Aug. 30, 1966 V. Z. CARACRISTI ET AL 3,269,366

VAPOR GENERATOR FURNACE WALL DESLAGGER

Filed Oct. 20, 1964 2 Sheets-Sheet 1

FIG. 1

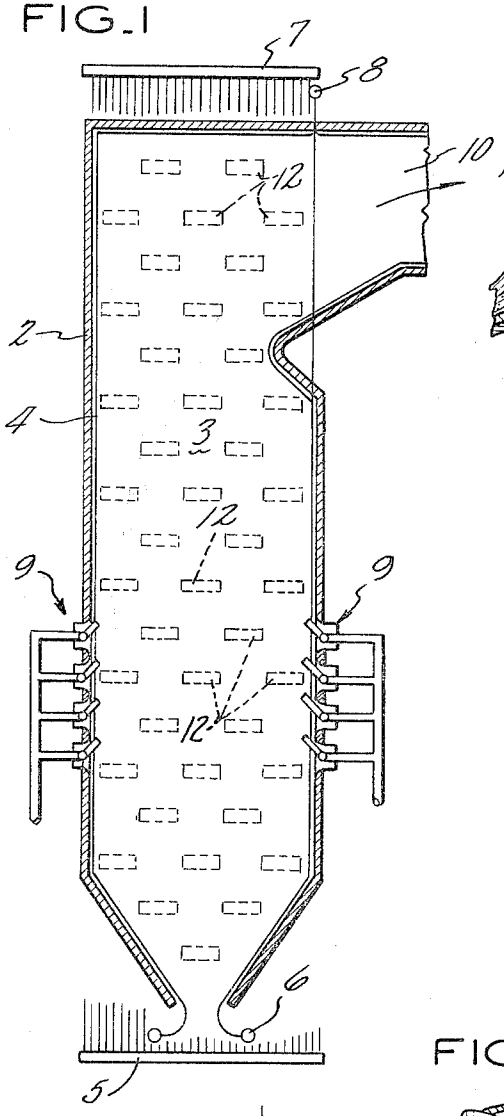


FIG. 2

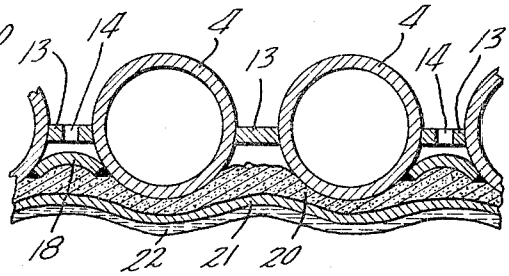


FIG. 3

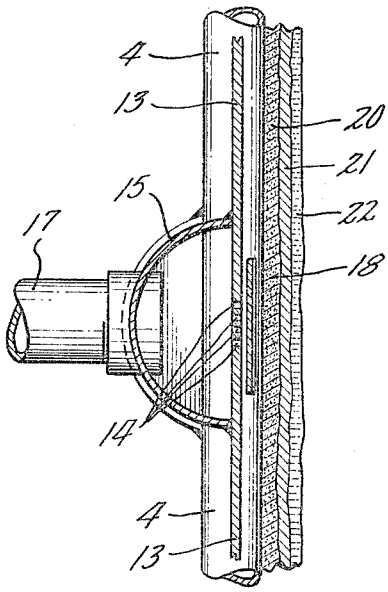
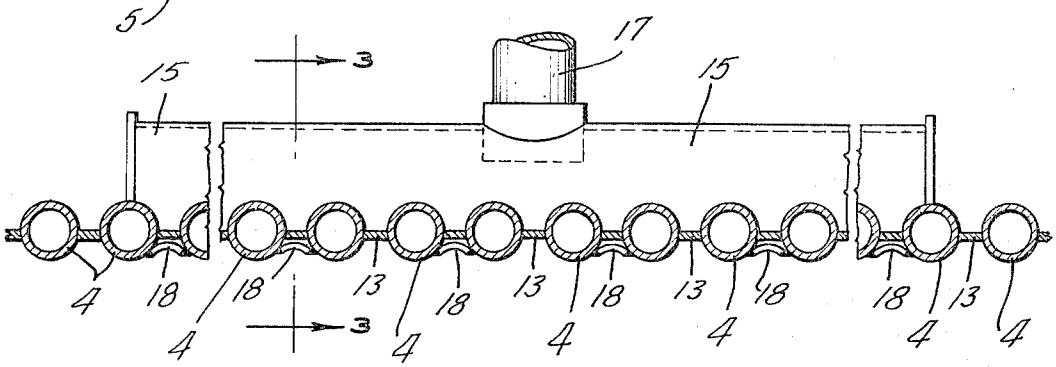


