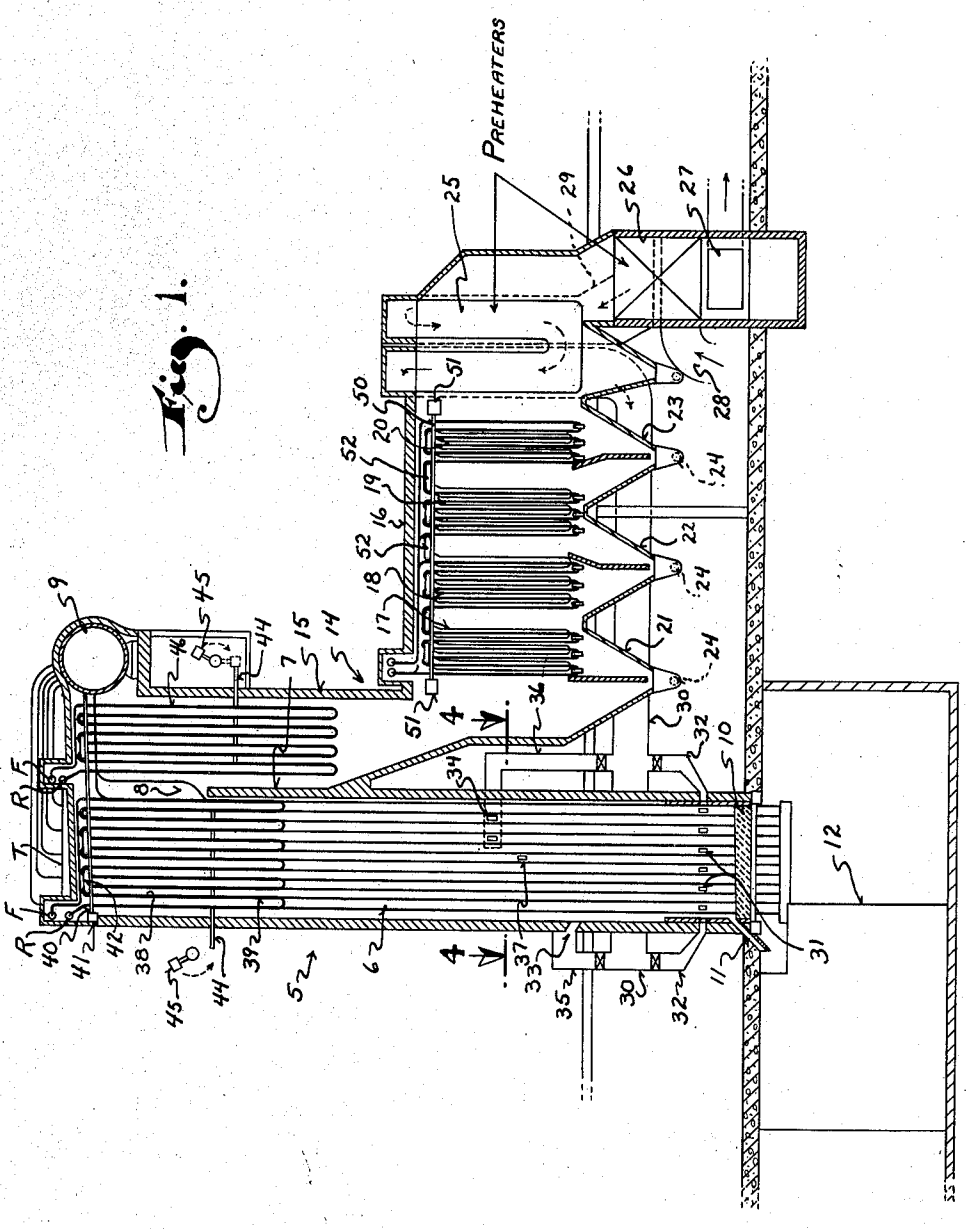
May 1, 1951 D. DALIN 2,550,676

COMBINED WASTE HEAT BOILER AND CHEMICAL RECOVERY UNIT

Filed Oct. 17, 1945 2 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

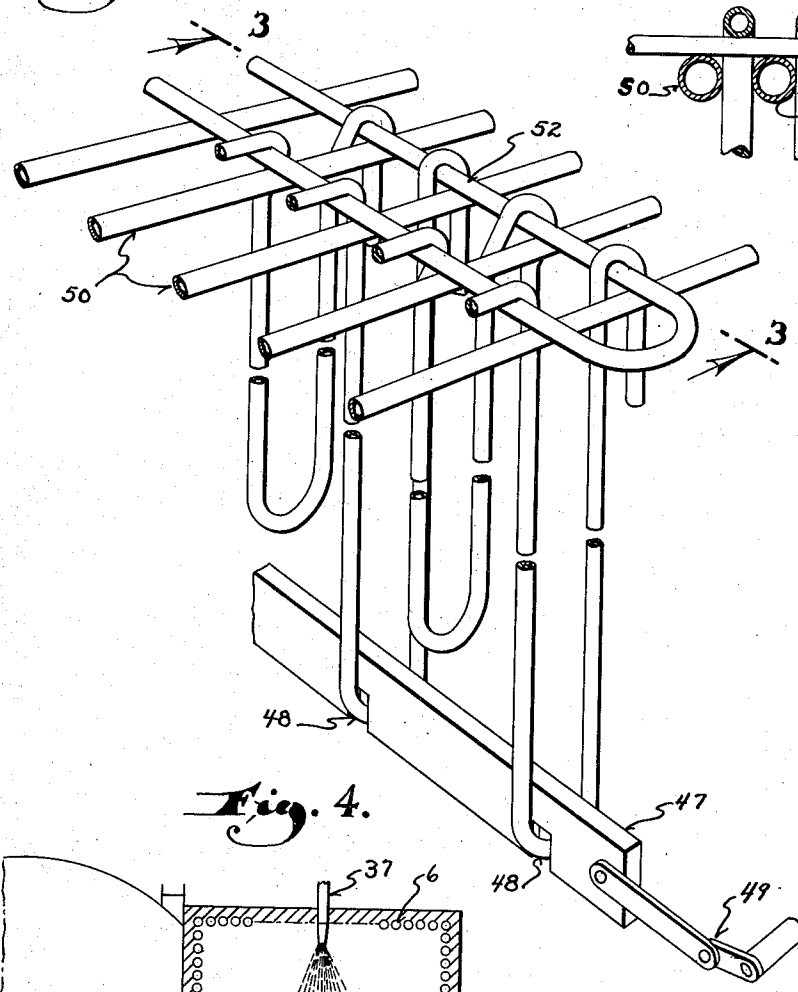


Fig. 3

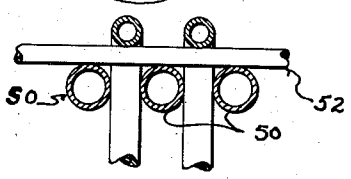
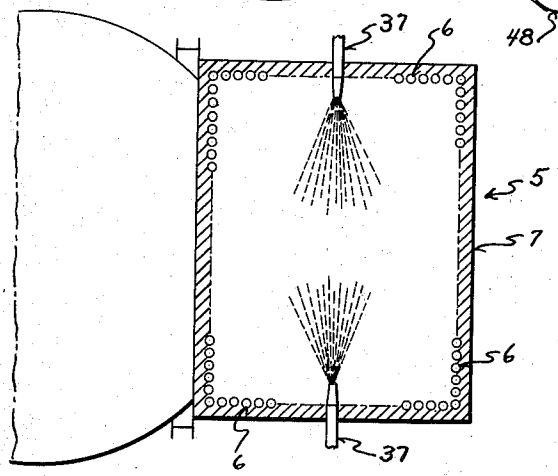


Fig. 4.



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UNITED STATES PATENT OFFICE

2,550,676

COMBINED WASTE-HEAT BOILER AND CHEMICAL RECOVERY UNIT

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Application October 17, 1945, Serial No. 622,832
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4 Claims. (Cl. 23—262)

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This invention relates to the recovery of valuable constituents of waste liquors such as the recovery of sodium sulphide from black liquor, and to furnace apparatuses used in this process.

The general object of this invention is twofold. First, it is the purpose of this invention to provide an improved furnace apparatus especially suitable for use in black liquor recovery processes but also of considerable value in furnaces of general utility; and second, this invention contemplates an improvement in the art of processing waste liquors to recover valuable chemical constituents thereof.

