July 17, 1956 C. S. SMITH 2,754,807

WASTE HEAT VAPOR GENERATOR

Filed Sept. 15, 1951

3 Sheets-Sheet 1

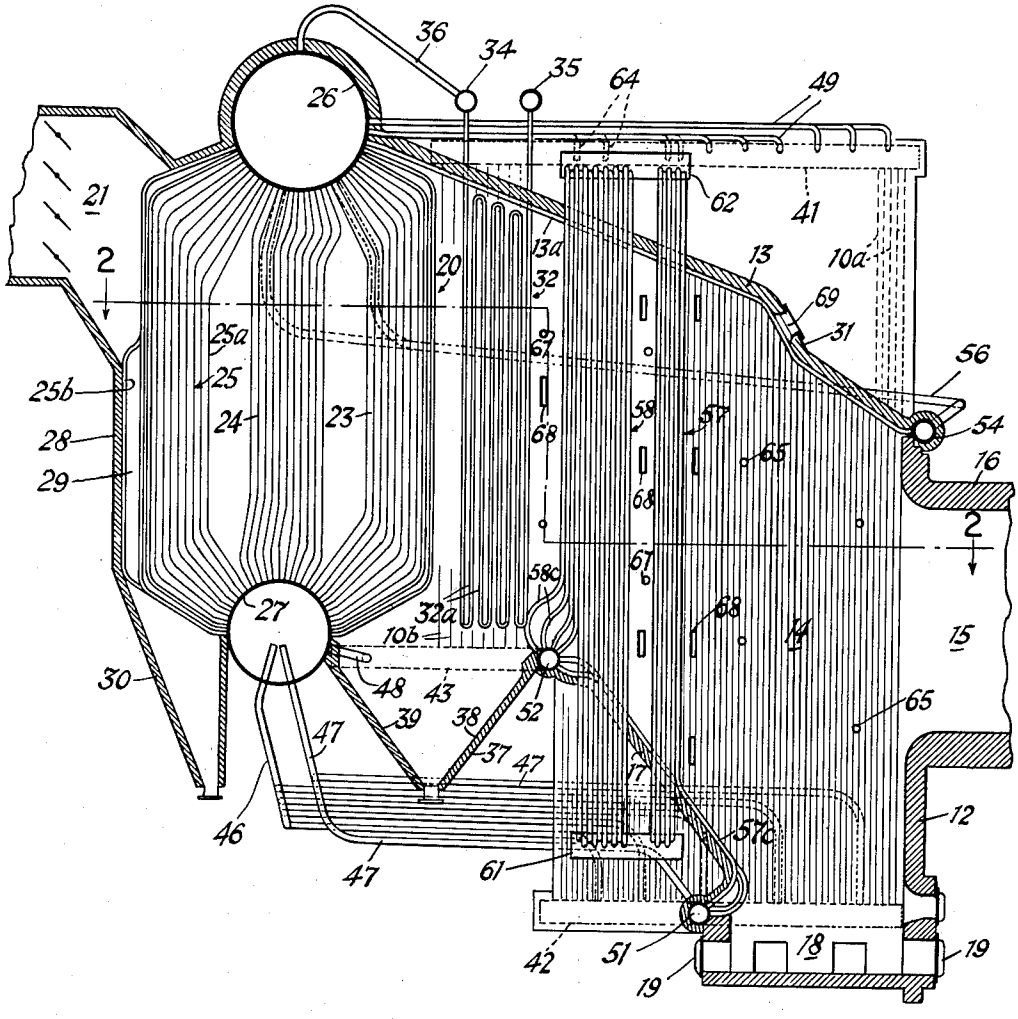


FIG. 1

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3 