

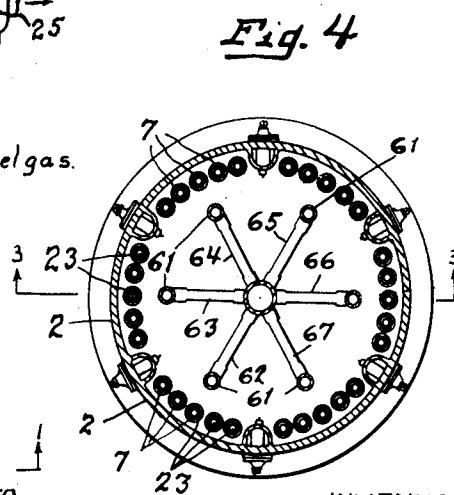
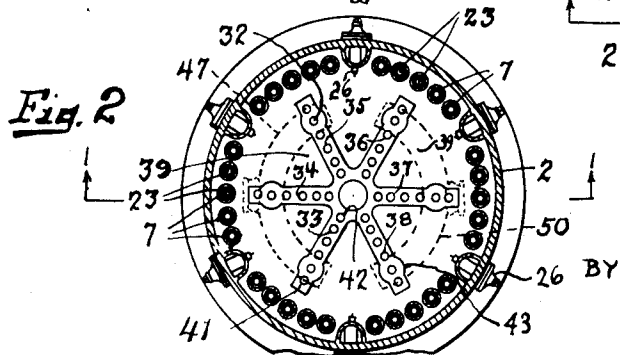
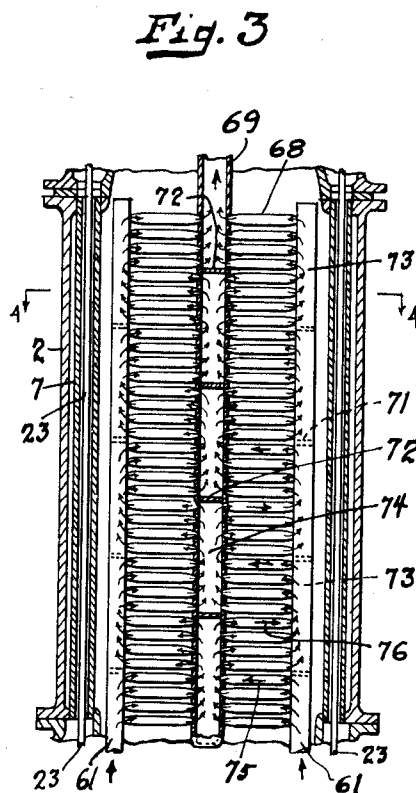
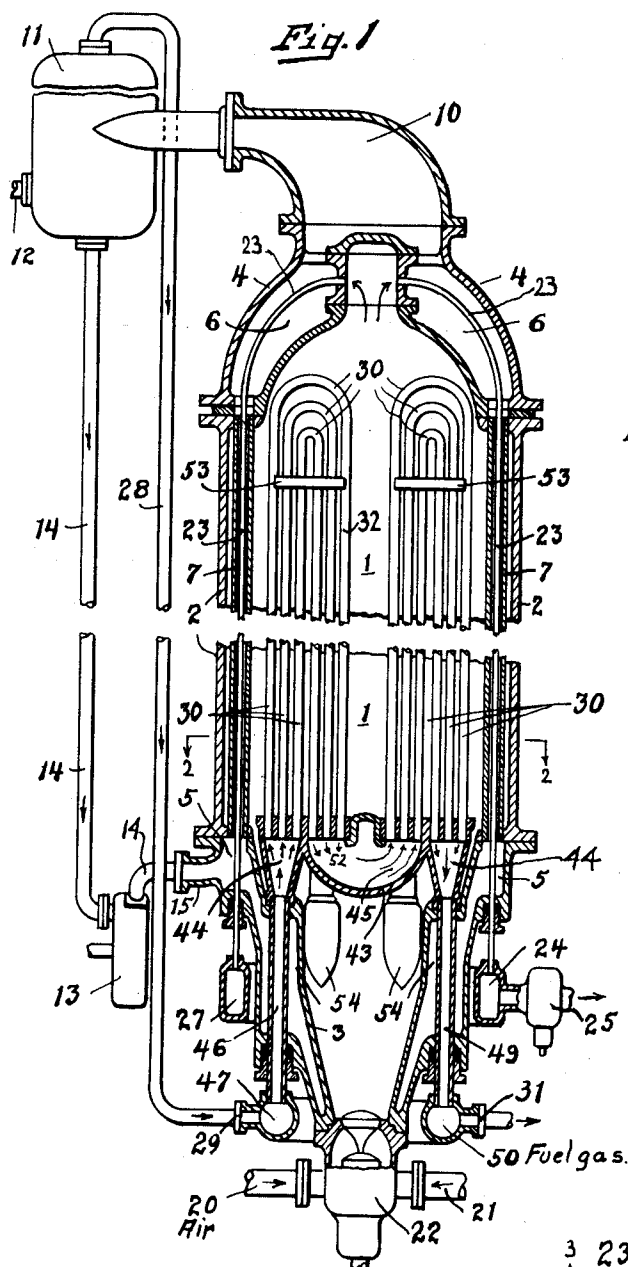
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STEAM SUPERHEATER

