Oct. 30, 1962 A. H. RUDD 3,060,903

VAPOR GENERATOR

Filed Jan. 25, 1960 2 Sheets-Sheet 1

FIG. 1

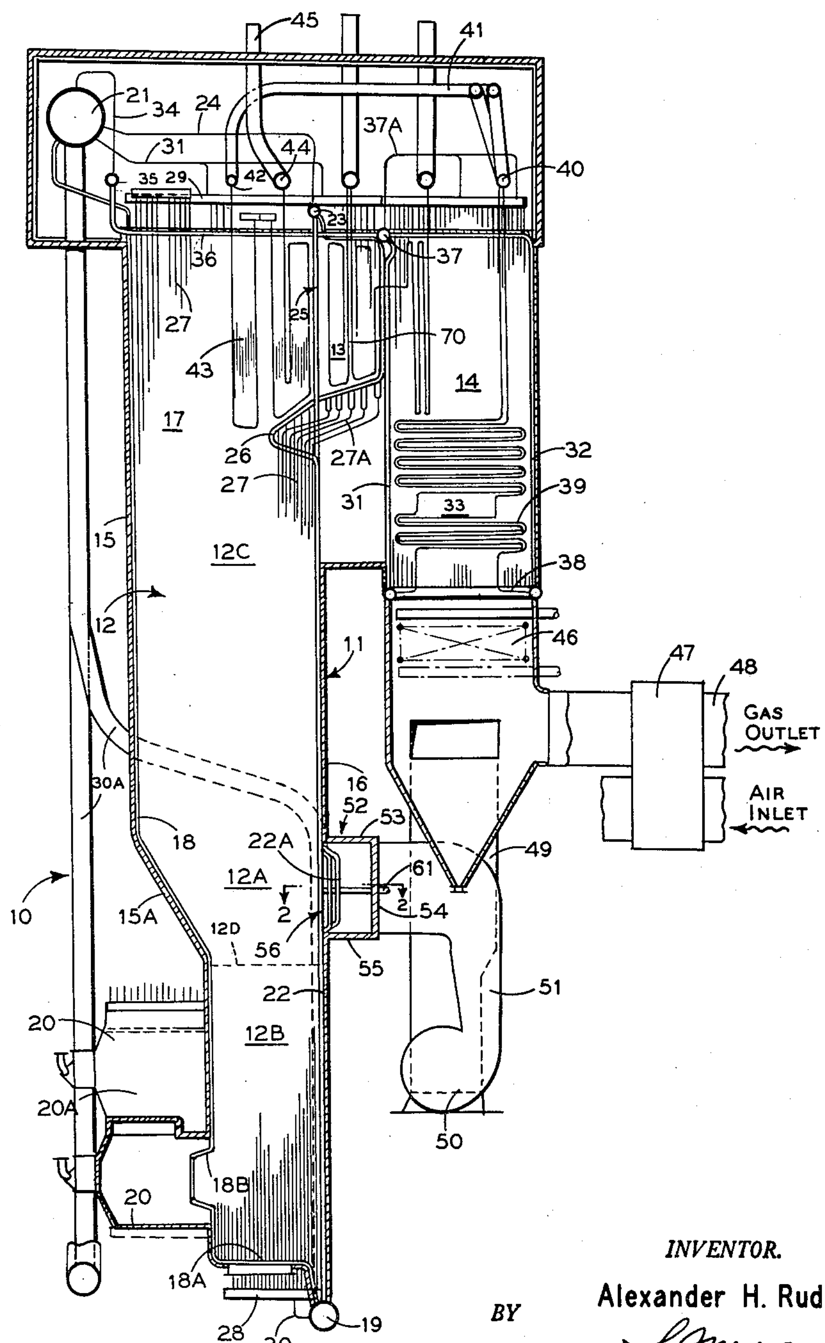


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FIG. 2

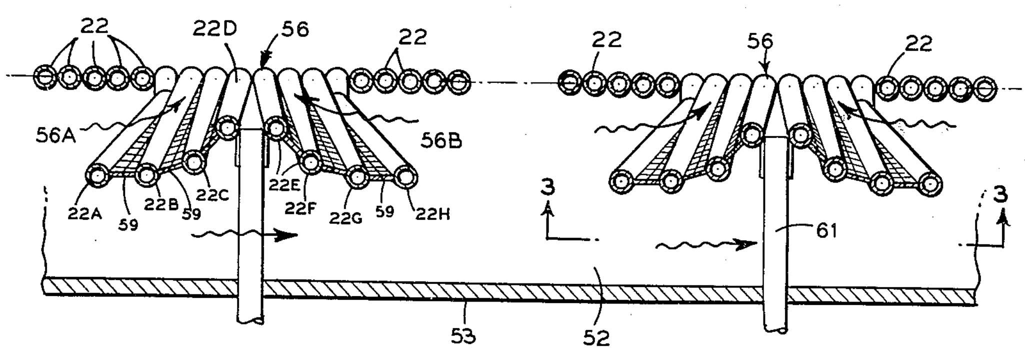
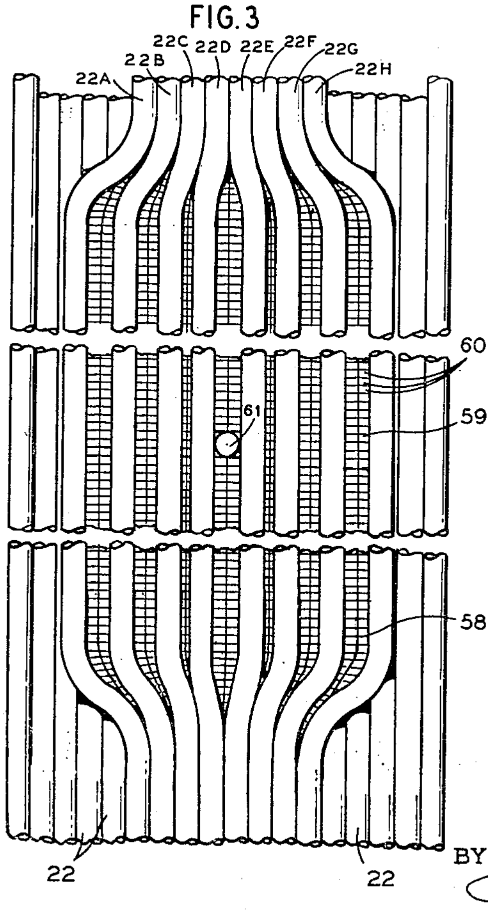



FIG. 3

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# 3,060,903
# VAPOR GENERATOR

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3 Claims. (Cl. 122—235)

This invention relates to the art of vapor generation and vapor heating, and is more particularly directed to an improvement to that class of vapor generating and heating unit in which additional heating gases are introduced directly into the furnace or radiant heat absorption chamber thereof.

In the design of many of the larger high temperature and high pressure vapor generating and heating units control of the gas temperature, the gas mass flow through the unit, and the resultant vapor temperatures are effected by a recirculating gas system that withdraws partially cooled combustion gases from a position downstream, gasflowwise, of the vapor heating section and effects the entry of the recirculated gases into the furnace chamber where it commingles with the gaseous combustion products.

In such units, recirculated gases are directed to a duct which extends transversely along a tubular wall portion of a fluid cooled furnace chamber, the recirculated gases being discharged from the duct directly into the furnace chamber through port openings formed by the displacement of alternate or spaced tubes forming the furnace wall in the vicinity of the duct. The recirculated gases thus introduced into the furnace have the effect of controlling slagging and/or maintaining a predetermined steam temperature. This is attained in part by the recirculated gases effecting either a reduction in the heat transfer to the heat absorption surfaces of the furnace wall tubes or a reduction in the gas temperature leaving the furnace chamber, and in part by effecting an increase in the gas mass flow over the convection heating surfaces of the unit.