Sheets-Sheet 2

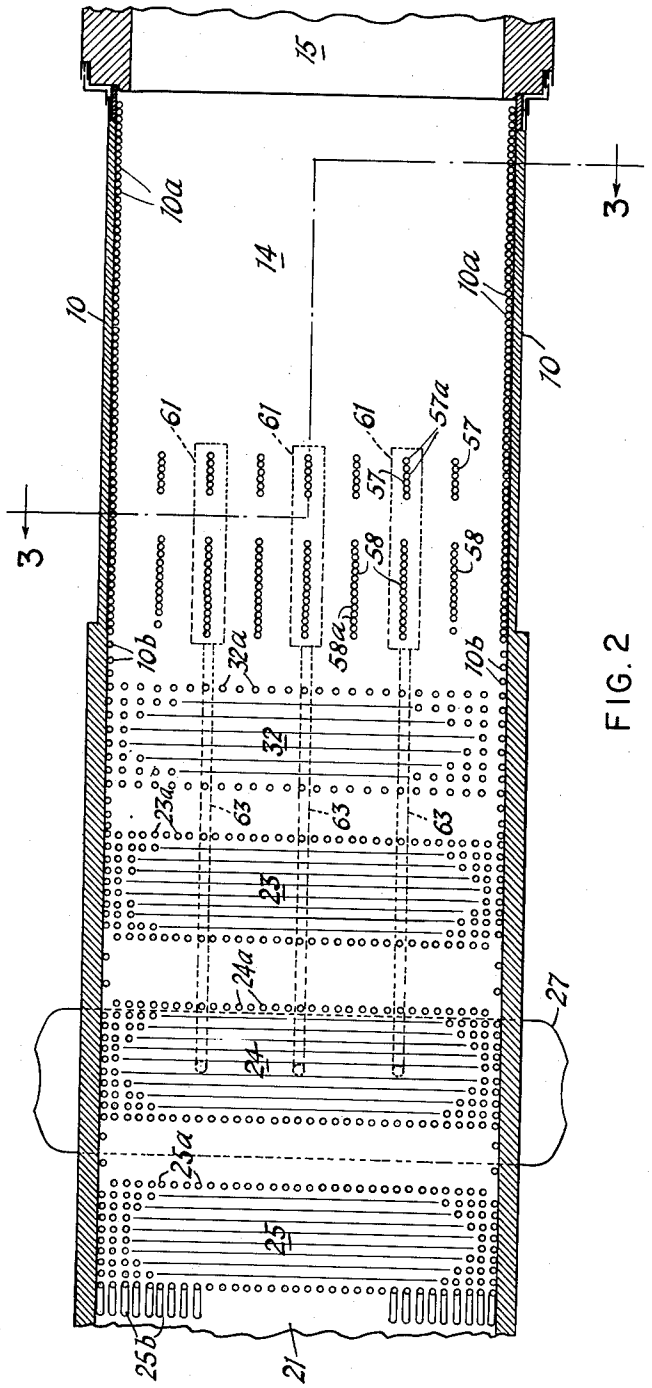


FIG. 2

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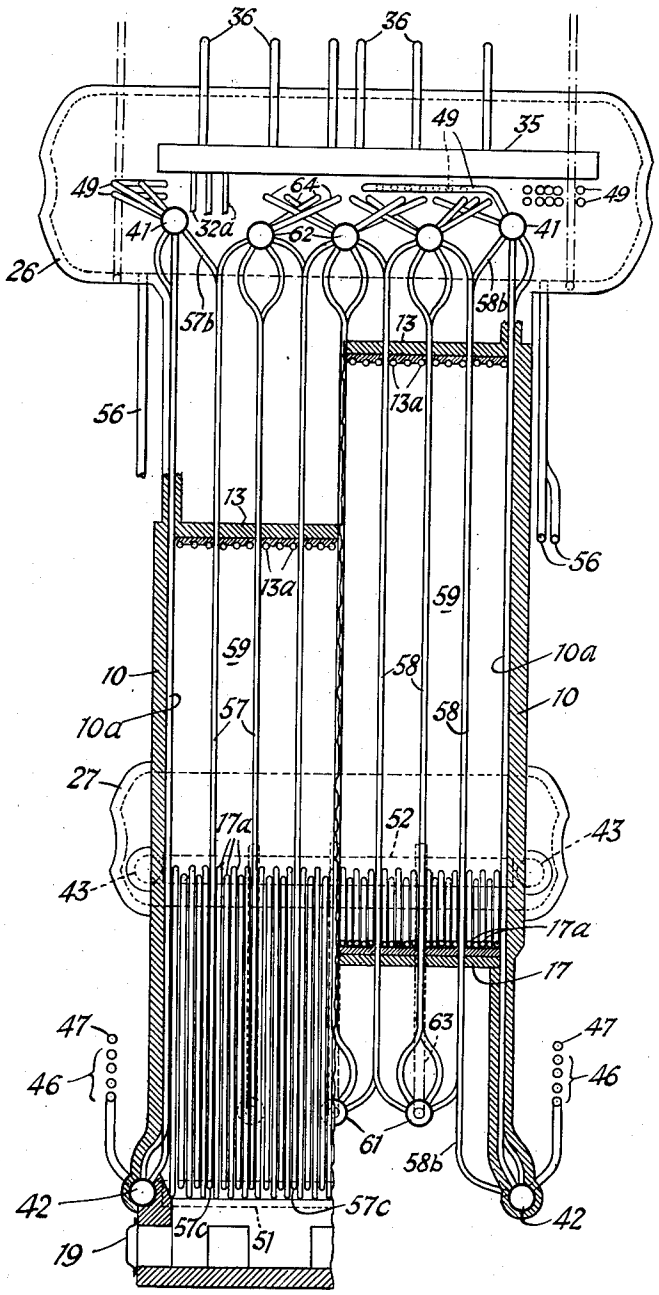