FIG. 4



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VAPOR GENERATOR FURNACE WALL DESLAGGER

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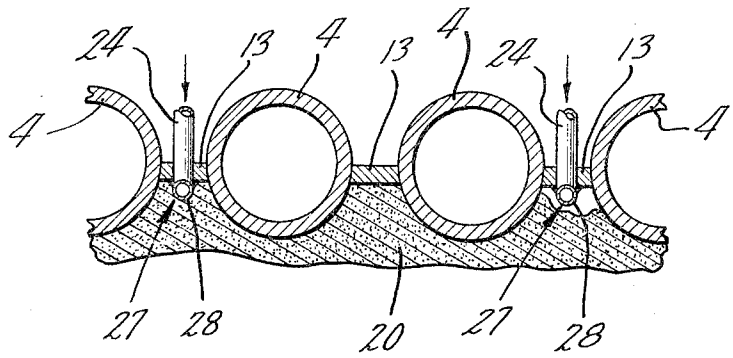
FIG_5



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3,269,366

VAPOR GENERATOR FURNACE WALL DESLAGGER

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Our invention relates to furnace wall ash and slag removal and in particular to a method and apparatus which may be used in a high temperature zone of a vapor generator.

When an ash bearing fuel is burned in the furnace of a vapor generator a portion of the ash particles in the fuel deposit on the furnace wall tubes. This ash tends to build up on these walls forming a layer of ash and slag. This layer insulates the furnace walls, which disturbs the balance of heat absorption throughout the unit and also has a detrimental effect on the efficiency of the vapor generator.

Throughout the furnace the metal temperature of the wall tubing is much lower than any known ash softening temperature and consequently the ash adjacent to the tube surface must be solid. Conversely, the gas temperatures within the furnace generally exceed the ash softening temperature and the temperatures within the burner zone of an ordinary vapor generator always exceed the ash softening temperature. While the face of the slag layer which is adjacent the tubing approaches the temperature of the furnace wall tubing, the other face of the slag layer which is adjacent the furnace cavity approaches the gas temperature. Therefore, running slag can be anticipated throughout the furnace if the ash layer is permitted to build up and particularly in the burner zone, where there tends to be a very high heat absorption rate in the furnace wall tubing.

The method by which this ash layer forms should also be considered. The ash particles as they strike the wall surface are in a molten state and freeze as soon as they strike the walls. This continues until there is an ash buildup comprised of lightly bonded ash particles. At this point the ash may relatively easily be removed. As this becomes thicker the temperature of the outer layer increases so that the new ash particles impinging thereon are cooled less slowly, become sticky, and tend to form a sintered or vitrified layer. As additional ash collects on the surface, the surface temperature becomes high enough to permit the ash to liquefy in the form of fluid slag. Since most coal ash is a mechanical mixture of many compounds, the fluid temperature of the ash is not well defined and the wall deposit exists as a layer ranging from loosely bonded ash at the tube surface through the vitrified layer of solid ash, and then through a range of viscous semi-fluid to fluid slag on the outer surface which is immediately adjacent to the furnace cavity.

