Jan. 14, 1969 M. CARLONI 3,421,481

MULTI-STAGE VAPORIZATION STEAM GENERATOR

Filed April 17, 1967 Sheet 1 of 2

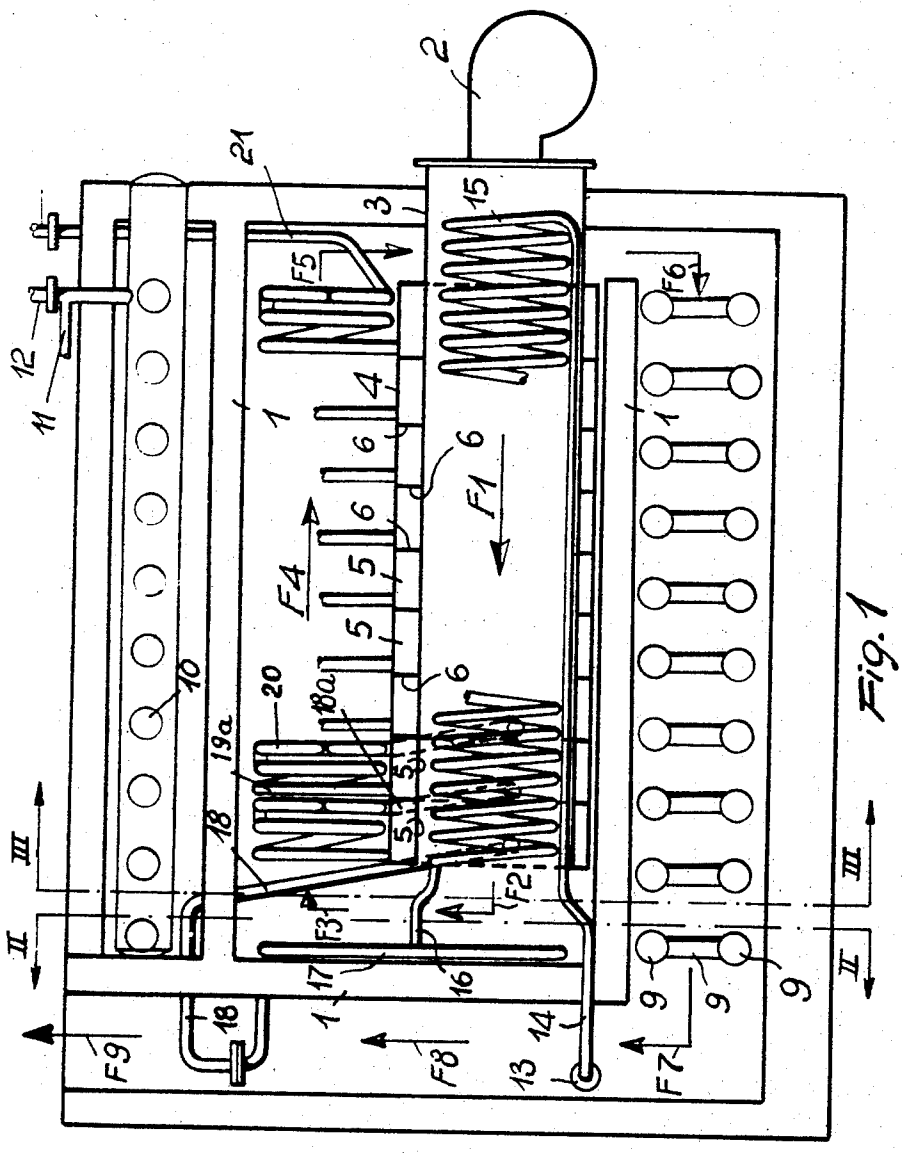

Fig. 1

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MULTI-STAGE VAPORIZATION STEAM GENERATOR

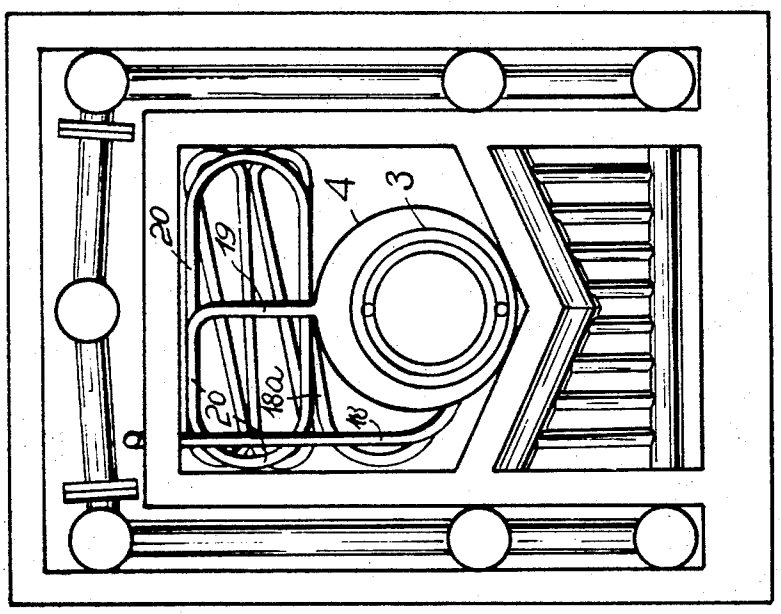

Fig. 3

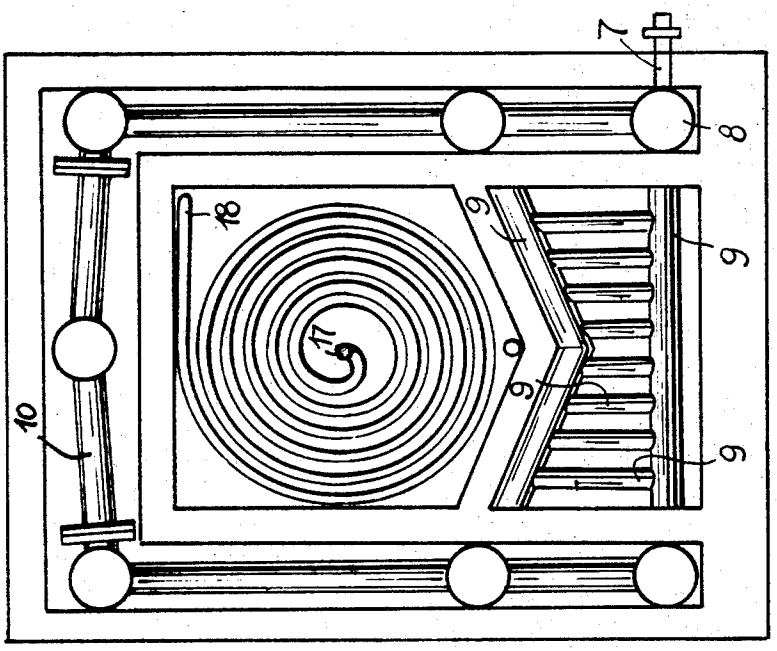

Fig. 2

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MULTI-STAGE VAPORIZATION STEAM GENERATOR

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Int. Cl. F22b *37/10*; F22d *7/00*

ABSTRACT OF THE DISCLOSURE

This disclosure relates to a steam generator including a boiler, a burner, a plurality of pipes within said boiler, a non-linear path between said pipes for the combustion products originating from said burner, a preheater occupying part of said boiler, water inlet and dry steam outlet pipes.

The present invention relates to a steam generator, in which vaporization is divided into several successive stages, especially for the production of dry, saturated steam.

Conventional steam generators, also called boilers, of the type for producing dry, saturated steam, are very bulky and require a very large volume of water, so that their operation must be supervised by skilled personnel.

Moreover, immediate vaporization steam generators are already known, operating according to the principle of water circulating in a coil struck by a burner flame or by combustion products. These generators have the inconvenience of very high operating costs, and of generating often unsufficiently dry saturated steam which contains a high percentage of finely subdivided water particles, a defect preventing their utilization in some industrial sectors.

The object of the present invention is to provide a steam generator avoiding the above-mentioned inconveniences, and capable of producing dry, saturated steam without suspended water particles, thus being suitable for all industrial fields, at very low operating costs.

Another object of the present invention is the provision of a steam generator ensuring good heat transmission between the combustion products and the water to be vaporized, with minimum losses from the thermal point of view, and particularly with sufficient elasticity of operation, in the sense that any unexpected increases in the steam demand may be easily met.

