gas flow has a high temperature refractory packed intermediate the fins with the outer extremity of the fin extending beyond or flush with the refractory outer surface. The rear side of the tube with relation to gas flow has no refractory but does have fins.

With this arrangement the metal wastage heretofore experienced is eliminated and the operation of the superheater, and particularly this heat exchange tubular element therein, is improved.

Accordingly it is an object of this invention to provide an improved superheater and reheater arrangement for coal fired high temperature steam generators.

A further object of this invention is to provide such an improved superheater and reheater arrangement utilizing a particular tubular construction in the high temperature portion thereof to prevent metal wastage due to slag deposit on the upstream portion of the tube relative to gas flow.

A still further object of the invention is to provide an improved heat exchange tube of finned construction for use in the high temperature sections of superheaters and reheaters of coal fired units.

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 inventive organization 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 drawings wherein:

FIG. 1 is a vertical sectional view fragmentary in nature, disclosing a steam generator utilizing the improvement of the present invention;

FIG. 2 is a detailed sectional view of a portion of the improved heat exchange tube which is utilized in the superheater and reheater of the generator of FIG. 1 and which view shows the details of construction of the invention;

FIG. 3 is a sectional view taken generally along line 3—3 of FIG. 2;

FIGS. 4 and 5 are views similar to those of FIGS. 2 and 3 but showing a modified construction;

FIG. 6 is a diagrammatic representation of a superheater or reheater tube employed in a coal fired steam generator and depicting the way in which ash deposits build up on the upstream surface of the tube; and

FIG. 7 is a graphical representation showing the wastage of the tube metal in coal fired steam generators wherein the metal is within the temperature range of approximately 1050 to 1300° F.

Referring now to the drawings wherein like reference characters are used throughout to designate like elements, the illustrative steam generator as disclosed in FIG. 1 comprises a furnace **10** into which pulverized coal is introduced and burned through the burners **12**. Steam is produced by this steam generator and for this purpose the furnace may be lined with heat exchange tubes through which the fluid medium of the steam generator is conveyed. The combustion gases pass up through the furnace **10** and thence through the horizontal gas pass **14** and the vertical gas pass **16**. In the illustrative arrangement there is disclosed the finishing stage **18** of the superheater and the finishing stage **20** of the reheater. These finishing

stages are comprised of tubular elements that are formed into panels with the panels being in spaced relation across the gas pass **14** such that the combustion gases pass through and over the spaced panels. In each of the finishing stages **18** and **20** the steam passes down through the tubes at the rear portion of the panels and then up through the tubes at the front portion of the panels. Thus the finishing leg of each of the tubes in these panels, and wherein the highest steam temperature is encountered, is at the front portion of the panels; and in the illustrative arrangement the first four tubular elements in each panel are the finishing legs. When a steam generator produces 1000° F. or higher steam, these final superheater legs will have a metal temperature in the 1050 to 1300° F. range and thus be subjected to metal wastage caused by ash deposits.

FIG. 6 indicates how the ash deposit builds up on the upstream side of the tubes with regard to gas flow. In this illustration the tube is identified as **22**, and the ash deposit as **26** with the direction of gas flow indicated by arrows **27**. When the tube metal is in the 1050 to 1300° F. range, serious metal wastage occurs throughout the upstream region of the tube upon which the ash deposit is disposed. In certain instances this metal wastage has been particularly severe generally at the location identified as **28**. The curve of FIG. 5 graphically illustrates the metal wastage that has been experienced in a coal fired unit using Illinois coal with stainless steel tubing. It has been found that this metal wastage occurs with any acceptable metals usable for superheater construction.

