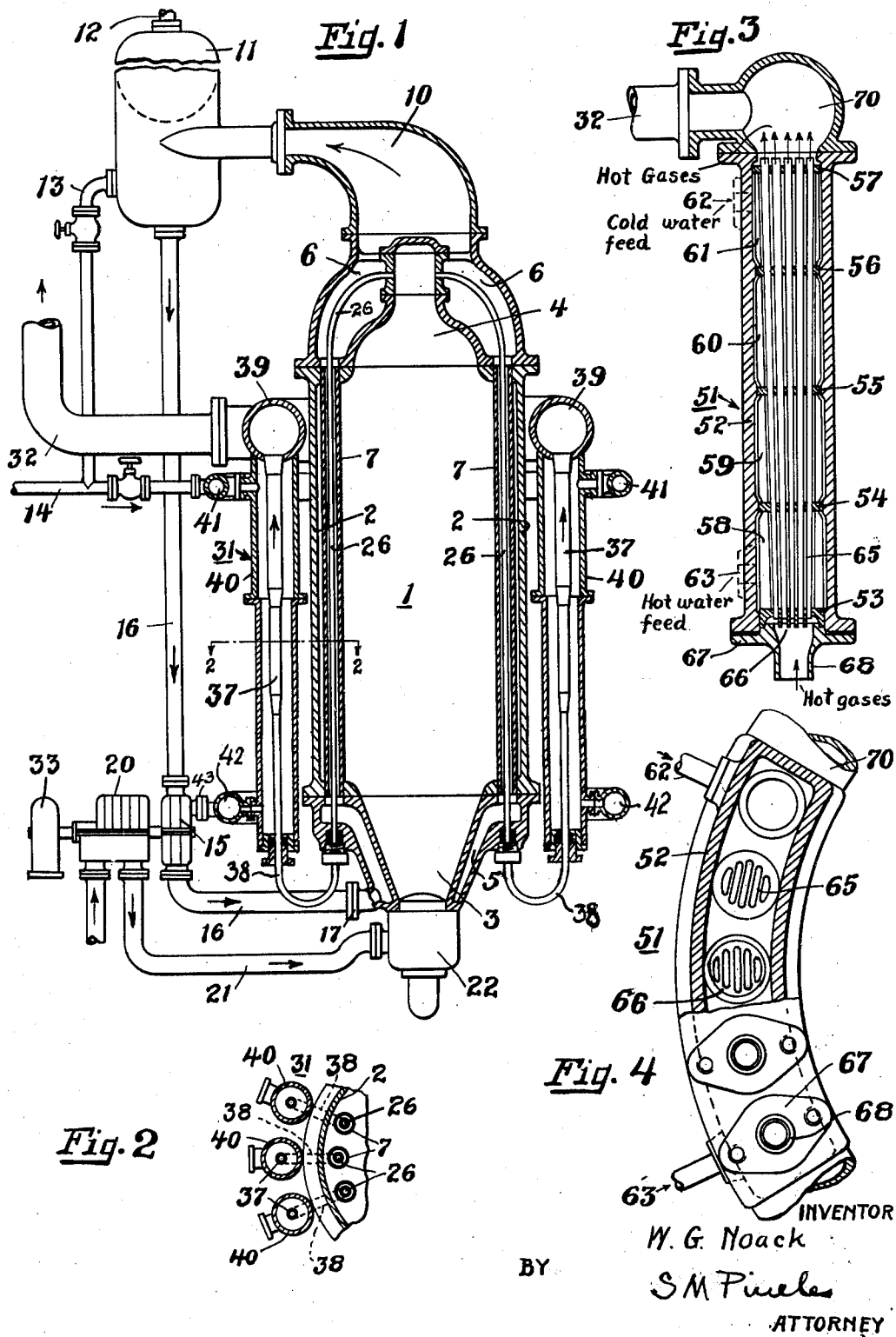


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HEATER SYSTEM

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HEATER SYSTEM

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This application is a continuation in part of my copending application Serial No. 502,681, filed December 16, 1930.

This invention relates to heater systems, and it has particular relation to devices for abstracting heat from hot, high-velocity gases discharged from pressure-combustion, high-gas-velocity steam generators as described in my copending applications Serial Nos. 343,745 and 414,428 filed in 1929.

In such steam generators, a combustion mixture is subjected in a pressure-proof combustion chamber to combustion under high pressure, and the pressure in the chamber is utilized to impart to the combustion gases a high velocity of the order of 200 meters per second or more along heat exchange surfaces, formed of a plurality of gas tubes around which a steam generating fluid, such as water, is passed. The compressed hot gases, flowing with high velocity through the heating tubes, transfer the heat at a very high rate to the surrounding water and produce steam. Although, by reason of the high gas velocity, this heat transfer is large, causing the gases to arrive considerably cooled at the heating tube outlets, nevertheless, the gases are not cooled down enough to undergo a decrease of volume sufficient to substantially lower their velocity. The temperature of the gases leaving the heating tubes is relatively high, since notwithstanding the high heat transfer caused by the high velocity, the gas temperature cannot be less than the temperature of the vaporized water, and the latter is high at high steam pressures. The combustion gases discharged from the vaporizer contain, therefore, in addition to the kinetic energy of flow, a great amount of tangible heat. For efficient operation, it is essential that as much as possible of the energy contained in the gases of combustion discharged from the vaporizer should be utilized in the heating process.