FIG. 3

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WASTE HEAT VAPOR GENERATOR

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11 Claims. (Cl. 122—7)

The present invention relates in general to vapor generators and more particularly to the construction and operation of steam generators of the water tube type arranged for the absorption of heat from waste gases carrying troublesome non-gaseous materials in suspension and furthermore comprising obnoxious gaseous constituents. For the purpose of the present disclosure it may be assumed that the source of such gases is a known type of metallurgical furnace, for example, a smelting furnace of the reverberatory type, as utilized in the smelting of materials bearing copper and other metals. The gases discharged from a copper smelter furnace, for example, are of sufficiently high temperature to make it desirable to recover the heat that might otherwise be lost, suitably by directing the gases through a form of heat exchange apparatus such as a water tube boiler. However, such gases, which are available at temperatures ranging upwardly to about 2270° F., are heavily loaded with sticky slag particles and sulphurous fumes so that their use in the usual form of vapor generator involves severe operating difficulties. Moreover, in the smelting of copper bearing materials in a reverberatory furnace, the customary process utilizes natural draft produced by a high chimney to effect withdrawal of the gaseous products from the combined furnace and boiler, and requires the maintenance of a low draft of about 0.05 in. at the outlet of the smelting furnace. Thus, the draft loss through the boiler section must be kept to a reasonably low figure, because of chimney limitations, if the desired subatmospheric pressure conditions are to be maintained in the boiler section. However, in heat recovery apparatus heretofore employed in conjunction with smelting processes, positive pressure conditions have prevailed within portions of the furnace and also within gas passes of the associated waste heat boiler. As a result of such positive pressure conditions, there has heretofore been a substantially continuous discharge of sulphurous fumes from upper portions of the waste heat boiler setting. Furthermore, when lance doors were opened to dislodge slag from the various heat absorbing surfaces, the discharge of fumes was increased to an almost intolerable degree.

In general, therefore, an object of the present invention is to provide a form of waste heat vapor generator wherein positive gas pressure conditions within all gas flow regions are substantially obviated. Moreover, it is my purpose to provide a distinctive arrangement of the various heat absorbing elements whereby the accumulation of slag thereon is reduced to a minimum, and the cleaning of such elements greatly facilitated.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described an embodiment of my invention.

Of the drawings:

Fig. 1 is a sectional side elevation of a vapor generating unit embodying the various features of my invention;

Fig. 2 is a sectional plan view of the illustrated vapor generating unit, taken along line 2—2 of Fig. 1; and

Fig. 3 is a sectional front elevation of the unit taken along line 3—3 of Fig. 2.

In more detail, Figs. 1–3 illustrate an embodiment of my invention in the form of a steam generating unit particularly adapted for operation as a waste heat water tube boiler deriving heat from high temperature heating gases which are delivered thereto from an associated copper reverberatory furnace or smelter as hereinbefore described.

The illustrative embodiment of my invention comprises a fluid cooled setting having upright lateral walls **10**, **10** and **12**, and an inclined upper arch wall or roof **13**, which define a gas receiving furnace chamber **14**, the roof **13** having an intermediate portion **31** of relatively steep inclination, of about 60°, whereas other portions have a maximum inclination of about 30°. High temperature heating gases, from a copper reverberatory furnace, not shown, are admitted to chamber **14** through a gas inlet passage **15** which is provided by a flue **16** suitably joined to front wall **12**. The lower portion of chamber **14** is formed as a hopper having a steeply inclined rear wall **17** directed downwardly and forwardly toward an ash pit **18** having side and end walls provided with cleanout openings and doors **19** as indicated.