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STEAM SUPERHEATER

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10 Claims. (Cl. 122—476)

This invention relates to superheated steam generator devices, and is a continuation in part of my copending application, Serial No. 343,745 filed in the United States on March 1, 1929 which is based on a corresponding application for patent filed in Germany on March 19, 1928. It has among its objects an improved combination of steam superheaters with pressure-proof combustion chambers in which a combustible charge is subjected to combustion under high pressures and the heat of the compressed combustion gases is partially, or entirely used for steam generation, as, for instance, in connection with gas turbines or in steam generators described by me in my copending U. S. applications, Serial No. 333,453, filed January 18, 1929, Serial No. 343,745 and Serial No. 343,746, filed March 1, 1929, and Serial No. 414,428, filed December 16, 1929. It is of particular importance in connection with such devices in which the combustion of the charge in the chamber is carried on periodically in the form of explosions.

In accordance with the invention, the superheater is mounted within the combustion chamber and has its tubes arranged in partitions separating the combustion chamber into several separate compartments intercommunicating with each other. This subdivision of the combustion space facilitates the charging of the chamber with fresh combustion charges as well as the combustion process itself and the subsequent scavenging of the chamber with the fresh charge. The partitions formed by the superheater tubes also serve to guide the burned gases to the exhaust outlets of the chamber and assists in preventing mixture of burned gases with fresh charges admitted to the chamber.

The foregoing and other features of the invention will be best understood from the following description of exemplification thereof, reference being had to the accompanying drawing, wherein

Fig. 1 is a diagrammatic vertical sectional view of steam generator embodying one form of the invention taken along line 1—1 of Fig. 2;

Fig. 2 is a horizontal sectional view, along line 2—2 of Fig. 1;

Fig. 3 is a sectional view similar to Fig. 1 of the combustion chamber embodying a modified form of the invention, along line 3—3 of Fig. 4; and

Fig. 4 is a horizontal sectional view, along line 4—4 of Fig. 3.

In Figs. 1 and 2 there is shown an exemplification of my invention as applied to an explosion type steam generator.

The steam generator comprises a pressure-proof combustion chamber 1 having a main cylindrical section 2 with an inlet header 3 enclosing the bottom and an outlet header 4 enclosing the top of the chamber. Within the walls of the inlet header 3 is formed a water inlet chamber 5 and within the walls of the outlet header 4 is formed a water outlet chamber 6. A set of water tubes 7 is mounted along the periphery of the chamber 1. The tubes 7 are connected between the water inlet chamber 5 and the water outlet chamber 6 to pass water that is heated and vaporized while passing through the tubes, the mixture of hot water and steam being discharged through a conduit 10 into a steam separator 11, where the steam separates and collects in the upper part of the separator, and the water collects in the lower part of the separator. Fresh feed water is supplied to the separator through pipe 12, and the water from the separator 11 is circulated through the water tubes 7 of the chamber with a suitably driven water pump 13 which is connected by pipes 14 between the separator 11 and inlet 15 of water inlet chamber 5.

A combustible charge, such as compressed air and gas fuel is delivered to combustion chamber 1 by way of conduits 20 and 21, through a suitable automatically operated valve 22. From the combustion chamber 1 the hot combustion gases are arranged to be discharged through a set of gas or fire tubes 23 into the gas outlet duct 24 and the outflow therefrom is controlled by a suitable automatically operated outlet valve 25. The inlet and outlet valves 22, 25 and the ignition by spark plugs 26 are periodically controlled to cyclically charge the combustion chamber through the inlet valve 22, while the outlet valve is closed, thereupon exploding the charge and opening the outlet valve 25 to impart with the high pressure developed in the chamber a high velocity of about 200 meters per second or above to the combustion gases, and thereby securing transfer of the heat to the water in the water tubes 7 surrounding the gas tubes, and generation of steam which separates in the separator 11. From the gas-outlet valve the gases are passed through suitable devices for depriving them of the remnant energy, and then discharged into the atmosphere.

