Nov. 4, 1930. H. H. BAUMGARTNER 1,780,220

STEAM GENERATOR

Filed March 5, 1927 2 Sheets-Sheet 1

Fig. 1.

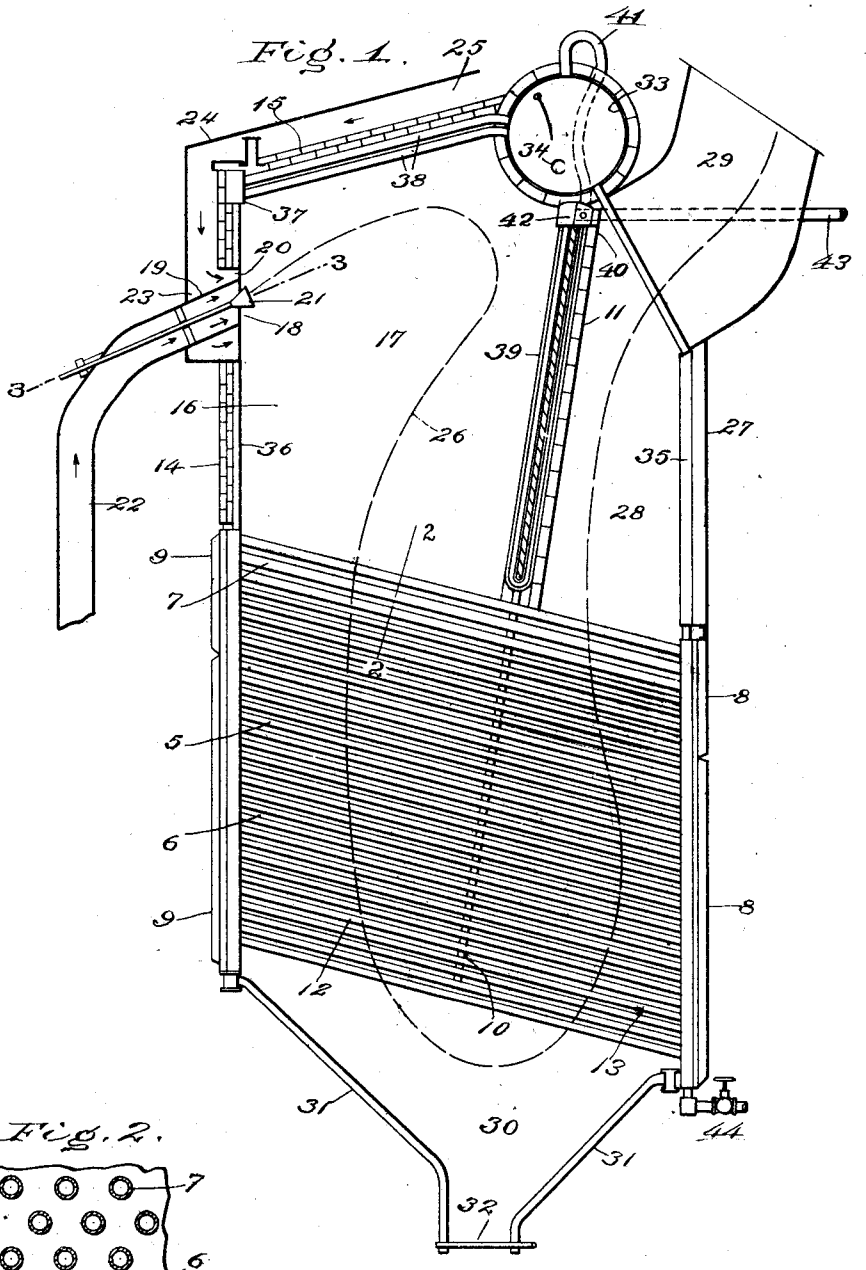
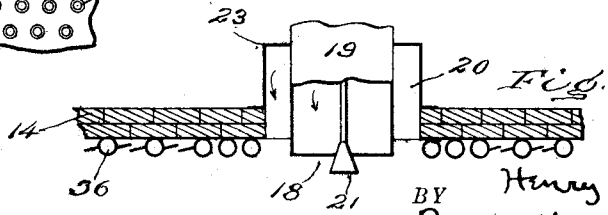


Fig. 2.

Fig. 3.