A two-drum natural circulation boiler **20** is positioned at the rear of the setting directly adjacent the damper-controlled gas outlet flue passage **21**. The boiler **20**, as illustrated, is arranged for single-pass gas flow therethrough in a generally horizontal direction, and comprises upright boiler tubes arranged in horizontally spaced banks **23**, **24** and **25**, and connected at their upper and lower ends to upper and lower drums **26** and **27** respectively. As seen in Fig. 2, the tubes **23***a*, **24***a* and **25***a* of the respective banks are arranged in rows extending parallel to drums **26** and **27** and also in other rows extending parallel to the setting side walls **10**, **10**. At the rear of the setting, below gas outlet **21**, the boiler wall **28** is spaced from the major portion of the rear tube bank **25** so as to provide an additional gas flow space **29** leading to the gas outlet **21**, alternate tubes **25***b* having rearwardly offset portions to line and support the wall **28**. A dust hopper **30** is provided between the lower drum **27** and the lower end of wall **28**.

A continuous multiple loop type superheater **32** is arranged forwardly of the boiler unit **20** with tubes **32***a* forming interconnected loops which are connected at opposite ends to vapor inlet and outlet headers **34** and **35** respectively. Tubes **32***a* are arranged in rows parallel to side walls **10** and, in a transverse direction, in rows parallel to the steam and water drum **26**, similar to boiler tubes **23***a*, **24***a*, **25***a*, except at somewhat tube-to-tube spacings. Steam is conducted from drum **26** to header **34** through steam inlet tubes **36**. A hopper **37** having downwardly converging front and rear walls **38** and **39**, is positioned below the superheater **32** and the front boiler bank **23**, the front wall **38** having its upper end sealed to the upper end of wall **17** at the rear of chamber **14**, and the rear wall **39** having its upper end sealed to the lower boiler drum **27**.

The side walls **10**, forwardly of boiler **20**, are fluid cooled throughout by upright tubes **10***a* and **10***b* of different lengths which are arranged in single rows along the inner sides of the respective walls as indicated in Fig. 2; the longer tubes **10***a*, for each wall, occupying a region forwardly of hopper **37**, and the shorter tubes **10***b* occupying a rearward region at the side of superheater **32**, as in-

dicated in Fig. 1. In each side wall **10**, the wall cooling tubes **10***a* and **10***b* are connected at their upper ends to a common upper side wall header **41** disposed at an elevation corresponding to that of the lower half of drum **26**. At their lower ends, the longer tubes **10***a* are connected to a lower side wall header **42**, adjacent the bottom of the setting, and the shorter tubes **10***b*, to a lower side wall header **43** disposed at an elevation corresponding to that of the lower half of drum **27**. Water is supplied to each side wall header **42** through downcomer tubes **46** and **47**, and to each side wall header **43** through downcomer tubes **48**, all of which downcomer tubes **46**, **47** and **48** have upper inlet ends connected to the lower boiler drum **27**. Both upper side wall headers **41** are suitably connected to the upper boiler drum **26** through riser tubes **49**.

The lower inclined furnace wall **17** is lined with cooling tubes **17***a* having opposite ends connected to lower and upper headers **51** and **52** which are respectively arranged at substantially the same elevations as the lower side wall headers **42** and **43**. Water is supplied to lower downtake header **51** through the remaining downcomer tubes **47**.

The inclined upper furnace wall or roof **13** is lined with wall cooling tubes **13***a* which have their lower ends connected to a front wall header **54**, and their upper ends to upper drum **26**, with downcomer tubes **56** forming external water supply connections from drum **26** to header **54**.

At the rear of furnace chamber **14**, and forwardly spaced from superheater **32**, vertically extending tube platens **57** and **58** are arranged to divide the total horizontal width of available gas flow space into a multiplicity of separate relatively narrow fluid cooled passages **59** through which the incoming slag-laden gases must flow prior to entering the considerably narrower gas lanes provided by the tubes of superheater **32** and of boiler **20**. The platens **57** and **58** are disposed in vertical planes parallel to side walls **10** with the tubes **57***a* and **58***a* thereof arranged vertically throughout the height of chamber **14** through which they extend. The platens are also arranged in sets or groups which are horizontally spaced in the direction of gas flow through the furnace.