Among the objects of the invention is an improved device for abstracting the kinetic energy of flow as well as the remaining heat energy from the discharged combustion gases and for utilizing the abstracted energy in the form of heat for heating purposes, particularly, for preheating the feed water of the generator.

The objects and features of the invention will be best understood from the accompanying drawing in which

Fig. 1 is a diagrammatic vertical view of a steam generator provided with a feed water heater embodying the invention;

Fig. 2 is a top view partially in section along line 2-2 of Fig. 1;

Fig. 3 is a vertical sectional view of another construction of a water heater; and

Fig. 4 is a sectional view along line 4-4 of Fig. 3.

In Fig. 1 is shown a steam generator with a feed water preheater therefor made according to the invention, a part of the feed water heater of this generator being shown in Fig. 2, in horizontal section along line 2-2 of Fig. 1. This steam generator is of the type described in my copending applications referred to above, and generates steam at a very high rate by subjecting a combustible charge to combustion under pressure in a pressure-proof chamber and utilizing the pressure of the hot combustion gases formed in the chamber for imparting to said gases a very high velocity through a set of gas tubes traversed on the outside by a steam generating fluid, such as water, thereby securing a very high rate of heat transference from the hot gases to the water and, as a consequence, very large steam generation within a relatively small structure.

The steam generator comprises a pressure-proof combustion chamber having a main cylindrical wall 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 wall 2 covering the interior thereof. The water 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 admixed steam being discharged through a conduit 10 into a steam separator 11, the steam separating and collecting in the upper part of the separator from where it is supplied to the load through pipe 12, and the water being collected in the lower part of the separator, fresh feed water being supplied thereto through pipe 13 leading from feed water pipe 14. The water from the separator 11 is circulated through water tubes 7 by means of water pump 15 which is connected by pipes 16 between the separator 11 and inlet 17 of water chamber 5.

A combustible charge, such as a gas or air with fuel admixed thereto, is compressed by compressor 20 and delivered to combustion chamber 1 through conduit 21 and a suitable inlet 22. The admitted compressed combustible charge is sub-

jected to combustion in the chamber. The pressure of the generated hot combustion gases is utilized to drive the gases at a velocity of about 200 meters per second or above through a set of gas or fire tubes 26 connected to the upper end of the chamber and leading through the interior of the water tubes 7. The gases leaving the outlet ends of the gas tubes 7 are then discharged through the tubes 37 in a set of water preheaters 31 mounted around the chamber wall 2, leaving therefrom into the exhaust duct 32. The compressor is driven by a suitable auxiliary driving aggregate, such as a steam engine or Diesel engine, or gas turbine to produce in the compressor the pressure head necessary for imparting to the combustion gases the high velocity through the gas tubes 26.

The combustion within the chamber 1 may be carried on either as a continuous process, in which case the inlet 22 forms a burner at which a continuously supplied compressed charge is continuously burned within the chamber; or the combustion may be carried on as a periodical process like in a combustion engine, in which case the inlet 22 is arranged as a valve which periodically opens and admits an initially compressed charge which is then exploded in the chamber, as by spark plugs mounted within the chamber, the process being cyclically repeated and the pressure of the generated hot combustion gases imparting to them the high velocity through the gas tubes 26.

The construction and arrangement of the water preheaters are constructed to utilize with a high degree of efficiency the energy of the combustion gases leaving the gas tubes 7 of the steam generator. According to the invention, the water heater is provided with a plurality of tubes of increasing cross section, the small ends of the tube being connected to receive the still hot, high-velocity combustion gases and to discharge them through the tubes in the direction of their divergence. This causes a reduction of the velocity of the gases during their flow through the divergent tubes, increasing the pressure of the gases and their temperature. From the so slowed-down combustion gases, the residual heat is abstracted by circulating relatively cold water, such as boiler feed water, in heat exchange relation around the tubes.

One form of such feed water preheater is shown in Figs. 1 and 2. Around the tubular chamber wall 2 are mounted a plurality of water heater units 31, each unit comprising a gas tube 37 which is divergent in upward direction. The lower ends of the individual gas tubes 37 are connected by tubular loops 38, that may be externally insulated, with the lower outlet ends of the fire tubes 26 of the steam generator, and the upper ends of the preheater gas tubes open into a manifold 39 surrounding the upper end of the chamber 1, the exhaust duct 32 leading from the manifold. The gases discharging at high velocity from the fire tubes 26 are thus forced to flow through the preheater tubes in the direction of increasing cross section, going then by way of the manifold 39 and exhaust duct 32 into the atmosphere.