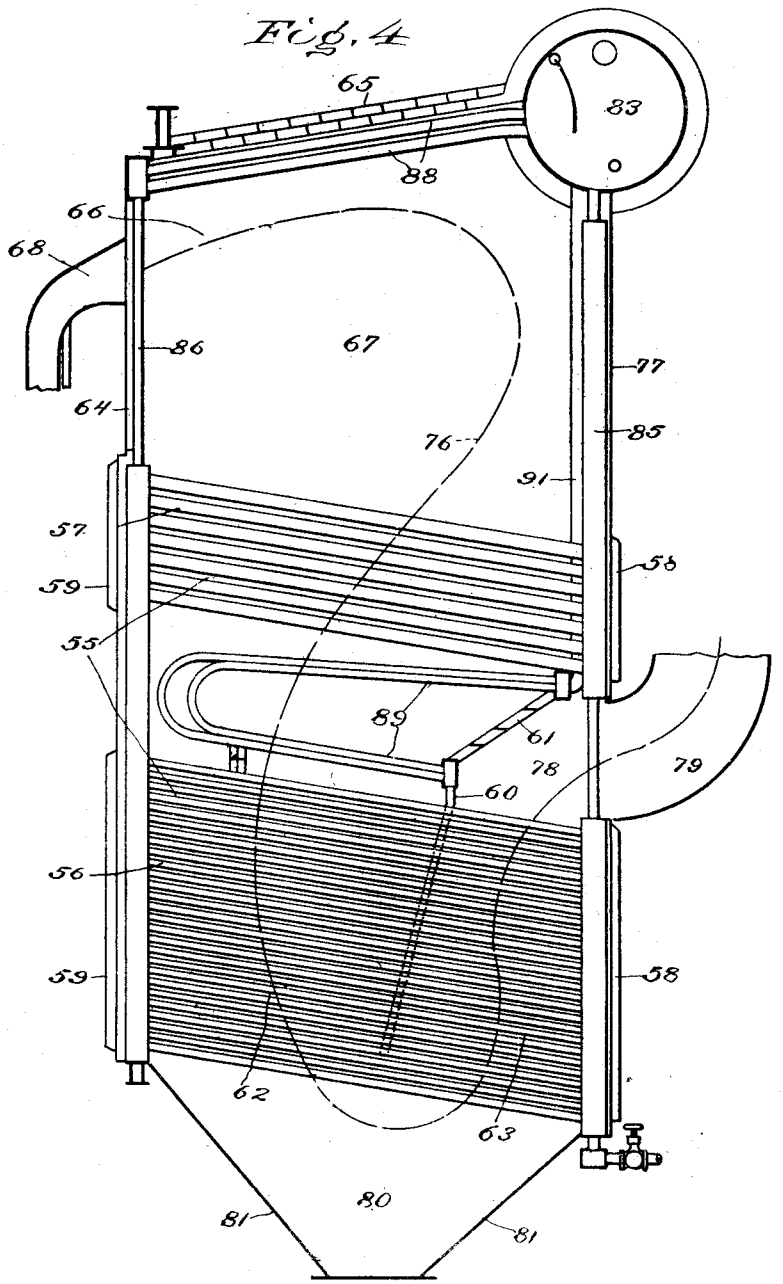
INVENTOR
Henry H. Baumgartner
BY
Rogers, Kennedy & Campbell
ATTORNEYS.

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Fig. 4



INVENTOR
Henry H. Baumgartner,
BY
Rogers, Kennedy & Campbell
ATTORNEYS.

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UNITED STATES PATENT OFFICE

HENRY H. BAUMGARTNER, OF BELLEVILLE, NEW JERSEY, ASSIGNOR TO DRAKE NON-CLINKERING FURNACE BLOCK COMPANY, INC., OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

STEAM GENERATOR

Application filed March 5, 1927. Serial No. 173,177.

This invention is a novel steam generator, that is to say an apparatus combining a furnace and steam boiler.

The herein disclosed improvements are designed more especially for steam generating plants wherein pulverized coal, or oil, or other fluent fuel is fed to the furnace through a suitable burner and burned at a high combustion rate for the purpose of developing a high rate of steam generation, as, for example in large central power stations.

The general object of the invention is to improve the efficiency and operation of steam generators of the kind referred to while mimimizing the difficulties frequently encountered in high service plants. A particular object is to afford a superior embodiment or arrangement of the boiler with respect to the furnace, and path of travel of the flames of combustion in respect to the furnace and boiler. Other and further advantages of the present invention will be explained in the hereinafter following description of one or more embodiments thereof or will be understood to those skilled in the subject matter of steam generation.