Where high heat absorption rates exist, particularly in the burner zone, there is a great tendency for the formation of this vitrified layer along with the fluid outer layer. This is so because at the high heat absorption rate the outer surface of the slag reaches the fluid temperature with a relatively thin insulating layer of ash.

Fixed soot blowers have been used which are located on the furnace wall surface as illustrated in U.S. Patent No. 1,732,429. Fixed soot blowers have also been used on superheater tubes as illustrated in U.S. Patent No. 1,930,782 as well as on boiler banks as illustrated in U.S. Patent Nos. 1,992,336 and 2,027,495.

Modern units are designed with very high release rates, high gas temperatures and high absorption rates. In a zone of high heat absorption the fixed deslaggers as used in the past are not adequately cooled and therefore rapidly

corrode or burn away. The use of fixed soot blowers in the furnace walls has thus given way to the use of retractable rotating type wall blowers such as illustrated in U.S. Patent No. 2,662,241. These soot blowers operate by inserting a nozzle within the wall so that it blows from a position 1½ to 2 inches on the furnace side of the crown of the furnace wall tube, and in a direction almost parallel to the furnace wall. The jet of cleaning medium tends to blow against and across the slag layer to remove the slag.

A soot blower of this type is very effective on the the loosely bonded ash particles which comprise the earliest formation in the burner zone and in lower heat absorption zones comprise the total formation. However when the vitrified layer forms, the efficiency of these soot blowers decreases. If the soot blower is able to penetrate the vitrified layer, it may then operate on the edge of the remaining slag layer so that it is peeled back by the action of the jet which works on the remaining edge of the existing slag layer. The nozzle so inserted is rotated throughout 360 degrees to effect cleaning of the general furnace wall area.

According to our invention a fixed soot blower so arranged that it may be adequately cooled by the furnace wall tubes is operative to effectively remove dry ash from the furnace wall tubes. If for any reason the wall is not cleaned before a sticky layer of ash is formed, a gaseous cleaning medium is introduced intermediate the tube surface and the slag. The viscous semi-fluid slag contains the pressure while the cleaning medium expands, ballooning the slag from the wall by placing a force on the slag perpendicular to the furnace wall. The dry ash layer is put under tension causing it to rupture and separate from the wall. Since the soot blower is still in service, additional cleaning of the dry ash remaining is accomplished.

It is an object of our invention to provide an effective furnace wall soot blower which has no moving parts that need be subjected to high furnace temperatures.

It is a further object to provide a furnace wall soot blower which may be inserted in a furnace wall without a requirement for extensive outside fittings in that area in which it is located whereby interference with gas ducts, burner piping, buckstays, and other external equipment, can be avoided.

It is a further object to provide a furnace wall soot blower which may be placed in the burner zone of a furnace without interfering with burner operation.

It is a further object of this invention to provide a furnace wall soot blower which may be made gas-tight since there is no relative movement between the furnace wall soot blower and the furnace wall structure.

It is a further object to provide a furnace wall soot blower which is cooled and shielded by the furnace wall tubing.

It is a further object to provide a soot blower which is effective in removing dry ash and is also effective in removing wet slag.

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:

FIGURE 1 is a side elevation of a typical vapor generator showing groupings of fixed furnace wall soot blowers in various sections of the furnace;

FIGURE 2 is a plan view through the furnace wall tubes showing a detail of the furnace wall soot blower;

FIGURE 3 is a side elevation through the furnace wall tubes illustrating the furnace wall soot blower;

FIGURE 4 is a plane view through a larger section of the furnace wall tubes showing a plurality of soot blowers along with a scleaining medium supply header; and

FIGURE 5 is a sectional plan view through the furnace wall tubes showing a detail of an alternate fixed wall soot blower.

In the illustration of FIGURE 1 the walls **2** of the furnace **3** are lined with furnace wall tubes **4**. These tubes convey water to be heated from the lower headers **5** and **6** the upper headers **7** and **8** from which steam is released and conveyed through additional steam heating surface (not shown). Coal is introduced through burners **9** with combustion occurring in the furnace **3** and the gas passing out to exhaust through the flue **10**.