The presence of fly-ash in combustion gases and accummulating on the surfaces of heat exchangers over which the combustion gases flow has long presented a troublesome problem. The removal of the fly-ash or soot from the heat exchange surfaces has generally been effected in the past by means of soot blowers arranged to direct blasts of compressed air or steam against the surfaces to be cleaned. This past method is only partly effective especially when the soot or fly-ash consists of material that is exceedingly sticky, as for instance, the fly-ash entrained in the combustion gases of smelting furnaces. Such fly-ash has a tendency to bake on the surfaces it adheres to so that it is often impossible to remove it by blasts of air or steam. In such instances mechanical means must be used for cleaning the surfaces involved.

The present invention overcomes these objections through the provision of a novel arrangement of the heat exchange surfaces with respect to the direction of gas flow thereover and through periodic agitation or shaking of the heat exchange surfaces.

To this end it is an object of this invention to provide a furnace of the character described wherein heat absorbing and dissipating members are loosely mounted or supported in the path of the combustion gases to be impinged by the fly-ash entrained therein, which thus adheres to the surfaces of these members from which it may be dislodged by periodic bodily agitation or shaking of the members.

With a view toward realizing the advantages of this invention to the fullest extent it is another object of this invention to form the heat exchange surfaces on which the accumulation of fly-ash and soot occurs as serpentine tubes or ducts having elongated substantially vertical portions and to loosely drape these tubes or ducts over suitable supporting structures so as to enable violent agitation or shaking of the tubes

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to dislodge accumulated fly-ash and soot therefrom.

In the process of treating black liquor and other waste liquors for the recovery of their valuable chemical constituents, various methods have been proposed and employed in the past. One of the methods heretofore found generally satisfactory has been to spray evaporated waste liquor into a combustion chamber where the organic constituents of the black liquor burn and the constituents sought to be recovered are discharged from the bottom of the combustion chamber as a liquid.

Difficulty has been experienced, however, with this previous method of recovering chemical constituents of waste liquors, due to the clogging of the gas passages by the adherence of the sticky fly-ash on the surfaces of the heat exchangers by which the heat of the process is utilized for steam generation and other useful purposes. The difficulties resulting from the adhesion of the fly-ash of this process on the heat exchange surfaces can be readily appreciated from the fact that until cooled down to a temperature below thirteen hundred degrees Fahrenheit (1300° F.) this fly-ash will stick to everything with which it comes in contact.

With a view toward overcoming this disadvantage the present invention has as another of its objects an entirely new manner of handling the fly-ash entrained in the combustion gases whereby the fly-ash is deliberately intercepted and accumulated on fluid cooled surfaces which not only enable useful utilization of the heat generated but are so arranged that the accumulated fly-ash may be easily dislodged therefrom.

In this connection, it is a further object of this invention to so locate the intercepting surfaces that the fly-ash which does not adhere thereto is frozen to reduce its tendency to stick to subsequently encountered surfaces as it leaves the combustion chamber.

Another object of this invention is to provide a more compact furnace unit made possible through the utilization of a novel arrangement of gas passages which enables material reduction in the height of the unit.

Another object of this invention is to provide a gas passage so constructed that separation of the entrained frozen less sticky fly-ash particles is materially facilitated and promoted by an abrupt change in direction of the flow of combustion gases.

With the above and other objects in view which will appear as the description proceeds, this in-

vention resides in the novel application of the method and procedure and in the construction, combination and arrangement of parts substantially as hereinafter described and more particularly defined by the appended claims, it being understood that such changes in the precise embodiment of the hereindisclosed invention may be made as come within the scope of the claims.

The accompanying drawings illustrate one complete example of the physical embodiment of the invention constructed in accordance with the best mode so far devised for the practical application of the principles thereof, and in which:

Figure 1 is a vertical sectional view through a furnace apparatus embodying this invention;

Figure 2 is a perspective view illustrating a portion of the novel heat exchanger of this invention showing the manner in which its component parts are loosely supported to be agitated or shaken;

Figure 3 is a fragmentary detail sectional view taken on the plane of the line 3—3 of Figure 2 to more accurately illustrate the actual spacing of the heat exchanger; and

Figure 4 is a cross sectional view through the combustion chamber, said view being taken on the plane of the line 4—4 in Figure 1.