In the accompanying drawings Fig. 1 is a general elevation view of the interior parts of a steam generator with certain portions thereof shown in section.

Fig. 2 is a detail section taken substantially on the line 2—2 of Fig. 1.

Fig. 3 is a section taken substantially on the line 3—3 of Fig. 1.

Fig. 4 shows a modified arrangement of furnace, boiler and superheater permitting the combustion chamber or space to occupy the full width of the generator.

The boiler 5 is shown as a tubular boiler, preferably a water tube boiler, as most commonly used in modern generating plants. For reasons to be hereinbelow explained the boiler preferably is composed of a number of tiers of tubes 6 constituting the main part of the boiler, and several tiers of special tubes 7 at the upper part of the boiler, all of these tubes being tilted or inclined in the usual manner to afford an upward trend of the circulating water and steam. As shown in Fig. 2 the upper three tiers of boiler tubes 7 are arranged further apart than the main tubes, giving increased spacing between the tubes. This cooperates in the minimizing of slag, since any molten ash particles are caused to give up heat through radiation to the upper tubes, thus being chilled as they descend through the open spaces, and prevents any molten ash attaining access to the main tubes of the boiler. It will be noticed also that the upper tiers of tubes are substantially larger than, or double the diameter of, the main tubes, and they may be of 4″ diameter as compared with the 2″ or 2½″ in the main tubes. This relative arrangement improves the action at both parts of the boiler, since the larger tubes, exposed to the fire, are of the best character for absorbing radiant heat, while the main tubes, being more numerous and of smaller diameter, present greater surface for absorbing heat by convection from the traveling gases.

The lower ends of all of the tubes 6 and 7 are shown connected to one or more headers or drums 8, while the higher ends of the tubes are shown connected to upper headers or drums 9, the latter being placed at what may be termed the front side of the boiler.

A characteristic feature of the present generator is the employment of a baffle, meaning any sort of wall or separating means, which is depending or otherwise arranged so as to establish first and second boiler passes, the first pass being for down-travel of the combustion gases and the second pass for return or up-travel thereof, the gases taking a turn or bend beneath the depending baffle wall. Thus a baffle wall 10 is shown extending preferably upwardly and downwardly in a plane transverse to the direction of the boiler tubes, and extending to or substantially to the lowermost tiers of tubes. Connecting with the upper end of the baffle wall 10 is shown a continuation or wall 11 which may extend to the boiler drum to be described and may be considered as one of the furnace walls bounding the combustion chamber.

The described baffle wall 10 divides the boiler into a first or down-travel pass 12 and a second or up-travel pass 13. The boiler of this invention is preferably a two pass boiler

and by this arrangement the combustion space, and the outlet to the stack, are both at the same or upper side of the boiler. In some cases it may be advantageous to add a third or additional down-travel pass, but if this is done there preferably should be a fourth or additional up-travel pass, so that the final exit discharges upwardly. However, for the purposes of this invention, the two pass boiler is found to be the simplest and most efficient.

The furnace walls hereof are arranged to define or enclose a combustion chamber above the first boiler pass, for delivering the gaseous products of combustion with a downward trend into the first pass, so that the upper tiers of tubes have their upper sides directly exposed to the radiant heat of combustion. Thus in Fig. 1 there is shown the front wall 14 which may extend upwardly in line with the front header 9, and a top wall or arch 15. These, with the rear wall 11 already referred to, and the two opposite walls 16 constitute and bound the combustion chamber 17.

The fuel may be introduced by positive pressure or forced draft through a burner 18. Any fluent fuel may be used with proper design of furnace and burner, for example liquid, gaseous or colloidal fuels, but for purposes of illustration the burner 18 is shown of a type adapted for the combustion of pulverized fuel or finely powdered coal. The burner may consist of a fuel tube 19 directed to the combustion space, preferably at an upward slant, this tube surrounded by an annular air passage 20. An adjustable spreader 21 is indicated, although this is not in all cases necessary. Any other form of burner may be employed in place of that shown, preferably such as to produce the so-called "short flame", with turbulence and quick mixing and combustion of the fuel. Leading to the burner 18 is shown a fuel pipe 22 which may for example lead directly from a pulverizer, operated in conjunction with a blower, under the so-called unit system, so that, as stated, the fuel is delivered to the furnace under forced or positive pressure. Surrounding the fuel tube 19 of the burner is shown an annular box or casing 23 supplying air to the annular passage 20 and thus surrounding the incoming suspended fuel stream with air of combustion. The combustion air thus delivered to the entering fuel may be preheated. A casing or shell 24 is shown surrounding the top and part of the front of the boiler, forming an air passage 25 by which the air is preheated, this passage connecting with the air box 23 delivering into the chamber. The air passing through the preheating passage 25 may be preliminarily preheated by the outgoing or flue gases. The usual preheater may be arranged in the flues leading to the stack and the cold atmospheric air passed therethrough and thence to the air passage 25.