These and other objects are attained by the steam generator, according to the invention, which includes a boiler, a burner, a plurality of pipes within said boiler, a non-linear path between said pipes for the combustion products originating from said burner, a preheater occupying part of said boiler, water inlet and dry steam outlet pipes, and comprises at least one tendentially cylindrical outer element, a tendentially cylindrical inner element, said outer element and said inner element being not co-axial, but one inside the other, a plurality of annular cross walls between said elements, a plurality of expansion chambers between said elements, cross annular walls, a frontal coil remote with respect to said burner, a connection of said frontal coil to said water inlet pipe, hydraulic connections between each of said expansion chambers, a connection between the expansion chamber nearest to said frontal coil and said frontal coil itself, and a connection between the chamber closest to said burner and the dry steam outlet pipe.

The invention will now be made more apparent from the description of a preferred embodiment, illustrated by

way of indication, in the accompanying drawings, in which:

FIG. 1 shows a longitudinal diagrammatic sectional view of a generator according to the invention, and

FIGS. 2 and 3 show cross sectional views according to lines II—II and III—III respectively, of FIG. 1.

With reference to said drawings, the generator comprises a boiler defined by walls **1**. Burner **2** is conventionally fixed to the boiler, frontally. A cylinder **3** is arranged in axial prolongation to said burner. This cylinder **3** is inside another cylinder **4**, non-coaxial, that is, eccentric in cross-section compared with cylinder **3**. An annular chamber is thus formed between the walls of the two cylinders. This chamber is subdivided into a number of expansion chambers, **5**, and by a number of annular walls **6**. In view of the non-coaxial arrangement of cylinder **3** and cylinder **4**, each of these chambers will define, in transverse section, an upper zone of greater section compared with the lower zone, of smaller section.

7 indicates a water inlet pipe (FIG. 2) which enters the collector pipes **8**, flowing from these pipes into the lower pipes **9** and from these into the upper pipes **10** of the preheater formed precisely of this nest of pipes, and situated close to the areas where the combustion products circulate, in the boiler. In other words, with respect to the boiler, these pipes are arranged in layers similar to jackets adjacent to the walls defining the boiler itself.

A pipe **11** and a pipe **12** branch off from the upper pipes **10**. Pipe **12** consists of a breather pipe for the preheater, while pipe **11** passes through the pump (not illustrated), and terminates at inlet **13** in the boiler, from which pipe **14** branches off in the direction of the burner inside cylinder **4**.

Arriving near to burner **2**, pipe **14** starts to form a cylindrical spiral coil **15** inside cylinder **4**, forming a kind of protective screen with regard to the flame and to the combustion products coming from the burner. The space within the turns of the coil **15** in turn, forms the flue for said flame, as well as a first portion of the path travelled by said combustion products. At one end of cylinder **4**, remote from the point where burner **2** is situated, coil **15** continues with a pipe **16** which joins to the centre of a frontal plane coil **17**. The other peripheral end **18** of the coil has a curved course and is connected to the inlet of the expansion chamber **5** which is further away from the burner. The end reaches a lower point of this chamber, according to a direction close to the tangential one (directed downwards) with respect to the outer cylinder **4**. From an upper point of this first expansion chamber (first downstream with regard to the direction of the flame) pipe **19** branches off and extends to form in an upper part of the boiler a series of curves which form an irregular coil **20**, best visible in FIG. 3. This coil provides a free passage for the combustion products and, in any case, extends downwards with a pipe **18*a*** which, like pipe **18**, reaches, with an almost tangential direction, inclined downwards, a lower point of the second expansion chamber **5**. From an upper point of chamber **5** pipe **19** branches which forms another irregular coil **20*a***, and so on, in relation to the second, third, and fourth expansion chamber **5**. For simplicity of the diagram, in the longitudinal section of FIG. 1, these other coils are not illustrated, except the last, indicated by **20*n***, connected to pipe **19*n*** at the side coming from the expansion chamber **5** closest to the burner **2**, as well as to the pipe **21**, at the other side, such a pipe forming then turns the outlet of dry, saturated steam.

In FIG. 1, arrows F1, F2, F3, F4, F5, F6, F7, F8 and F9 indicate the path of the combustion products (flame, smoke, hot air).