Referring now more particularly to the accompanying drawings in which like numerals indicate like parts, the numeral 5 designates generally an upright combustion chamber the walls of which are lined with vertical boiler tubes 6. The front and side walls of the combustion chamber continue unbrokenly for their entire height, but the rear wall 7 terminates short of the top or the ceiling to provide an opening through which gases leave the combustion chamber. To enable the combustion gases to pass through this opening alternate ones of the boiler tubes lining the rear wall 7 are offset rearwardly as at 8 to provide adequate spacing between adjacent tubes.

It is, of course, understood that all of the boiler tubes 6 are suitably connected with a steam drum 9 and that the circulation through these tubes may be natural or forced.

The bottom of the combustion chamber has a lining 10 of heat insulating material capable of withstanding the high temperature and the chemical reaction taking place therein, and has a spouted outlet 11 leading therefrom through which the chemicals sought to be recovered flow as a liquid. The liquid thus discharged from the bottom of the combustion chamber flows into a tank 12 or may be conducted to any other desired reservoir or place of use.

The exit for the combustion gases in the upper portion of the combustion chamber provides the inlet of a gas pass indicated generally by the numeral 14 and along which the combustion gases flow to be subsequently discharged to the stack. The gas pass 14 is substantially right-angular and has an upright section 15 overlying the back wall of the combustion chamber and of substantially the same height as the combustion chamber. At its bottom the upright section of the gas pass connects with a substantially horizontal section 16 in which a plurality of serially arranged heat exchangers 17, 18, 19 and 20 are located.

At the juncture of the upright and substantially horizontal sections of the gas pass and extending under the upright section, is a collecting hopper 21. Similar collecting hoppers 22 and 23 are disposed under the heat exchangers 18, 19 and 20. Each of these collecting hoppers has a screw conveyer 24 in its bottom whereby the material accumulated in the collecting hoppers may be continually discharged into a duct (not shown) or other suitable means by which it is conveyed back to the combustion chamber to be reprocessed.

Attention is directed to the fact that the positioning of the first collecting hopper 21 under the verical or the upright section 15 of the gas pass facilitates the separation of solid particles entrained in the combustion gas by virtue of their tendency to continue downward as the combustion gases abruptly change direction from downward to horizontal.

Beyond the final heat exchanger 20 the gas pass continues through serially arranged air preheaters 25 and 26, the latter of which preferably has a cast iron housing to more successfully withstand the acids which develop at this stage of the process. After leaving the air preheater 26 the combustion gases continue along a duct 27 to the stack.

Though the specific arrangement of the air preheaters forms no part of this invention, it should be noted that air is admitted thereto through an inlet duct 28, passes through the preheater 26 and from there, through a duct 29 to the inlet of the air preheater 25. The outlet of the air preheater 25 discharges into a duct 30 which leads forwardly to the combustion chamber to provide primary and secondary combustion air.

The primary combustion air enters the combustion chamber through ports 31 fed from the duct 30 through suitable valved branch ducts 32. Secondary combustion air enters the combustion chamber through ports 33 and 34 supplied by suitable valved branch ducts 35 and 36 respectively.

At an elevation between the lower and upper secondary air admission ports 33 and 34, respectively, injection nozzles 37 project through the opposite side walls of the combustion chamber. The waste liquor to be processed is sprayed into the combustion chamber through these injection nozzles 37, it being understood that the waste liquor is first substantially evaporated and that it is forced through the nozzles at high pressure.

After the combustion chamber is initially heated, either by means of an oil burner (not shown) or by building a fire in the bottom of the chamber, the process is self-regenerative as the organic matter contained in the waste liquor sprayed into the combustion chamber burns with a hot flame. As the process proceeds the chemical constituents of the waste liquor sought to be recovered are liquified and flow from the bottom of the combustion chamber. Much of the chemicals sought to be recovered, however, are carried along by the combustion gases as fly-ash. This fly-ash, as hereinbefore noted, due to its high temperature, is quite sticky and will adhere to any surface with which it comes in contact. This is particularly so in the recovery of sodium sulphide from black liquor.

To trap the fly-ash in a manner which will enable easy recovery of the valuable chemical constituents thereof, an intercepting unit in the form of a heat exchanger 38 of novel design is mounted in the top of the combustion chamber adjacent to the point of communication between the combustion chamber and the gas pass 14. This heat exchanger 38 consists of a plurality of

side-by-side serpentine coils or tubes 39 loosely suspended at their upper ends and hanging vertically down into the combustion chamber.