As seen in Figs. 1 and 3, the majority of platen tubes **57***a* and **58***a* are extended downwardly through the inclined rear wall **17** and are connected at their lower ends to horizontal inlet headers **61** which are positioned directly below the respective platens. Platens nearest the side walls **10** include longer tubes **57***b* and **58***b* respectively which are connected at their lower ends to side wall headers **42**. In each rearward platen **58**, the four rearmost tubes **58***a* have lower end portions **58***c* which are bent toward the rear of the platen and connected to the transverse header **52** at the top of wall **17**. Furthermore, in all forward platens **57**, the foremost tubes **57***a* include lower portions **57***c* which are extended downwardly along the inclined rear furnace wall **17**, between groups of wall tubes **17***a*, and connected at their lower ends to header **51**. At the top of furnace **14**, the platen tubes **57***a*, **58***a*, and **57***b*, **58***b*, are extended vertically to positions above roof **13** where tubes **57***a*, **58***a*, are connected at their upper ends to platen headers **62**, while the remaining tubes **57***b*, **58***b*, in platens nearest the side walls, are connected to the upper side wall headers **41**. The lower platen headers **61** are supplied with water through downcomer tubes **63** which have upper inlet connections with the lower boiler drum **27**. The upper platen headers **62** are suitably connected to the upper drum **26** through riser tubes **64**.

In view of the unusually high slag content of the heating gases, openings may be provided at suitable locations in the enclosing wall structure to permit the insertion of lances or blowers in order to reach surfaces on which slag or dust particles may tend to collect; such openings, as indicated in Fig. 1, including circular openings **65** and **67**, for example, for the accommodation of soot blowers for blowing dust from walls and tubes, respectively, and also vertically elongated rectangular openings or ports **68** and **69** for the insertion of a hand lance

or other slag or dust dislodging tool. Openings **69**, of which only one is shown, extend through the steeply inclined arch wall portion **31** and are horizontally spaced in a row across the width of the furnace at locations directly opposite the respective platens **57**, thereby affording access to the platens throughout the greater portions of their heights. However, in a boiler unit of the particular arrangement herein disclosed, the deposition of viscous slag occurs mainly in a region preceding the main convection heating surfaces of the unit such as are provided by the boiler **20** and superheater **32**. Cooled and solidified slag particles are collected in the hopper bottom of furnace **14**, and in hoppers **37** and **30** beneath the superheater and boiler, this slag being in a form which facilitates handling for remelting in the smelter furnace.

The improvement in operation is attributed to the provision of a completely water cooled furnace structure to which the furnace gases radiate heat whereby the temperature of the gases is rapidly reduced to an extent of about 1000° F., with an accompanying reduction in temperature of entrained slag particles; the provision of a deep furnace hopper formation below the relatively long upwardly inclined flow path of gases traversing the furnace chamber **14**; and furthermore, as a significant contributing factor, the provision of multiple gas flow paths between the horizontally spaced, vertical, fluid cooled tube platens **57** and **58**. As a result of the high temperature drop in the furnace, the sticky slag particles are chilled sufficiently to prevent their accumulation on the furnace walls, and the deposition of viscous slag is mainly confined to the leading edges of the platens where it accumulates in wedge-shaped masses which project forwardly to a thickness or depth of about six inches. The front half of this accumulation is soft and plastic while the remaining rear portion is hard and solidly attached to the tubes. As a result of this concentration of slag accumulation, of limited amount, the time and labor required for periodic lance cleaning of the unit has been almost eliminated, in distinct contrast over the extent of such cleaning operations required in waste heat boilers heretofore similarly employed for waste heat recovery in the smelting industry, the soot blowers being adequate for the dislodging of dust which may collect on the walls and tubes. Moreover, with all convection heat absorbing surfaces arranged in a single substantially horizontal gas flow passage and providing straight and parallel gas flow paths through all heat absorbing sections, the draft loss through the entire unit is maintained at a low enough value to maintain negative pressures throughout the setting and thereby permit the unit to be operated continuously at maximum load without the risk of fumes escaping from within the setting.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form and mode of operation of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