In one sense the relative arrangement of combustion chamber and boiler may be said to be herein attained by a reversal of the ordinary arrangement. That is to say the boiler, usually located high, and partly occupying the space of the combustion chamber of this invention, has been dropped substantially to the bottom of the plant, and the combustion chamber, burners, etc., shifted to the superposed position as shown, with advantages as hereinbelow pointed out. It will be understood that the indication of a burner 18 is representative of a series of such burners across the front of the furnace. The burners are shown directed at an upward slant, causing the flames to travel in an arc, swinging rearwardly and downwardly so as to occupy and utilize to the best advantage the space within the combustion chamber. The flames however should not be caused to impinge against the top wall of the chamber, nor the tubes thereon to be described. The preferable plan is to keep the fuel traveling within the combustion space as long as possible so as to bring about combustion as complete as possible before the flames reach the boiler.

The path of gas travel may be generally as indicated by the axial travel line 26. The combustion chamber is of ample height. The flames traverse the chamber and after complete combustion enter the first boiler pass 12 with a downward trend. The gases pass on downwardly through the first pass and thence bend around beneath the baffle 10 and swing up into the second boiler pass 13. Between the chamber rear wall and a furnace wall 27 is a flue space 28 and this discharges into a damper controlled pipe or passage 29 leading to a preheater or other auxiliary apparatus and thence to the stack.

The described arrangement permits the ashes of combustion, or the major part thereof, including the heavier particles, to be separated from the gases and withdrawn through an ash space arranged below the baffle wall 10. Thus an ash space or chamber 30 is shown; this being preferably in the form of a hopper enclosed by inclined walls 31 and gate 32 at the bottom for periodic dumping. The bend in the fuel travel occurs directly above the ash hopper so that centrifugal force cooperates with gravity in diverting the ashes downwardly into the hopper, where they are readily removed in any well known manner. The hopper and the ashes therein are far removed from the heat of combustion, so that the usual tendency to melt ashes and form clinker and slag at the discharge is wholly eliminated, and no excess air or water screen is required to obviate this objection.

The boiler drum 33 is seen to be spaced high above the boiler and may advantageously constitute part of the bounding surface of the combustion chamber 17. The circulation tubes between the boiler and the

drum thus have an extended vertical dimension, giving a tendency to more active and effective circulation. The boiler feed or water supply may enter the drum through openings 34 in the ends of the drum, and water may first be warmed by the use of a low pressure economizer arranged in the outgoing flues.

The passages from the drum 33 to the lower headers 8 of the boiler may comprise downcomers 35. The upper boiler headers 9 may be connected to the drum by upcomers 36. These as shown in Fig. 3 may be closely spaced tubes constituting a water wall at the front of the combustion chamber, certain of the tubes being curved and crowded together to accommodate the fuel burners, and the spaces between the tubes being closed by fins or other means adapted to protect the refractory brickwork 14 of the front wall. The upper ends of the upcomers 36 may advantageously discharge into a common header 37 at the upper front corner of the chamber, well protected from direct impingement of flames. From the header 37 to the drum are shown two tiers of staggered water tubes 38, conveying ascending steam to the steam spaces of the drum, and thus completing the circulation of the boiler. The front and top wall tubes 36 and 38 constitute water walls, and are directly exposed to the radiant heat, thus reducing the temperature of combustion, and effectively increasing evaporation. If a tendency to torching should exist at any point the tubes at such point may be protected in any usual manner.

An advantageous feature of the present invention is its ability to accommodate a superheater in a compact and effective arrangement. Thus in Fig. 1 is shown a radiant superheater 39 consisting of recurved steam tubes, the downlegs connected by a header 40 which draws steam through a pipe 41 from the steam spaces of the drum, while the uplegs are connected to a header 42 from which the steam is drawn for engine or other uses through an outgoing steam pipe 43. The superheater 39 is shown as mounted at the front side of the chamber wall 11 and extending from the drum down to the upper tier of tubes of the boiler, thus constituting a water wall at the rear of the chamber. This superheater is in a very effective position as it absorbs radiant heat without any undue length of travel from the drum to the superheater.