Inasmuch as the recirculated gases are oftentimes introduced through port openings located in the high temperature zone of a furnace, experience has indicated the necessity for protecting the inside surfaces of the gas recirculating duct in the vicinity of the furnace walls from the high temperature radiant emission of the furnace gases radiating through the port openings. Heretofore, high temperature insulation, secured by pin studs, was used on the inside of the duct to withstand the deleterious effects of the direct radiation emanating from the adjacent furnace chamber. The use of such insulation increased the initial capital expenditure for such duct work in addition to creating a condition which required continuing maintenance.

In furnaces fired by slag forming fuels, a further difficulty was encountered in that gas discharge ports of the known constructions, had a tendency to become slagged over and thus rendered inoperative. This condition was particularly aggravated at ratings on the unit, when little, or no, recirculated gases are introduced into the furnace to discourage the accumulation of slag across the port opening.

An object of this invention is to overcome the abovementioned difficulties by providing a duct arrangement operatively associated with a wall portion of the radiant



furnace chamber, wherein the ports through which the recirculated gases are introduced into the furnace are defined by portions of the furnace wall tubes arranged to effect a highly efficient shield in the vicinity of the port opening to protect the interior of the duct from the destructive radiant heating effects emanating from the adjacent furnace chamber.

Another object of this invention is to provide a gas recirculating system with novel discharge gas port construction, arranged and constructed in a manner to minimize the tendency for slag to accumulate and seal the port opening, particularly during operation of the unit when little or no recirculated gases are flowing therethrough.

Another object of this invention is to provide a port construction having a relatively low resistance to gas flow therethrough.

The above objects and other features are attained by a recirculating gas system which includes a duct that extends transversely along a wall portion of the unit setting so that an upright portion of the generating tubes defining the wall portion of the setting or furnace chamber forms a wall portion of the duct through which the recirculated gases are directed to the furnace. According to this invention, a plurality of tubes which define the common wall between the duct and adjacent radiation chamber are bent outwardly of the setting and into the duct to define openings at spaced intervals along the width of the wall through which the recirculated gases are discharged directly from the duct into the furnace. The adjacent outwardly bent tubes are progressively displaced laterally so as to fan outwardly on either side of the center line of the port to form a radiation shield spaced inwardly of the duct. The portions of the tubes so displaced form a fluid cooled radiation shield to protect the interior of the duct from the deleterious effects of direct radiation emanating from the adjacent furnace chamber. Baffle means are disposed between adjacent laterally displaced tube portions of the radiation shield to close spaces existing therebetween so that a substantially imperforate shield is formed encompassing the area of the port opening.

A feature of this invention resides in the provision that the amount of insulation required on the interior of the duct discharging the recirculated gases into the furnace may be substantially reduced, thereby decreasing the initial capital outlay, and also greatly reducing the amount of future maintenance which would otherwise be required to maintain the duct in proper operating condition.

The various features of novelty which characterize the 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 is illustrated and described a preferred embodiment of the invention.

In the drawings:

FIG. 1 is a vertical sectional view of a vapor generating and heating unit embodying the invention.

FIG. 2 is a plan section taken along line **2—2** of FIG. 1.

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

Referring to the drawings, the invention herein described is illustrated in conjunction with a high capacity, high pressure and high temperature natural circulation steam generating and heating unit **10**. Generally, the unit **10** comprises a setting **11** which includes a vertically elongated furnace **12**, a laterally extending gas pass **13** connected adjacent the upper end of the furnace, and a downwardly extending convection heating section **14** serially connected with the gas pass **13**.