This process is cyclically repeated and the generated steam collected in the top of the separator 11, from where it is led through a pipe 28 and inlet 29 to a superheater 30 mounted inside the combustion chamber, the superheated steam being discharged to the consuming devices through

the superheater outlet 31. The combustion within the chamber 1 may also be carried on as a continuous process, in which case a burner 22 is formed at the chamber inlet at which a continuously supplied compressed charge is continuously burned within the chamber.

Large combustion chambers in which combustible charges are subjected to combustion under high pressure and discharged through small diameter heat exchanger tubes, and the combustion gases replaced by fresh charges similarly subjected to combustion and discharge, give a great deal of troubles due to non-uniform charging of the chambers with fresh combustible charges. These troubles affect in a particularly detrimental way devices in which the combustion is carried on in the form of periodical explosions, due to the difficulties of uniformly scavenging the large chambers after each explosion, and providing them with clean fresh charges.

I have found that by subdividing such large combustion chambers into several smaller separated compartments, while leaving them in intercommunication, the difficulties of uniform replacing of the burned combustion gases with fresh charges, and mixture of partially burned gases with partially unburned gases is prevented, thus greatly improving and rendering more economical the operation. These compartments are preferably shaped to lead the gases in several streams from the inlet to the outlet of the combustion chamber, such smaller streams, because of their shape and dimensions, securing better and easier uniform charging, burning, and scavenging of the gases, and rendering the entire operation much safer and simpler, particularly in explosion type combustion chambers, where the difficulties are the greatest.

According to the invention, these reduced size compartments are provided by arranging the superheater tubes of the superheater close to each other in the form of walls extending through the interior space within the large chamber and separating the same into the separate compartments with intercommunication between the same. This secures not only all the advantages that could be obtained by providing separating compartment walls, but also improves the superheater action, because it results in a full and uniform irradiation of the superheater tubes.

One embodiment of the invention is shown in Figs. 1 and 2. The superheater 30 has its tubes 32 grouped in a plurality of flat bundles 33 to 38 extending radially from the center of the combustion chamber 1 crosswise through the same, providing a plurality of segmental compartments 39 separated over their major adjoining surfaces by the walls formed of the flat tube bundles, but intercommunicating around the outer and inner edges 41, 42 thereof. Each bundle comprises a plurality of aligned superheater tubes 32, looped at the top, and connected at their open bottom ends to a supporting star-shaped manifold 43 divided into a plurality of outer ducts 44 and inner ducts 45, one for each bundle half. The outer ducts 44 of the left side tube walls 33 to 35 connect the lower tube ends of these bundles through inlet pipes 46, tightly fitting the bottom header 3, to a segmental inlet duct 47 to which the superheated steam is supplied through inlet 29 from the separator 11. The outer ducts 44 of the right side tube walls 36 to 38 similarly connect the outer tube ends of these bundles through outlet pipes 49 to a segmental outlet duct 50 from where the superheated steam is discharged to the

consumption devices through superheated steam outlet 31. The inner tube ends of the tube bundles 33 to 38 are all connected by the inner ducts 45 which intercommunicate at the center to pass the superheated steam coming from the tube bundles 33 to 35 into the tube bundles 36 to 38 and therefrom to the load, the direction of the steam flow being indicated by the arrows 52. The tubes 32 are held near the top by supporting strips, and at the bottom by the duct manifold 43 which is mounted on sleeves 54 of the bottom header 3 fitting the inlet and outlet tubes 46 and 49. Since the specific volume of the steam is smaller at the entrance into the superheater than after superheating, the tubes of the inlet bundles 33 to 35 should be of smaller cross section than the tubes of the outlet bundles 36 to 38.

By the provision of these superheater partition walls, the steam is generated as well as superheated in the same structure, and at the same time the difficulties with the charging, combustion and the scavenging of the combustion chamber are reduced. This increases the efficiency and permits material savings in the cost and the space of the devices. Each compartment bounded by two tube bundles will act as an independent small chamber. Because of the guiding of the superheater-tube partition walls, the displacement of the burned gases by the scavenging or the charging air is facilitated, and the mixing of the exhaust gases with fresh combustion charges is avoided.