The support for these coils comprises a plurality of substantially horizontal parallel spaced tubes 40. The tubes 40 may connect the steam drum 9 with a header 41 for the upper ends of the boiler tubes 6 overlying the front wall of the combustion chamber. Resting on these substantially horizontal supporting tubes 40 is a network of zigzag secondary supporting tubes 42. These tubes 42, like the tubes 40, form part of the steam generating surfaces of the boiler.

The sets of serpentine coils or tubes 39 are draped over the secondary supporting tubes 42 in a manner similar to that illustrated in Figures 2 and 3, so that they hang freely. They may form part of the boiler surfaces or provide a heat exchanger for any other purpose. In any event, a suitable coolant is circulated through the serpentine coils or tubes.

Inasmuch as the serpentine coils consist substantially entirely of elongated vertical members which are merely joined at their upper and lower ends by U-shaped bends, very little of the surface of these coils is not vertical. As a consequence, the fly-ash accumulating on these non-vertical portions of the tubes covers but a very small part of the total area of the tubes, so that even though the agitation or shaking of the tubes employed to dislodge accumulated fly-ash therefrom may not succeed in removing all of the accumulation from these curved surfaces the retention of the accumulation on these small surfaces does not seriously lower the cooling efficiency of the tubes.

To enable bodily shaking or agitating the tubes to dislodge accumulated fly-ash therefrom, the tubes are connected by rods 43, welded between adjacent tubes; and the foremost tubes have rod extensions 44 projecting through the front wall of the combustion chamber. These projecting rod extensions are therefore accessible to be acted upon by any suitable vibrating mechanism as for instance a hammer structure 45 adapted to be periodically lifted by mechanism (not shown) to swing down and strike the ends of the rod extensions 44.

As will be readily apparent, the serpentine coils or tubes 39 collectively form a labyrinth of passages through which the combustion gases must flow to leave the combustion chamber and enter the gas pass. Most of the sticky fly-ash is thus intercepted and accumulated on these tubes. At the same time the combustion gases are cooled and the fly-ash which escapes contact with the tubes 39 is cooled to the point of being frozen so that it will not readily adhere to subsequently encountered surfaces.

In the upper portion of the upright section of the gas pass, a heat exchanger 46 similar to the heat exchanger 38 is provided to further cool the combustion gases, usefully utilize the available heat, and accumulate fly-ash. This heat exchanger 46 also consists of serpentine coils or tubes draped over fluid cooled supporting tubes and adapted to be bodily agitated or shaken by periodically lifted hammers 45. Preferably the unit 46 constitutes the superheater of the boiler.

As will be readily apparent, fly-ash and other material accumulated on the heat exchanger unit 46, upon being dislodged therefrom, is free to fall down into the first collecting hopper 21. In every instance, the dislodged fly-ash breaks off in chunks or pieces of sufficient size and weight to fall, notwithstanding the possible upward current of combustion gases.

This manner of supporting the serpentine coils or tubes not only allows them to be shaken or vibrated but also has the added advantage of facilitating removal and replacement thereof. As shown in Figure 1 each serpentine coil has its ends connected to feeding and receiving headers F and R located above the tops of the serpentine coils in positions easily reached upon lifting the top wall T. Lifting the top wall T also exposes all of the serpentine coils. Hence by merely cutting the ends of any selected serpentine coil from its headers, this coil may be lifted from its supporting tubes 42 without in anywise disturbing the adjacent coils, and of course by the same token and with equal facility a new coil can be dropped into place and its ends welded to the headers.

The heat exchangers 17, 18, 19 and 20 are all substantially of the same construction as that described, that is, they all consist of serpentine coils or tubes draped over supporting tubes and arranged to be bodily agitated or shaken to dislodge accumulated fly-ash therefrom. The fly-ash, so dislodged from these heat exchangers, falls into the hoppers 22 and 23. The specific use to which the heat exchangers 17, 18, 19 and 20 are put is a matter of choice but the first two (17 and 18) may be the convection part and the last two (19 and 20) the economizer part of the boiler.

The manner of agitating or shaking the serpentine coils of the heat exchangers 46 differs slightly from that previously described. As best illustrated in Figure 2 this agitation is effected by transverse bars 47 extending into the gas pass and hooked onto the lower bends of the tubes as at 48. Preferably the bottom loops of alternate tubes are at a lower elevation than those of the intervening tubes and the agitating bars 47 are hooked only onto these lowermost bends.