The furnace **12** is defined by upright front, rear and side walls **15**, **16** and **17**, respectively. The front wall **15** includes a row of steam generating tubes **18** which extend upwardly from a lower water supply drum **19**. As shown, tubes **18** first extend along the bottom **18A** of the furnace thence upwardly along the front wall of the furnace. A portion **18B** of the front wall tubes **18** defines the throat portion of the cyclone furnaces **20** which generate the gaseous products of combustion that are discharged into the furnace **12**. The front wall **15** at an intermediate portion **15A** of the furnace immediately above the cyclone furnace level is inclined outwardly and upwardly to define with the adjacent side and rear walls an intermediate or transition radiant furnace chamber **12A**. Beyond this transition section, the front wall tubes **18** extend upwardly and connect with the steam and water separating drum **21** of the unit. The rear wall **16** includes a row of steam generating tubes **22** which extend upwardly from the supply drum **19** to an upper rear wall header **23**, the latter in turn being connected by suitable connectors **24** to the steam drum **21**. A portion of the rear wall tubes **22** immediately below the furnace outlet **25**, which connects with the lateral gas pass **13**, is inwardly bent to define a nose arch **26**. The opposed side walls **17** of the furnace each include a row of generating tubes **27** extending between their respective lower and upper side wall headers **28** and **29**, respectively. Each of the side wall headers **28**, **29** in turn is connected into the circulation system of the unit by suitable conduits **30**, **31** connecting to the supply drum **19** and main steam drum **21**, respectively. Portions **27A** of the side wall tubes **27** adjacent the upper end of the setting are laterally displaced to define the side walls of the lateral gas pass **13**.

The tubular walls **18**, **22** and **27**, thus define a vertically elongated furnace **12** which has a relatively small lower or primary radiation chamber **12B** which forms a chamber common to each of the cyclone furnaces **20**. The lower segments of the tubular walls defining chamber **12B** are preferably covered with suitable high heat resistant refractory material **12D**. The lower chamber **12B** is open at its upper end and is connected by the transition chamber **12A**, formed by the upwardly diverging portion **15A** of the front wall **15** to an upper superposed secondary radiation chamber **12C**.

A plurality of cyclone furnaces **20** of the general construction as disclosed in U.S. Patent No. 2,357,301 generate the gaseous products of combustion which flow upwardly through the furnace **12**. While cyclone furnaces **20** are herein illustrated as the means employed for generating the gases of combustion, it is to be understood that other burner means may be equally suitable for firing the unit in accordance with this invention.

In the illustrated form, FIG. 1, the cyclone furnaces **20** are arranged in superposed position and are adapted to be independently fired by relatively low quality, high ash content, coarsely pulverized or granulated coal. Each of the cyclone furnaces **20** is arranged to separately discharge the hot products of combustion and molten slag directly into the lower chamber portions **12B**, wherein the gases of the several cyclones are thoroughly mixed.

Each of the cyclones **20** is substantially circular in cross-section, and the barrel portion **20A** thereof is defined by steam generating tubes which together with the front wall tubes **18**, rear wall tubes **22** and side wall tubes **27** constitute the steam generating circuits of the unit. The generating unit shown is of the natural circulation



type with feedwater being supplied to the upper drum **21**. Downcomers **30A** connect the steam and water drum **21** to the lower water supply drum **19** which feeds the individual steam generating circuits.

The steam generated in each of the wall circuits during operation of the unit is delivered to the steam drum **21** and is separated therein. Saturated steam from the steam drum **21** is then superheated by flowing through suitable steam heating surfaces which are disposed in heat transfer relationship to the heating gases flowing through the unit.

As shown, the walls **31**, **32** and opposed connecting side walls **33** defining the convection section or "bird cage" **14** are lined with steam cooling tubes. Saturated steam is delivered from the steam drum **21** through steam conduits **34** to a collecting header **35**. From the collecting header **35**, the steam flows through a row of furnace roof tubes **36** to a distributing header **37**.

The distributing header **37** in turn supplies steam to each of the tubular wall circuits defining the walls **31** and **32**, and by connectors **37A** to side walls **33** of the convection gas pass **14**, the circuits terminating in a ring header **38** positioned in the lower portion of the chamber **14**. From the ring header **38** the steam flows serially through a primary superheater **39**. As shown, the primary superheater **39** comprises a plurality of platen elements, each platen element being formed of multiple looped return bend tubes. Each of the primary superheater platens discharges into the outlet header **40**.

From the primary superheater outlet header **40** the steam flows serially through suitable conduit means **41** to the inlet header **42** of a secondary superheater **43** wherein the steam is finally superheated.