If the combustion charge is burned in the combustion chamber by an explosion process, the temperature of the gases in the interior of the chambers undergoes large oscillations, because it changes periodically between the low temperature of the scavenging and charging air, the very high temperature at the end of the explosion processes, and the gradually decreasing temperature during the expansion and discharge of the combustion products. These variations of the temperature take place only on the exterior surface of the irradiated tube walls. At a depth of but a few millimeters under the contact surface of the tube walls, the medium temperature stays constant, the depth depending on the duration and the intensity of the irradiations. By making the wall thickness sufficiently large, it is possible to store in the superheater tubes sufficient heat at sufficiently high temperature to transfer the heat to the steam in the interior of the tubes by a continuous heat stream. In accordance with the invention, the heater tubes are made with such increased wall thickness, it being usually larger than the wall thickness of the superheater tubes required to overcome the mechanical stresses.

In combustion chambers with the explosion-like combustion, the medium temperature of the combustion chamber at the charge inlet is lower than at the combustion gas outlet because some hot exhaust gases usually stay there. According to the present invention, the superheater tubes are arranged in a plurality of groups within the chamber so that the steam to be superheated is admitted near the relatively cooler inlet into the combustion chamber and is discharged from the superheater tubes near the hot outlet of the combustion chamber. This is shown in Figs. 3 and 4. The steam to be superheated is led into the combustion chamber, through a set of vertical tubes 61, and discharged through horizontally extending bundles 62 to 67 of superheater tubes 68 forming a plurality of flat radial parti-

tion walls dividing the chamber into a plurality of separate compartments as in the prior arrangement. At the inner ends of the horizontal superheater tubes, they open into a central outlet tube 69 having at its upper end, near the gas outlet of the chamber, a superheated-steam outlet. The inlet tubes 61 and the outlet tubes 69 are provided with partition walls 71 and 72 which segregate the spaces within the tubes into a plurality of sections 73 and 74. By these sections 73 and 74 successively higher groups of parallel superheater tubes are connected in series, so that the superheated steam flows consecutively from the lower relatively cool part of the combustion chamber through gradually higher groups of tubes until it leaves near the upper outlet of the combustion chamber, as indicated by the arrows 75 and 76. Thus the separating walls 71 and 72 between the individual sections of the inlet tubes and outlet tubes 61 and 69 divert the gas from one section to the other so that the hot superheated steam leaves through the hottest part of the combustion chamber.

Many other modifications of the invention will suggest themselves to those skilled in the art, and it is accordingly desired that the claims be given a broad interpretation commensurate with the scope of the invention within the art.

I claim:

1. In combination with a steam generating device comprising a pressure-proof combustion chamber, means for supplying a combustible charge to said chamber and subjecting said charge to combustion in said chamber to produce high temperature combustion gases of high pressure, and heat-exchanger gas discharge duct means holding steam generating fluid and connected to said chamber to discharge said hot combustion gases for heating said fluid and produce steam, of a superheater for superheating said steam comprising a plurality of closely positioned interconnected tubes forming partition walls subdividing the space within the chamber into a plurality of compartments guiding the gases in parallel separated paths through said chamber.

2. In combination with a steam generating device comprising a pressure-proof combustion chamber, means for supplying a combustible charge to said chamber and subjecting said charge to combustion in said chamber to produce high temperature combustion gases of high pressure, and heat-exchanger gas discharge duct means holding steam generating fluid and connected to said chamber to discharge said hot combustion gases for heating said fluid and produce steam, of a superheater for superheating said steam comprising a plurality of closely positioned interconnected tubes forming partition walls subdividing the space within the chamber into a plurality of compartments guiding the gases in parallel separated paths through said chamber, the space within said chamber occupied by said superheater tube partition walls being small compared to the spaces of said compartments between said partitions.

3. In combination with a steam generating device comprising a pressure-proof combustion chamber, means for periodically supplying a combustible charge to said chamber and periodically subjecting said charge to explosive combustion in said chamber to produce high temperature combustion gases of high pressure, and heat-exchanger gas discharge duct means holding steam generating fluid and connected to said chamber to discharge said hot combustion gases

for heating said fluid and produce steam, of a superheater for superheating said steam comprising a plurality of closely positioned interconnected tubes forming partition walls subdividing the space within the chamber into a plurality of compartments, the space within said chamber occupied by said superheater tube partition walls being small compared to the spaces of said compartments between said partitions.

4. In combination with a steam generating device comprising a pressure-proof combustion chamber, means for periodically supplying a combustible charge to said chamber and periodically subjecting said charge to explosive combustion in said chamber to produce high temperature combustion gases of high pressure, and heat-exchanger gas discharge duct means holding steam generating fluid and connected to said chamber to discharge said hot combustion gases for heating said fluid and produce steam, of a superheater for superheating said steam comprising a plurality of closely positioned interconnected tubes forming partition walls subdividing the space within the chamber into a plurality of compartments guiding the gases in parallel separated paths through said chamber.