I claim:

1. A waste heat vapor generator comprising, in combination, wall means forming a gas passage arranged for single pass flow of slag laden heating gases therethrough in a generally horizontal direction, upright fluid heating tubes disposed in the gas passage, a chamber at the inlet end of said passage in which said gases are initially received, said chamber having upper and lower walls, means in said chamber forming a multiplicity of unidirectional fluid cooled passages through which said gases are directed prior to contacting said fluid heating tubes, said means comprising horizontally spaced fluid cooled platens arranged parallel to one another in the direction of flow of said gases and formed of mutually contacting upright

tubes aligned in the direction of gas flow and extending through a lower wall of said chamber, and means connected to the lower ends of said platen tubes for directing cooling fluid therethrough.

2. A waste heat vapor generator as defined in claim 1 and further comprising other tubes extending along said lower wall between said platens, said other tubes having lower end portions interspersed with said selected platen tubes and connected in common therewith to said fluid directing means.

3. A low draft loss waste heat vapor generator comprising a setting arranged for single pass flow of slag laden heating gases therethrough in a generally horizontal direction, said setting comprising walls defining a furnace chamber adapted to receive said gases and walls defining a passage through which said gases are conducted from said furnace, one of said walls constituting an upright front wall of said furnace chamber and providing an inlet through which said gases are horizontally received, other walls forming upper and lower boundaries of said passage and directing said gases along an upwardly inclined path from said chamber, a heat exchanger having upright tubes disposed across said passage and defining a plurality of parallel gas flow lanes through which said gases are directed in a single pass, vertically extending tube platens arranged parallel to the sides of said furnace at intervals across the width of said furnace and terminating at elevations exteriorly of said upper and lower boundaries, said platens forming a plurality of single pass gas flow lanes each of greater width than the gas flow lanes of the heat exchanger, and means connecting said platens and said heat exchanger tubes to form parallel natural circulation flow paths of a common fluid circulating system, said connecting means comprising upper and lower headers to each of which tubes of a plurality of said platens are connected.

4. A waste heat boiler comprising fluid heating tubes disposed in a gas passage arranged for single pass flow of slag laden heating gases therethrough in a generally horizontal direction, a chamber adapted to initially receive said gases and providing the inlet end portion of said passage, means defining the upper and lower boundaries of said chamber and passage comprising an upper and a lower wall each inclined upwardly and rearwardly in said gas flow direction, fluid heating tubes associated with each of said walls and upper and lower headers to which the corresponding ends of said lower wall tubes are connected, said headers extending transversely of said gas flow direction, and horizontally spaced fluid cooled platens arranged between said headers forwardly of said boiler tubes and parallel to one another in the direction of flow of said gases, said platens comprising tubes having lower ends connected to one of said headers.

5. A waste heat boiler as defined in claim 4 wherein said platens are arranged in horizontal succession parallelling the flow of said gases and wherein tubes of the respective platens are separately connected to the respective headers associated with said lower wall.

6. A waste heat vapor generator comprising fluid heating boiler tubes disposed in a gas passage arranged for single pass flow of slag laden heating gases therethrough in a generally horizontal direction, an upper and a lower drum to which said tubes are connected for circulation of fluid therethrough, a chamber arranged forwardly of said tubes and constituting the inlet end portion of said passage, means defining the upper and lower boundaries of said chamber and passage comprising an upper and a lower wall each inclined upwardly and rearwardly in said gas flow direction, upright walls arranged at opposite sides of said chamber and comprising upright fluid heating tubes together with lower side wall headers to which said side wall tubes are connected, horizontally spaced fluid cooled platens arranged forwardly of said boiler tubes in parallel relation to said side walls and comprising vertically extending tubes of which selected tubes are connected to said side wall headers, and means for separately supplying fluid to other tubes of said platens.

7. A waste heat vapor generator comprising fluid heating boiler tubes disposed in a gas passage arranged for single pass flow of slag laden heating gases therethrough in a generally horizontal direction, a chamber arranged forwardly of said tubes and constituting the inlet end portion of said passage, upright walls arranged at opposite sides of said chamber and comprising upright fluid heating tubes together with lower wide wall headers to which said side wall tubes are connected, horizontally spaced fluid cooled platens arranged forwardly of said boiler tubes in parallel relation to said side walls and comprising vertically extending tubes of which selected tnbes are connected to said side wall headers, and means for separately supplying fluid to other tubes of said platens.