The secondary superheater **43** comprises a plurality of transversely spaced platen elements formed of vertically depending tubes disposed adjacent the furnace outlet **25**. The steam flowing therethrough is discharged to an outlet header **44** from whence the finally superheated steam is delivered to a point of use through conduit **45**. An economizer **46** for preheating the feedwater supplied to the drum is located in the downflow pass **14** beyond the superheater **39**.

In accordance with this invention the gas flow is generally upwardly through the furnace chamber **12**, thence laterally through the lateral gas pass **13** and thence downwardly through the convection heating section or downflow pass **14** from whence the gases are directed through an air heater **47** to a suitable gas outlet or flue **48**. If desired a steam reheater **70** comprising spaced platens of return bend tubes may be disposed in the gas pass **13**.

In order to control the gas temperatures and/or gas mass flow through the unit to maintain and control superheat temperatures, it has been customary to withdraw a portion of the gases downstream gasflow-wise of the primary superheater **39** and recycle the same through the furnace **12**.

In accordance with this invention the gas recirculation system for introducing additional heating gases into the furnace **12** comprises a duct **49** for withdrawing a portion of the flue gases after they pass through the convection heating section **14**. The outlet end of duct **49** connects with a fan or blower **50** which discharges the recirculating gases through an outlet duct **51** to a manifold or distributing duct **52**. As shown, duct **52** extends transversely along the furnace rear wall tube row **22**.

The manifold duct **52** comprises a sheet metal casing which defines the top **53**, rear **54** and bottom **55** of the duct. The front face of duct **52** is defined by that portion of water cooled tubes **22** of the furnace wall which are adjacent the duct.

As shown in FIGS. 1 and 2, the duct **52** extends transversely of the furnace at a position above the refractory lined portion of the lower furnace chamber **12B** and is located adjacent the rear wall opposite the inclined wall portion **15A** of the front wall. The rear wall tubes **22**, in the plane of the wall, are disposed in substantially tangent relationship as shown in FIGS. 2 and 3. In accordance with this invention, and as shown in FIGS. 2 and 3, a plurality of adjacent upright tube portions **22A** and **22H** of the rear wall tubes **22**, in the vicinity of duct **52** and located at spaced intervals along the length of duct **55**, are bent out of the plane of the wall to define port openings **56**. The recirculated gases are thus discharged through port openings **56** directly from the duct **52** into the furnace **12** to mix with the combustion gases flowing upwardly therethrough.

As shown in FIGS. 2 and 3, portions of tubes **22A** to **22H** are bent outward of the furnace and inwardly within the duct **52**. Tube groups **22A** to **22D**, and **22E** to **22H**, respectively, are grouped on either side of the center line of port **56**, the tubes of each group being laterally displaced to fan outwardly from the port center line a progressively increasing amount to a point beyond the port opening **56** to more effectively shield the inside of the duct from radiation. In this manner the outermost or end tubes **22A** and **22H**, which define the extreme limits of the openings **56**, are spaced rearwardly of the plane of the rear wall tubes **22** and to one side of the port opening to define the entrance to passageways **56A**, **56B** which lead to port opening **56**. The passageways **56A**, **56B** and opening **56** are sufficiently large so as not to be easily closed or clogged by slag accumulations, even under the most adverse operating conditions, as for example during operation when little or no gas is being recirculated through duct **52**. Also the arrangement facilitates sizing of the port openings **56** so that a relatively low gas flow pressure drop therethrough is maintained. This feature is important where large quantities of recirculated gas are required.

In the spaces **58** formed by the lateral displacement of tubes **22A** to **22H**, there is disposed a baffle means **59** which substantially closes spaces **58**. In the illustrated embodiment these baffle means **59** are formed by closely spaced flat studs **60** welded to opposed surfaces of the tube as shown. The irregular portions of spaces **58** formed where the tubes are bending back into the plane of the wall may be closed by appropriately shaped plates and/or suitable refractory.

With this arrangement, the tubes **22A** to **22H** and studs **60**, defining the port construction **56** described, provide a highly effective shield or baffle means disposed inwardly of the duct to protect the inner surfaces of the duct **52** from the harmful effects of direct radiation caused by the combustion of fuel in the adjacent furnace chamber **12**. For this reason the amount and/or quality of insulating material heretofore required to protect the interior of the ducts, can be substantially reduced.