5. In combination with a steam generating device comprising a pressure-proof combustion chamber having an inlet and an outlet, means for periodically supplying a combustible charge to the inlet of said chamber and periodically subjecting said charge to explosive combustion in said chamber to produce high temperature combustion gases of high pressure, and heat-exchanger gas discharge duct means holding steam generating fluid and connected to the outlet of said chamber to discharge said hot combustion gases for heating said fluid and produce steam, of a superheater for superheating said steam comprising a plurality of closely positioned interconnected tubes forming partition walls subdividing the space within the chamber into a plurality of compartments guiding the gases in parallel separated paths from the inlet to the outlet of said chamber.

6. In combination with a steam generating device comprising a pressure-proof combustion chamber, means for periodically supplying a combustible charge to said chamber and periodically subjecting said charge to explosive combustion in said chamber to produce high temperature combustion gases of high pressure, and heat-exchanger gas discharge duct means holding steam generating fluid and connected to said chamber to discharge under the action of said high pressure said hot combustion gases at velocity through said ducts for heating said fluid and generate steam, of a superheater for superheating said steam comprising a plurality of interconnected tubes extending through the interior of said chamber, said superheater tubes having a wall thickness greater than required for withstanding the stresses to which they are subjected and sufficient to convert the periodical heat flow from the periodically exploding gases to the exterior of the superheater tubes into a substantially steady heat flow from the tubes to the steam in the interior thereof.

7. In combination with a steam generating device comprising a pressure-proof combustion chamber, means for periodically supplying a combustible charge to said chamber and periodically subjecting said charge to explosive combustion in said chamber to produce high temperature combustion gases of high pressure, and

- heat-exchanger gas discharge duct means holding steam generating fluid and connected to said chamber to discharge said hot combustion gases for heating said fluid and produce steam, of a superheater for superheating said steam comprising a plurality of closely positioned interconnected tubes forming partition walls subdividing the space within the chamber into a plurality of compartments, said superheater tubes having a wall thickness greater than required for withstanding the stresses to which they are subjected and sufficient to convert the fluctuating heat flow from the periodically exploding gases to the exterior of the superheater tubes into a substantially steady heat flow from the tubes to the steam in the interior thereof.
8. In combination with a steam generating device comprising a pressure-proof combustion chamber, means for periodically supplying a combustible charge to the inlet of said chamber and periodically subjecting said charge to explosive combustion in said chamber to produce high temperature combustion gases of high pressure, and heat-exchanger gas discharge duct means holding steam generating fluid and connected to the outlet of said chamber to discharge said hot combustion gases for heating said fluid and produce steam, of a superheater for superheating said steam comprising a plurality of closely positioned interconnected tubes forming partition walls subdividing the space within the chamber into a plurality of compartments guiding the gases in parallel separated paths from the inlet to the outlet of said chamber, said superheater tubes having a wall thickness greater than required for withstanding the stresses to which they are subjected and sufficient to convert the fluctuating heat flow from the periodically exploding gases to the exterior of the superheater tubes into a substantially steady heat flow from the tubes to the steam in the interior thereof.
9. In combination with a steam generating device comprising a pressure-proof combustion chamber having an inlet and an outlet, means for supplying a combustible charge to the inlet of said chamber and subjecting said charge to combustion in said chamber to produce high temperature combustion gases of high pressure, and heat-exchanger gas discharge duct means holding steam generating fluid and connected to the outlet of said chamber to discharge said hot combustion gases for heating said fluid and produce steam, of a superheater for superheating said steam comprising a plurality of closely positioned interconnected tubes forming partition walls subdividing the space within the chamber into a plurality of compartments guiding the gases in parallel separated paths from the inlet to the outlet of said chamber and having a steam inlet in the tube group lying near the chamber inlet and a steam outlet near the chamber outlet for successively passing the steam to be superheated through tubes lying in regions of successively higher temperature in said chamber.
10. In combination with a steam generating device comprising a pressure-proof combustion chamber having an inlet and an outlet, means for periodically supplying a combustible charge to the inlet of said chamber and periodically subjecting said charge to explosive combustion in said chamber to produce high temperature combustion gases of high pressure, and heat-exchanger gas discharge duct means holding steam generating fluid and connected to the outlet of said chamber to discharge said hot combustion gases for heating said fluid and produce steam, of a superheater for superheating said steam comprising a plurality of closely positioned interconnected tubes forming partition walls subdividing the space within the chamber into a plurality of compartments guiding the gases in parallel separated paths from the inlet to the outlet of said chamber and having a steam inlet in the tube group lying near the chamber inlet and a steam outlet near the chamber outlet for successively passing the steam to be superheated through tubes lying in regions of successively higher temperature in said chamber.
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