Located in the furnace wall throughout the furnace are a plurality of furnace wall deslaggers at each location **12**. Although deslaggers of this type may be located anywhere in the furnace they are particularly useful in areas of very high heat absorption rates.

FIGURES 2 and 3 show these deslaggers in detail. The furnace will tubes **4** are joined by welded webs **13**. These webs run the length of the furnace wall tubes, and are approximately ¼ inch thick and ⅜ inch wide. At the location of the deslagger four 5/16 inch holes **14** are drilled through the web. These holes are spaced about ⅜ inch apart. Manifold **15** is securely welded to the tubes and fins, with supply pipe **17** connected so that air may be introduced into the manifold. Air thus introduced into the manifold passes through the drilled holes in the web towards the furnace. Deflector plate **18** is located directly in front of these holes so that the air stream is deflected vertically upward and downward. The orifice may be of any desired shape, such as a slot, rather than in the form of drilled holes **14**.

The deflector plate **18**, the tube **4**, and the web **13** cooperate to form a nozzle projecting the air along the wall surface. When a jet stream is produced by a conventional nozzle, eddy currents form at the nozzle outlet. In a furnace these eddy currents sweep ash into the jet stream, so that they are projected at high velocity against the tubes during soot blower operation. This results in considerable erosion and tube damage immediately adjacent the conventional nozzle. Since the webs and tubes continue from the furnace wall surface to form a portion of our nozzle, there is no opportunity for eddy currents to form on the wall side of the jet, sweeping ash into the air stream. Consequently, erosion in this area is substantially diminished.

The furnace wall tubes **2**, the webs **13** and the deflector plate **18** are exposed to the furnace gases at all times. These elements are cooled only by the flow of water being heated through the tubes **4**. The web **13** while receiving full radiation from the furnace directly in front of the web, is shielded by the tubes with regard to oblique radiation. The web being continuously welded to these tubes is cooled by the fluid passing therethrough since the heat may be readily conducted from the web **13** through the tube **4** to the water being heated inside the tube.

The deflector **18** is also located so as to be partially shielded from furnace radiation thereby decreasing the heat which is absorbed in the deflector plate. This plate is welded throughout its length to the immediately adjacent tubes. Heat absorbed in the deflector plate is thereby conducted directly into the tube and from there to the water being heated, so that the fin is kept cool and low alloy steel may be used. The use of high alloy deflectors on austhenitic ferritic tubes is not generally recommended. Inasmuch as many of these materials expand about one-third more than ferritic material, there is a tendency of the deflector to expand relative to the tube when both are raised to a common high temperature. This differential expansion leads to high stress at the weld location which will start cracking, with consequent tube failure at this point. It is therefore extremely important that this fin be so located that it may be kept cool since the use of a high alloy steel at this location is not acceptable.

Even when the same material is used for the deflector which is used for the tubes and webs, some differential expansion will occur. The deflector being somewhat less shielded than the webs will operate at a slightly higher temperature and will tend to expand relative to the webs. When air is injected for soot blowing, the deflector will be suddenly cooled with high velocity air impinged against it. Provisions should be made for some flexibility in the deflector, and it is therefore recommended that the deflector **18** be arcuate as illustrated in FIGURE 2.

During operation of the vapor generator ash from the fuel collects on the furnace walls forming a layer of loosely bonded ash particles **20**. In some areas of the furnace, if the loose ash is not removed, a layer of vertified ash **21** and a layer of molten slag **22** forms.