Further, the curvature of the baffle wall or shield formed by the progressively displaced portion of tubes **22A** to **22H**, as shown in FIG. 2, streamlines the flow of gases through the port, particularly since they approach each other as indicated by the arrows, and thus minimizes the impact and promotes controlled introduction of the gases into the furnace. Thus the pressure drop through the port **56** tends to be minimized.

If desirable a retractable soot blower **61** may be located within each port **56**, as shown, the arrangement being such that when it is not in operation it is retracted within duct **52** to protect it from furnace radiation.

While the location of ports **56** of duct **52** are illustrated adjacent the rear wall **22** of the transition section **12A**, it will be understood that location of the duct **52** and its port openings **56** to attain the desired gas temperature and/or mass flow of any particular operating unit.

While in accordance with the provisions of the statutes there is illustrated and described herein the best form and mode of operation of the invention now known to the inventor, 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 the claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of other features.



What is claimed is:

1. A furnace chamber within which combustion gases are generated and bounded in part by a wall including upright fluid cooled tubes, means for introducing low temperature heating gases into said furnace chamber to mix with the gases of combustion generated therein, said means including a duct extending transversely of and connected to said wall with said wall forming a common wall between said duct and said furnace, a group of consecutive tubes of said common wall having intermediate portions offset outwardly a substantial distince into said duct to provide an opening in said common wall and bent laterally in said duct relative to the centerline of said opening, with the intermediate tube portions near to the center line of the opening being outwardly offset from the plane of said common wall a lesser distance than the remaining intermediate tube portions, means for substantially closing the intertube spaces of said intermediate tube portions so bent to form a shield for the protection of said duct from radiation from said furnace, said shield and common wall cooperating to define a passageway of decreasing vertical cross-sectional area in the direction of gas flow therethrough arranged to discharge low temperature gases from said duct to said opening.

2. A furnace chamber within which combustion gases are generated and bounded in part by a wall including upright fluid cooled tubes, means for introducing low temperature heating gases into said furnace chamber to mix with the gases of combustion generated therein, said means including a duct extending transversely of and connected to said wall with said wall forming a common wall between said duct and said furnace, a group of consecutive tubes of said common wall having intermediate portions offset outwardly a substantial distance into said duct to provide an opening in said common wall and bent laterally in said duct relative to the centerline of said opening, with the intermediate tube portions near to the centerline of the opening being outwardly offset from the plane of said common wall a lesser distance than the remaining intermediate tube portions and with the intermediate tube portions on opposite sides of the centerline of said opening being bent laterally in opposite directions away from said centerline, means for substantially closing the intertube spaces of said intermediate tube portions so bent to form a shield for the protection of said duct from radiation from said furnace, said shield and common wall cooperating to define a passageway of decreasing vertical cross-sectional area in the direction of gas flow therethrough arranged to discharge low temperature gases from said duct to said opening.

3. A furnace chamber within which combustion gases are generated and bounded in part by a wall including upright fluid cooled tubes, means for introducing low temperature heating gases into said furnace chamber to mix with the gases of combustion generated therein, said means including a duct extending transversely of and connected to said wall with said wall forming a common wall between said duct and said furnace, a group of consecutive tubes of said common wall having intermediate portions offset outwardly a substantial distance into said duct to provide an opening in said common wall and bent laterally in said duct relative to the centerline of said opening, with the intermediate tube portions near to the centerline of the opening being outwardly offset from the plane of said common wall a lesser distance than the remaining intermediate tube portions and with the intermediate tube portions on opposite sides of the centerline of said opening being bent laterally in opposite directions away from said centerline, means for substantially closing the intertube spaces of said intermediate tube portions so bent to form a shield for the protection of said duct

from radiation from said furnace, said shield and common wall cooperating to define a pair of passageways of decreasing vertical cross-sectional area in the direction of gas flow therethrough disposed on opposite sides of and leading to said opening and arranged to discharge low temperature gases from said duct to said opening.



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