The steam generator operates as follows:

Taking into account the path F5, F6 of the combustion products the liquid penetrating pipes **9** of the preheater undergoes a first preheating before reaching inlet **13** with forced circulation due to a pump not illustrated. In pipe **14** a first counter-current relationship is set up between the direction of the water (contrary to the direction of arrow F1) and the direction of the combustion products (according to arrow F1). The water is thus progressively heated as it draws closer to burner **2**.

Thus, in coil **15** the water reaches a high temperature as this coil is in most direct contact with the flame and the combustion products. This water partially evaporates into steam.

This vaporization continues and increases in the frontal coil **17**, also for the fact that this is frontally invested by the front of flame and of combustion products. However, the steam is not completely dry as it drags over water particles.

This flow of damp steam flows, at this point, through pipe **18** to the first chamber **5**, at an almost tangential direction. The flow therefore acquires a rotatory movement in the annular chamber **5** for which, as a result of the centrifugal effect, the heaviest water particles in the mass of steam are dashed against the walls of the annular chambers **5** which are very hot, as they are in contact with the combustion products. Further vaporization occurs in this chamber, and this vaporization is increased by the fact that during the rotary movement in chamber **5** the vapours expand adiabatically, in view of the extremely short time to reach the largest section, and also the continuous supply of heat.

Nevertheless, the steam is still not completely dry. It flows out of pipe **19**, reaches coil **20** and continues to be heated there, as these coils are in contact with the flow of the combustion products defined by arrow F4.

The flow of still damp steam now descends through pipe **18***a* and enters chamber **5** successive to the first, in a substantially tangential direction. Here again, separation of the steam and the water particles by means of centrifugal force occurs, followed by contact of said particles with the metal of chamber **5** and adiabatic expansion when the wide part of said chamber is reached.

The operation continues successively in counter-current with respect to the direction of the combustion products within the inner cylinder **3** (arrow F) and in relation to the subsequent chambers **5**, which are progressively hotter, the closer they are to the burner.

Thus, the flow of steam in the last chamber **5** is perfectly dry, and it therefore reaches the outlet pipe **21** in this condition, as required.

It has been observed that such an arrangement permits obtaining a compact generator, with an excellent thermal yield, and the use of a relatively limited quantity of water.

Many modfications of the embodiment may be devised, with regard to the described form. All rights are reserved for all those modifications falling within the concept of the invention.

What is claimed is:

1. A steam generator including a boiler, a burner, a plurality of pipes within said boiler, a non-linear path between said pipes for the combustion products originating from said burner, a preheater occupying part of said boiler, water inlet and dry steam outlet pipes, and comprising at least one substantially horizontal cylindrical outer element, a substantially horizontal cylindrical inner element, said inner element being located within said outer element and having spaced parallel axes, the inner element axis downwardly spaced from the outer element axis, a plurality of annular cross walls between said elements forming a plurality of expansion chambers between said elements and cross annular walls, said burner being located at one end of said inner element for discharging combustion products therethrough, a frontal coil remote with respect to said burner at the other end of said inner element, means connecting the preheater to the water inlet pipe, means connecting said frontal coil to said preheater, hydraulic connections between each of said expansion chamber, a connection between the expansion chamber nearest to said frontal coil and said frontal coil itself, and a connection between the chamber closest to said burner and the dry steam outlet pipe.

2. A steam generator according to claim **1**, which the connections between each of the said chambers comprises a pipe branching from the larger section upper part of the chamber, an irregular coil connected to said pipe, a descending pipe connected to said irregular coil and also to a low point of a chamber successive to said expansion chamber, said descending duct having in correspondence to said lower point a substantially tangential direction compared with the circular boundaries of said successive chamber.

3. A steam generator according to claim **1**, comprising at the inside of the inner cylindrical wall, a coil of cylindrical turns, said means connecting said frontal coil to said preheater including said coil of cylindrical turns being connected to the preheater at the burner end of the inner element and connected to the frontal coil at the end of the inner element remote from the burner.

4. A steam generator according to claim **1**, characterized by the fact that said preheater comprises a number of pipes in hydraulic communication with one another, situated externally to said boiler, and a course for the combustion products defined by walls leading said combustion products through at least part of said numerous pipes, the water inlet pipe being directly connected to a point which forms one end of said numerous pipes, while the other end is connected to a pipe which, through a pump, connects with the frontal coil connecting means.

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CHARLES J. MYHRE, *Primary Examiner.*

U.S. Cl. X.R.

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