FIGURE 4 shows an arrangement wherein the manifold is about 3½ feet wide so that it supplies a plurality of fixed furnace wall soot blowers. When soot blowing action is desired air is introduced through supply pipe **17** and manifold **15**. The air passes through the drilled holes or orifices **14** in the web and is deflected by the deflector **18** so that it passes at high velocity along the surface of the furnace wall. This air is effective to remove soot and ash from the furnace wall surface in the general area of the soot blower. This soot blower need operate for only a very short period of time, such as one second, and is therefore well adapted for puff blowing operation, thereby keeping the walls clean with very little air consumption. The deflector in this embodiment is so arranged that air is introduced to the furnace in both the upward and downward direction. It has been found that, even when the wall is heavily slagged, the cooling effect of the deflector solidifies the slag, so that it does not run between the deflector and the web plugging it up. Although the deslagger could be constructed so that the air is introduced only in one of these directions, introductions in both directions obviously is effective to clean more of the furnace wall surface.

If for any reason timely removal of the dry ash is not accomplished, our soot blower is extremely effective in removing the layer of molten slag which develops. This slag starts building up on some portions of the various tubes and gradually increases until a generally contiguous layer in a particular section of the furnace wall is formed. When such a contiguous layer is formed in the area of the deslagger, air is introduced through the manifold. This air passes through the drilled holes or orifices **14** in the web and is deflected by the deflector **18** so that it is introduced intermediate the tube surface and the slag layer. The air places a force on the slag layer perpendicular to the wall and forces it out from the wall. The viscous layer of slag seals the air in the space between the tubes and the slag so that this slag tends to balloon out from the wall with the introduced air continuing to spread out underneath the slag and continuing to exert an outward force on the slag until this slag ruptures and pops out into the furnace. Very effective results have been obtained with an introduction of air to a manifold supplying ten deslaggers by supplying 8000 c.f.m. of air measured at standard conditions for a period of about one second. This is equivalent to about 7 cubic feet of air at standard conditions for each deslagger. The expansion of the air underneath the slag is achieved not only by the quantity which is forced under, but also due to the expansion of the air as it receives heat from the tubes and slag, after introduction intermediate the tubes and the slag.

It is important that this air be deflected in a direction generally parallel to the furnace wall surface rather than

being injected with a substantial velocity component perpendicular to the wall surface. Obviously removal of dry ash from the wall surfaces can only be accomplished by flow of air along the wall surface. Introduction of the air perpendicular to the wall in the event of a wet slag coating will cause the air jet to break through the slag locally, and the only effect will be to break a small hole in the slag, rather than spread the air out under a relatively large area of slag, thus imposing a uniform force thereon so that a large section of furnace wall area may be cleaned. Furthermore as the slag builds up on the walls of the tube lined furnace, obviously a thicker layer occurs intermediate the tubes than occurs at the crown of the tubes. It is important that the air be introduced so that it may be expanded behind the slag layer with precautions being taken to avoid a premature breakthrough of the air. The air should therefore be introduced at this thickest part of the slag layer which has the greatest strength in a location that is behind, i.e., away from the furnace side of, the crown of the tubes. It has further been found that operation of the furnace wall deslaggers after the sticky layer has formed, but before a contiguous layer is formed, is ineffective since this contiguous layer is essential to the retention of the air for a short period of time. Small holes in the slag layer may be present without being particularly detrimental since the air cannot escape through these rapidly enough to destroy the effectiveness of the deslagger.

The deflector in this embodiment is arranged so that air is introduced to the furnace in both the upward and downward direction. Although the deslagger could be constructed so that air was introduced in only one of these directions, introduction in both directions gives superior performance, and it is found that the cooling effect of the deflector solidifies the slag so that it does not run between the deflector and the web plugging it up.

As illustrated in FIGURE 4 a single manifold supplies a plurality of furnace wall soot blowers. The resistance to air flow from the manifold to the furnace includes the resistance through the orifices **14** in addition to that of the vertical flow portion through the soot blower and that imposed by any ash or slag layer which may be covering the soot blower. In the event that some of the soot blowers are covered with slag while others are clean, provision should be made to balance the flow of the air under such adverse conditions. The flow area through the orifies **14** is selected so as to be less than the flow area intermediate the web and the deflector considering, of course, that the air may flow both upwards and downwards between the deflector and the web. By putting a major portion of the pressure drop in the orifices **14** generally uniform air flow is obtained to the various deslaggers even under adverse slagging conditions.