Thus, upon reciprocation of the bars 47 in any suitable manner as by an eccentric 49, the tubes may be agitated to the point of collision with each other, thereby assuring the dislodgment of the accumulated fly-ash.

The supporting structure for the serpentine coils forming the heat exchangers 17, 18, 19 and 20 is of the same type as that hereinbefore described, that is, parallel horizontal main supporting tubes 50 connected at their ends to headers 51 have a series of zigzag tubes 52 resting thereon and the serpentine coils are draped over these zigzag coils.

From the foregoing description taken in connection with the accompanying drawings, it will be readily apparent to those skilled in the art that this invention affords a substantial improvement in the art of recovering valuable chemical constituents of waste liquors; and that it provides a substantial improvement in furnaces generally, and especially those adapted for such recovery processes.

What I claim as my invention is:

1. A combined waste heat boiler and chemical recovery unit comprising: means defining an upright combustion chamber having a ceiling; means for introducing chemical containing combustibles into the combustion chamber to be burned therein and to have the chemical to be recovered accumulate upon the floor of the combustion chamber; means defining a discharge opening at the bottom of the combustion chamber from which the accumulated chemical may be discharged as a liquid; a plurality of substan-

tially horizontal boiler fluid containing tubes providing supporting members near the ceiling of the combustion chamber; a group of side-by-side serpentine coils hanging from said supporting members with their legs vertical and substantially uniformly distributed across the horizontal area of the combustion chamber to provide a maze of vertical cooling surfaces in the upper portion of the combustion chamber; headers at the top of the combustion chamber to which the ends of each serpentine coils are connected and whereby boiler fluid may be circulated through the serpentine coils; means defining a gas pass leading from the upper portion of the combustion chamber, the entry to said gas pass being above the bottom of said group of serpentine coils so that the combustion gases leaving the combustion chamber must flow between said coils to reach the gas pass whereby chemical-containing fly ash entrained in said combustion gases impinges the coils to accumulate thereon; and means for vibrating said coils to dislodge accumulated fly ash from the coils in pieces of sufficient size and weight to drop to the bottom of the combustion chamber for reprocessing.

2. The structure set forth in claim 1 further characterized by the fact that the gas pass has a vertical component alongside the combustion chamber and connected thereto at the top so that combustion gases entering the gas pass from the combustion chamber flow downwardly in said component of the gas pass; and further by the provision of a collecting hopper at the bottom of the vertical component of the gas pass; and the provision of a group of hanging vibratable serpentine coils in the upper portion of the said vertical component of the gas pass as well as in the upper portion of the combustion chamber.

3. In an apparatus of the character described: means defining an upright combustion chamber; means defining a gas pass leading from the upper portion of the combustion chamber and through which combustion gases leave the combustion chamber; a group of serpentine coils, each containing boiler fluid and having parallel legs alternately connected at their opposite ends; a plurality of boiler fluid containing tubes disposed substantially horizontally in the top of the combustion chamber; said serpentine coils being draped over the tubes to hang loosely therefrom with their legs vertical and substantially uniformly distributed across the entire ceiling of the combustion chamber and with the bottom of the coils extending a substantial distance below the entry to the gas pass so that the combustion gases leaving the combustion chamber must flow between the coils to reach the gas pass and whereby fly ash entrained in the gases impinges the coils to accumulate thereon; and means for vibrating said coils to dislodge accumulated fly ash from the coils in pieces of sufficient size and weight to drop to the bottom of the combustion chamber.

4. In a boiler having a combustion chamber, an intercepting unit adapted to intercept fly ash and the like entrained in the combustion gases leaving the combustion chamber, comprising a plurality of substantially horizontal boiler fluid containing tubes; inlet and outlet headers containing boiler fluid; a group of serpentine coils each connecting said headers and containing boiler fluid and each having parallel legs alternately connected at their opposite ends, said serpentine coils being loosely hung from the substantially horizontal tubes to be supported thereby in a manner permitting vibration of the coils and bodily lifting of any coil off its supporting tubes without disturbing adjacent coils upon disconnection of said coil from the headers; and means for vibrating the dependent legs of the coils to dislodge accumulated fly ash therefrom.

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