In accordance with the present invention the tubular portions of the steam heater which would be operating in the 1050 to 1300° F. metal temperature range are of a particular construction whereby the problem of metal wastage is overcome. This construction is disclosed in detail in FIGS. 2 and 3 wherein the tube identified as **30** is provided with laterally extending spiral fins **32** with these fins being in relatively closely spaced relation. In the preferred embodiment of FIG. 2 the fins have a keystone transverse configuration such that they increase in thickness from their root where they join the tube to their outer extremity thereby providing a space between adjacent fins which decreases in width outwardly of the tube. The upstream side of the tube with relation to gas flow is provided with a coating of high temperature refractory **31** with this refractory being placed between the fins and in engagement with the tube. The refractory may be initially applied so that it extends somewhat beyond the outer extremity of the fins with this perhaps being the easiest manner in packing refractory in place. Alternatively, the refractory may be applied so that it is either flush with the extremity of the fin or the fin may extend somewhat beyond the refractory. If the refractory is packed so that it extends beyond the fin, after a relatively short period of operation, sufficient of the refractory will be worn away so that the extremity of the fins will be either flush with the refractory or extend somewhat beyond the refractory. The refractory is not placed all the way around the tube, and it has been found that satisfactory operation is obtained if the arc **34** through which the refractory extends is approximately 200° F. As a result of thus placing the refractory about the upstream region of the tube surface, the ash deposit does not come in contact with this tube surface. Because the refractory is a relatively poor heat transfer medium, the portion of the fins that are exposed to the combustion gas stream on the upstream side of the tube are elevated in temperature and are at a temperature above the critical 1300° F. range. Therefore, the fins are not subject to this metal wastage problem Furthermore, improved performance is obtained with this tubular heat exchange arrangement because a more uniform heat pickup throughout the entire circumference of the tube is realized. This is because the fins extend all the way around the tube and the fins at the rear portion of the tube do not have

refractory disposed therebetween. This increase in surface provides an increase in heat pickup on the rear side of the tube which is otherwise generally substantially below that of the front portion of the tube.

The refractory is applied to the finned tube in a paste-like or slurry form and is permitted to harden intermediate the fins. Because the area or space within which the refractory is placed progressively decreases in width outwardly from the tube, the refractory, once hardened, is firmly held intermediate the fins and cannot be easily removed. With this construction satisfactory results have been obtained even at locations in close proximity to soot blowers and utilizing an alumina silica base refractory bonding mortar which has the following analysis:

Chemical analysis

SiO_2	28.7
Al_2O_3	32.3
CaO	0.1
MgO	7.2
Na_2O	0.2
Cr_2O_3	15.9
FeO	8.6
Ign. loss	6.0

In lieu of the particular fin construction disclosed in FIGS. 2 and 3 the arrangement depicted in FIGS. 4 and 5 may be u ilized. In this arrangement the fins **34** are not of keystone transverse configuration but rather have parallel side walls. However, the fin portion disposed on the upstream region of the tube has openings **35** provided therein. The refractory **31** extends radially beyond these openings and fills the openings such that it is effectively locked in place intermediate the fins. With this arrangement essentially the same operating characteristics are obtained although here the elevated temperature at the outer region of the fin may be somewhat higher because of the refractory filled openings.

While we have illustrated and described a preferred embodiment of our invention 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, we therefore do not wish to be limited to the precise details set forth but desire to avail ourselves of such changes as fall within the purview of our invention.

What is claimed is:

1. A tubular arrangement for use in steam heating tubes disposed in a combustion gas stream generated by the burning of coal comprising a tubular element adapted to extend transversely of said combustion gas stream, laterally disposed fins extending about said element in closely spaced relation, the upstream region of said element having disposed thereon and retained intermediate said fins a high temperature refractory, and the downstream region of said element being free of refractory.

2. The organization of claim **1** wherein the lateral extremity of said fins extends beyond said refractory.

3. In combination a furnace into which coal is introduced and burned thereby creating a combustion gas stream, a tubular heat exchange member disposed within said stream and carrying steam such that the tube metal temperature would normally lie between the range of 1050 and 1300° F., said tube having laterally extending fins disposed thereon and extending thereabout in closely spaced relation, a high temperature refractory disposed on the upstream region of said tubes intermediate said fins effective to prevent contact of the gas stream with the tube wall at this region and effective to cause the extremities of the fins to be heated to a temperature above 1300° F., said fins being constructed and arranged so as to retain said refractory therebetween.

4. The organization of claim **3** wherein said fins are of keystone transverse configuration with the thickness of said fin progressively increasing laterally outward from the tube.

5. A heat exchange member comprising in combination a tube, spiral fins provided on the tube in closely spaced relation, said fins increasing in thickness outwardly of the tube, a predetermined region of the tube extending through an arc of at least 180° being covered by a high temperature refractory with said refractory being disposed intermediate said fins and in engagement with the tube and with the remainder of said tube circumference being free of refractory.

References Cited

UNITED STATES PATENTS

2,145,244	1/1939	Berg et al.	
2,146,352	2/1939	Rohrer	165—133 X
3,203,404	8/1965	Miller.	

CHARLES J. MYHRE, *Primary Examiner.*