The combustion chamber side walls 16 are shown blank, and they may be composed of cooled refractories, or the construction shown at the front and rear walls may be applied to these side walls.

Mud or other sediment tends to accumulate in the lower or cooler boiler tubes and in the lower end of the smaller drum or header 8, and such sediment therefore may readily be blown off and discharged by a blow down or valved connection 44 at the foot of the lower header.

It is manifest that many modifications in the employment of this invention may be made, and many variations in the design and arrangement of the essential elements, depending on the use to which the invention is to be put. The utility of the invention is not limited to stationary boilers nor to boilers and furnaces of the type illustrated. The principles may be made use of, for example in fire tube or other boilers and may be used for locomotive or marine engines.

In Fig. 4 is shown a modified embodiment wherein the baffle and the furnace walls are differently arranged in respect to the boiler and combustion chamber, thereby enabling a combustion chamber of greater width to be employed. The boiler 55 may have main tubes 56 and upper tiers of tubes 57 spaced somewhat above the main tubes to accommodate the superheater. The boiler tubes connect with lower headers 58 and upper headers 59. A baffle wall 60, extended above at 61 to the rear furnace wall, establishes a first boiler pass 62 and a second pass 63. Above the upper header 59 is the furnace front wall 64. This and the top wall 65 and side walls 66 enclose a combustion chamber 67, supplied by a burner 68 with fluent fuel. The flames and gases may follow generally the axis or travel line 76. The rear wall 77 of the furnace is also the rear wall of the combustion chamber. To the rear of the wall 61, above the second boiler pass, is a passage or flue 78 which connects with the passage 79 leading to the stack. The ash chamber 80 is provided by hopper walls 81 as before. The drum 83 supplies water to the boiler through downcomers 85, while the steam from the upper headers of the boiler passes through upcomers 86 and thence through the inclined top tubes 88 back to the drum.

In this embodiment the superheater 89 is of the convection type, being located in the space between the upper tiers of boiler tubes and the main tubes. A steam pipe 91 conveys steam from the drum to the superheater and the latter supplies steam for consumption purposes, for example through the end of the lower header of the superheater.

The general operation has been sufficiently indicated by the diagrams and detail description. Other points of operation and advantage may be recited as follows.

The circulation is greatly improved as compared with previous arrangements that I am familiar with. The greater vertical dimension or head between the boiler and drum accelerates both the downflow of water and the upflow of steam. The uptake steam tubes constituting the front wall of the chamber are well able to carry great volumes of steam to the drum. Circulation is further improved

for the following reasons. The higher rates of evaporation are in the higher tubes, while the lower tubes of the boiler evaporate at a less rate and the lowest ones not at all except when the generator is being pushed to high output. The generated steam therefore does not have to encounter an excessive hydrostatic head, as would be the case if the uppermost tubes were relatively idle and the lower ones furnished the bulk of the evaporation. The mixture therefore ascending the uptake tubes carries but a very small percentage of water.

The furnace can be operated at a lower temperature because the combustion space is surrounded by water walls, with a minimum of brickwork, which may be eliminated entirely. This arrangement moreover gives quicker and more thorough heat transfer as the radiant heat is to a large extent received by the water walls and applied to the circulating water. Steam generators therefore can be run at substantially higher ratings, and to afford higher CO_2 content, and therefore better thermal efficiency. Quicker and more complete mixing and combustion are possible without requiring much excess air, the best plan being to reduce the proportion of air until traces of CO appear, when the best and most complete conditions of combustion are attained.

Owing to the compactness of the arrangement and setting the present steam generator occupies minimum space or volume per rated horse power, thus permitting greater service for a given available volume.

Slag and clinker difficulties are minimized, as already partially described. Slagging on the boiler tubes is substantially eliminated, and owing to the complete removal of the ash receiving space from the combustion space there is no tendency to form clinkers in the ash discharge. No additional air at this point is required, nor any water screen, to prevent slagging, and the space otherwise occupied by such equipment is saved.