The location of the manifold as illustrated in FIGURE 1 is similar to that used in an actual test installation. The manifolds used covered an area about 1¾ feet wide and were placed so that the deslaggers were 6 feet apart in elevation. Each of these deslagger groupings was found to be quite effective in removing ash and slag for at least the 6 foot section including the 3 feet above and below each of the deslagger manifolds.

Although the introduction of gaseous cleaning medium between the tubes and the slag layer is required when the wet slag layer is to be removed, it is not essential that the cleaning medium be in the gaseous state initially. Water could be introduced intermediate the tubes and slag layer which would then be heated forming steam, thereby effecting the introduction of a gaseous medium intermediate the slag layer and the tubes.

FIGURE 5 illustrates an alternate method of constructing our fixed furnace wall soot blower. A T **27** is installed through the web **13** with the branch **24** passing through the web with the run **28** being parallel to the furnace wall tubes **4**. The T is inserted so that the run

of the T is tight against the web **13**. The run of the T is then securely welded throughout its length to the web **13** or the tube **4** on both sides. This construction gives us an apparatus which is similar to the previous embodiment. The entire structure is securely welded to the web or tube so that heat is effectively conducted from the T. This structure also has effectively an arcuate baffle which is flexible and capable of absorbing relative expansion between the outer surface of the T and the web to which the T is welded. The run of the T should be limited to not more than 2 or 3 inches in length since nothing is gained with a long run of T and additional stress would be built up near the ends of the welds if a long T were used.

All parts of the furnace soot blower system which are exposed to the hot furnace gases are fixed. We therefore have no problem with maintenance of moving parts which are subjected to the furnace radiation, the only moving part being the valve which regulates the flow of air and which is located well outside the furnace. These fixed parts which comprise the soot blower are also free from high temperature oxidation problems since they consist only of a short web or deflector plate which is securely welded to the tubes, and shielded from the full effect of furnace radiation. The tubes therefore are very effective in cooling this part thus avoiding any high temperature problem.

Since no equipment is required in the area of the soot blower to remove a nozzle or operate it in any manner, no outside fittings are required in this zone. The only requirement is the air supply pipe which must run to the manifold. These soot blowers are therefore particularly well adapted to the construction of a vapor generator in any area where there is interference problems with external items such as burner piping, the wind box or buckstays.

Also due to the fact that there are no moving parts in the deslagger it may be conveniently wilded so as to form a gas-tight seal. The sealing boxes and aspirators which are required for a retractable type soot blower are not required, making this deslagger particularly useful for use on pressurized furnaces.

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:

1. A furnace structure and apparatus for removing ash from the walls thereof comprising means for burning an ash bearing fuel within the furnace; a plurality of tubes lining a wall of said furnace, the axes of said tubes forming a first common plane; the furnace side of said tubes forming a second plane; means for intermittently introducing a gaseous cleaning medium intermediate adjacent tubes; and means for directing the cleaning medium in a direction essentially parallel to the tubes lining the furnace wall being cleaned, said means for directing the cleaning medium being substantially at a location outwardly of the second plane from the furnace.

2. A furnace structure and apparatus for removing slag from the walls thereof comprising: means for burning an ash bearing fuel within the furnace; a plurality of tubes lining a wall of said furnace whereby a contiguous slag layer forms on the furnace side of the tube lined furnace wall the axes of said tubes forming a first common plane; the furnace side of said tubes forming a second plane; means for introducing a gaseous cleaning medium at a preselected location in a direction essentially parallel to the tubes lining the furnace wall being cleaned at a location intermediate adjacent tubes and outwardly of the

second plane from the furnace; and means for intermittently effecting such introduction.