8. A waste heat vapor generator comprising fluid heating boiler tubes disposed in a gas passage arranged for single pass flow of slag laden heating gases therethrough in a generally horizontal direction, an upper and a lower drum to which said tubes are connected for circulation of fluid therethrough, a chamber arranged forwardly of said tubes and constituting the inlet end portion of said passage, said chamber and passage having an upper and a lower boundary wall each inclined upwardly and rearwardly in said gas flow direction, fluid heating tubes associated with each of said walls and sloping upwardly and rearwardly in conformity therewith horizontally spaced fluid cooled platens arranged forwardly of said boiler tubes and comprising upright tubes having fluid inlet ends and fluid outlet ends arranged exteriorly of said chamber respectively below and above said lower and upper walls, fluid conducting means connecting said lower drum to the lower ends of tubes associated with the lower inclined wall of said chamber, and fluid conducting means separately connecting said lower drum to the fluid inlet ends of tubes of said platens.

9. A waste heat vapor generator as defined in claim 8 and further comprising fluid conducting means separately connecting said upper drum to the lower ends of tubes associated with the upper inclined wall of said chamber and passage.

10. In a single pass gas flow waste heat vapor generator; a roof, side walls and a front wall enclosing a furnace chamber and a following gas passage; the front wall including upright vapor generating tubes and constructed with an opening through which the high temperature waste heat gases are received in the generally horizontal direction; vapor generating tubes included in the roof and the side walls; a bottom for the vapor generator including a plurality of solids receiving hoppers arranged in sequence from the gas inlet to the gas outlet of the unit so that the entire bottom of the unit consists almost wholly of this arrangement of hoppers; a bank of upright fluid heating tubes arranged transversely of gas flow toward the rearward portion of the gas passage, and arranged in a multiplicity of lines generally parallel to the gas flow and forming a multiplicity of unobstructed uni-directional gas flow lanes therebetween; a plurality of platens of upright tubes disposed between the furnace chamber and said bank of fluid heating tubes; the platens being constructed and arranged so that the platens form a plurality of single pass gas flow lanes extending generally in the direction of gas flow, these lanes being much wider transversely of gas flow than the first mentioned single pass gas flow lanes; and means forming a gas outlet for the unit disposed rearwardly, in a gas flow sense, of said bank of fluid heating tubes.

11. In a low draft loss waste heat vapor generator including a setting arranged for single pass flow of particle laden heating gases therethrough in a generally horizontal direction; said setting comprising a roof, a bottom, a front wall and a rear wall defining a furnace

chamber and a single pass gas flow passage through which the gases are conducted from the furnace chamber; the front wall of the setting arranged to form an opening through which the waste heat gases are generally horizontally received; an upper steam and water drum disposed at the upper part of the unit; a submerged drum disposed toward the lower portion of the unit; said roof and side walls including vapor generating tubes connected into a fluid circulation circuit including said drums; a bank of fluid heating tubes directly connecting said drums and arranged in rows the tubes of which are aligned in the rows in the direction of gas flow so as to form a multiplicity of single pass unobstructed gas flow lanes through the bank of tubes; the bottom of the unit including, and consisting almost wholly of, a plurality of hoppers having downwardly converging walls for the collection of solid particles separated from the gases; one of said inclined hopper walls including vapor generating tubes and facing the oncoming gases as they proceed directly from the gas inlet; means connecting the inclined hopper wall tubes into the fluid circulation of the generator; a plurality of upright tubular platens formed by upright and closely arranged tubes disposed transversely of gas flow, the platens being arranged on such wide centers transversely of gas flow that they form unobstructed single pass gas flow lanes forwardly of said bank of tubes; the gas flow lanes formed by the platens being much wider than the single pass gas flow lanes through the fluid heating tubes; the lower ends of the tubes forming said platens extending through the inclined hopper wall facing the oncoming heating gases and the gas inlet; means for connecting the various upright vapor generating tubes and the platen tubes into the fluid circulation of the unit; and means associated with the rear wall of the setting to form a gas outlet for the unit.

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