Scale and incrustation in the boiler tubes is minimized, and where it does occur its harmful results are substantially eliminated. Thus it is in the most elevated tubes that the highest evaporation takes place, but the tendency to formation of scale therein is low because all deposit of sediment trends toward the lower tubes of the boiler. The deposits forming in the lower tubes do not tend to produce scale because the evaporative action is at a minimum. Any scale forming in the uppermost tubes, exposed to the radiant heat, tends to lodge in the bottom of the tubes, therefore away from the side to which the radiant heat takes effect. This being the case the tendency to blister and burst is practically eliminated.

Sediment accumulated in the lower tubes and mud drums is readily removed by opening the blowndown connection. The points of accumulation of sediment and the position of the blowndown are furthest removed from the hottest part of the furnace and are therefore protected. The sediment gathering in the lower tubes, where there is less tendency to incrustation is quite readily removable. The tubes are relatively idle and the sediment may usually be blown out through the blow off connection. These advantages are due to the location of the tubular boiler below instead of above the combustion space.

By the arrangement wherein the boiler is set at a lower level the initial cost and the maintenance of the setting are minimized. But little brickwork is required and infrequent periods of shutdown for repair, thus improving the economic efficiency of the plant. Another important point is that the highest temperature in the furnace is at the point of lowest crushing strain upon the brickwork, that is at the upper part rather than the lower part of any given column or wall of refractories. The crushing stress therefore is prevented from effecting the injuries that otherwise would occur with a heavy column and pressure upon the bricks softened by the intense heat of combustion.

The described boiler affords improved accessibility for purposes of operation and repair. By placing the boiler at the lower point the firing equipment is placed at a convenient and accessible location. The engineer in charge of the generator has easy access to the water gages, regulators and other accessories at the firing level.

The generator as herein illustrated is designed with due regard to the so-called mean hydraulic depths, which refers to the average distance of the fuel particles from the enclosing surfaces of the combustion chamber. The combustion chamber is of ample proportions vertically and horizontally and such as to afford extended gas travel. In some cases it may be advantageous to decrease the length of the boiler tubes and increase their number, thus enabling the gases better to cover the boiler tubes and affording a mean hydraulic depth which offsets the shortening of the gas travel.

There have thus been described one or more steam generators embodying the principles and attaining the objects of the present invention. Since various matters of combination, arrangement, construction and operation may be variously modified without departing from the principles it is not intended to limit the invention to such matters except to the extent set forth in the appended claims.

What is claimed is:

1. Steam generating apparatus comprising a bank of boiler water tubes, a baffle wall therein establishing a down-travel first boiler pass and an up-travel second boiler pass, with the gases traveling beneath such baffle wall from the first to the second boiler pass, enclosing walls forming a combustion space

above the first boiler pass and a refuse space below the baffle wall, and a fluent fuel burner delivering into the combustion space, the upper boiler tubes having their top sides exposed to the radiant heat of the combustion.

2. Steam generating apparatus using pulverized fuel and comprising a bank of boiler water tubes, a baffle wall therein establishing a down-travel first boiler pass and an up-travel second boiler pass, both occupied by tiers of boiler tubes, and with the gases traveling beneath such baffle wall from the first to the second boiler pass, enclosing walls forming a combustion space above the first boiler pass, and an ash space at the bend of gas travel below the baffle wall, and a pulverized fuel burner delivering into the combustion space.

3. Apparatus as in claim 1 and wherein is a boiler drum spaced high above the boiler tubes, and circulation tubes for water and steam connecting the drum and boiler tubes, some of which are at the combustion space walls.

4. Apparatus as in claim 1 and wherein is a cross drum adjacent the top of the combustion space, with a header connecting the higher ends of the boiler tubes, and upcomers from said header exposed to the flames and leading to the drum.

5. Steam generating apparatus comprising a bank of boiler water tubes, a baffle wall therein establishing a down-travel first boiler pass and an up-travel second boiler pass, enclosing walls forming a combustion space above the first boiler pass and a space below the baffle wall, and a fluent fuel burner delivering laterally into the combustion space, whereby the flame and gases first travel transversely in said space then sweep down and through the first pass, then swing under said baffle around and up through the second pass.

6. In combination a water tube boiler, walls forming a combustion chamber having a width substantially greater than that of the first boiler pass and located above the boiler tubes, and a baffle wall separating the boiler into a first or down-travel pass and a second or up-travel pass, said baffle wall extending upwardly and laterally to a point above the lateral exit point of the gases from the second boiler pass.

In testimony whereof, I have affixed my signature hereto.

HENRY H. BAUMGARTNER.