3. In a vapor generator furnace having means for burning an ash bearing fuel therein and tubes lining the walls of said furnace whereby a contiguous ash layer forms on said walls, an apparatus for removing the ash comprising: means for introducing a gaseous cleaning medium between adjacent tubes in a direction essentially perpendicular to said wall; and baffle means for deflecting said gaseous medium essentially parallel to said furnace wall, said baffle being in welded contract with said adjacent tubes throughout a major portion of its length.

4. In a vapor generator furnace having tubes lining the walls of said furnace and burning an ash bearing fuel within said furnace whereby ash collects on the tube lined walls, an appartus for removing the ash comprising: means for introducing gaseous cleaning medium between adjacent tubes in a direction essentially perpendicular to a wall at a preselected velocity; and means for deflecting the flow of the cleaning medium in a direction essentially parallel to the wall at a lower velocity and at a location intermediate the adjacent tubes.

5. In a vapor generator furnace having means for burning an ash bearing fuel therein and tubular surface lining the walls of said furnace with adjacent tubes being joined by welded fins, at least one of said fins having an orifice therein, an apparatus for removing ash from said walls comprising: means for introducing cleaning fluid to the furnace through the orifice in the fin; a deflector connecting adjacent tubes and located directly in front of said orifice operative to deflect the cleaning medium in a direction essentially parallel to the furnace wall.

6. An apparatus as in claim 5 wherein said deflector is an arcuate baffle spanning between the adjacent tubes.

7. In a vapor generator furnace having means for burning an ash bearing fuel therein and tubular surface lining the walls of said furnace with adjacent tubes being joined by welded webs, said tubes and webs comprising pressure parts, at least one of said webs having an orifice therein, an apparatus for removing ash from said walls comprising: means for introducing cleaning fluid to the furnace through the orifice; a deflector welded in good heat exchange contact with said pressure parts and located directly in front of said orifice operative to deflect the cleaning medium in a direction essentially parallel to the furnace wall.

8. A furnace structure and apparatus for removing ash from the walls thereof comprising: means for burning an ash bearing fuel within the furnace; a plurality of tubes lining a wall of said furnace in the form of a web wall whereby ash collects on the furnace side of the tube lined furnace wall, the axes of said tubes forming a first common plane, the furnace side of said tubes forming a second plane; a nozzle for introducing a gaseous cleaning medium at a preselected location in a direction essentially parallel to the furnace wall being cleaned at a location intermediate adjacent tubes, and intermediate said first and second planes, said nozzle having a furnace side and a wall side, the wall side of the nozzle blending into the wall being cleaned so that cleaning medium flowing out of the nozzle does not form eddy currents on the wall side of the stream of cleaning medium leaving the nozzle.

9. In a vapor generator furnace having tubes lining the walls of said furnace, the axes of the tubes lining a wall forming a first plane, the furnace side of the tubes forming a second plane, and means for burning an ash bearing fuel within said furnace whereby a layer of ash forms on the tube lined walls, and an apparatus for removing ash comprising: a plurality of fixed soot blowers, each including means for introducing a gaseous cleaning medium intermediate adjacent tubes in a direction essentially parallel to the tubes of the furnace wall being cleaned, and at a location outwardly from the furnace of said second plane; said soot blowers positioned transversely to the longitudinal axis of the tubes and connected to a common header supplying cleaning medium to all of these soot blowers.

10. An apparatus as in claim 9 including a flow restrictor at the entrance to each soot blower whereby the flow between parallel soot blowers may be essentially balanced.

11. In a vapor generator having a furnace and tubes lining the walls of said furnace, the axes of the tubes lining a wall forming a first plane, the furnace side of the tubes forming a second plane, the method of maintaining the cleanliness of the furnace walls comprising: burning an ash bearing fuel within said furnace so that slag forms on the tube lined furnace walls, introducing intermediate the slag layer and the furnace wall to which the slag is bound a gaseous cleaning medium in a direction essentially parallel to the tubes lining the furnace wall at a location outwardly of said first plane, so that the cleaning medium expands underneath the slag layer lifting the slag layer away from the furnace wall.

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CHARLES J. MYHRE, *Primary Examiner.*