The individual preheater gas tubes are surrounded by water jackets 40, the upper ends of the water jackets being connected through an inlet duct 41 to the feed water line 14, and the lower ends of the water jackets are connected through duct 42 to pump inlet 43 of the water pump 15 to draw relatively cool water from the

feed water line 14 and admix it after preheating in heaters 21 with the water circulated by the pump through the water tubes 7 of the generator. The preheater gas tubes 37 are made up of a series of cylindrical tube sections of different diameters joined by conical sections as shown in Fig. 1, or may be of gradually widening divergent shape like diffusers.

The combustion gases leaving the fire tubes 26 of the steam generator reach the preheater gas tubes 37 with a high velocity of the order of 200 meters per second or more, and are still at a relatively high temperature. Due to the increasing cross section of the preheater tubes 37, they decrease the velocity of the combustion gases from the high value which they have when they reach the inlets, to a relatively low value at the outlets into the exhaust duct. The kinetic energy of the high velocity gases is thus utilized to recompress the gases in the preheater tubes, the recompression being accompanied by an increase of the temperature of the gases. The heat so generated in the heater tubes 37, and the friction heat produced by the gas flow are transferred with the tangible heat still present in the incoming gas to the cool feed water flowing around the preheater tubes 37. By the recompression of the gas in the tubes 37 of the preheater, the energy present in the gases leaving the fire tubes 26 is thus regained as heat and, together with the other heat therein, it is utilized for preheating of the feed water. The heat of which the combustion gases were deprived in being accelerated to high velocity at the entrance into the fire tubes 26 and by the subsequent expansion under temperature drop within the fire tubes is again usefully restored through the rise of the gas temperature produced by the recompression in the preheater tubes.

Another advantage of this arrangement resides in the condensation of the combustion water present in the combustion gases. On account of the still high velocity of the combustion gases flowing in the preheater tubes 37, the heat transmission to the walls and the cooling action of the cold feed water is so rapid that the water of combustion which is present in the discharged combustion gases in the form of steam, is condensed and precipitated, even if the temperature of the gases is still above the vaporizing temperature corresponding to the partial pressure of the combustion water. As a result, the latent heat of vaporization of the condensed water is given up to the walls and therethrough to the feed water. The preheating of the feed water by the latent heat of vaporization of the combustion water is thus a pure gain which was never before utilized in combustion processes.

Instead of using single tube preheaters as shown in Figs. 1 and 2, multiple tube preheaters as shown in Figs. 3 and 4 may be employed. Such preheaters may be arranged in the form of a plurality of sections 51 around the periphery of the combustion chamber wall 2, each section comprising a flat segmental casing 52 curved to fit for mounting around a portion of the chamber wall. The casing is subdivided by partition walls 53 to 57 into a plurality of transversal horizontal water compartments 58 to 61 that are connected at their opposite ends in series to form a zig-zag path from the water inlet 62 into the upper compartment 61, and then through the successively lower compartments 60, 59, 58 to the water outlet 63. At spaced points along the width of the casing 52 are mounted groups of flat gas tubes

65 extending longitudinally in vertical direction through the casing and sealed through the horizontal partition walls 53 to 57. The gas tubes 65 are also of divergent shape, becoming wider in the direction from the bottom to the top. The lower narrow ends of each group of gas tubes open into a small gas inlet chamber 66 formed in the cover plate 67 enclosing the underside of the casing 52, an inlet tube 68 being connected to the inlet chamber to admit high velocity exhaust gases coming from the fire tubes 26 of the steam generator. The inlet chamber 66 of each group of preheater tubes 65 may be completely separated from the others, and either one or several of the generator fire tubes 26 may be connected to each inlet chamber 66. The upper wide ends of the heater tubes open all into a gas manifold 70 mounted on the top side of casing 52, from where the gases then flow out through gas duct 32.

The operation of the multiple tube preheater in conjunction with the steam generator is similar to that of the arrangement shown in connection with Figs. 1 and 2. The combustible charges are subjected to combustion under pressure in combustion chamber 1 and are discharged with a velocity of the order of about 200 meters per second or more through the fire tubes 26 of the generator, generating steam in the preheated water circulating around it. The high velocity gases leaving the fire tubes 26 of the generator flow then through the inlet pipes 68 into the different gas tube groups 65 where they are slowed down, giving up their heat, increased by the compression in the diffuser-shaped tubes, to the feed water fed from the feed water supply through the zig-zag connected compartments 58 to 61 and outlets 63, in a direction opposite to the direction of the hot gas flow, to the water pump 15 of the generator.

Many other forms of the invention will suggest themselves to those skilled in the art.

I claim:

1. In a heater for abstracting the heat present in high-velocity gases of combustion of a steam generator, a casing for holding water to be vaporized, a plurality of groups of tubes extending through said casing, said tubes being flattened and of increasing cross sections and receiving hot gases at their small ends from the generator, and a manifold receiving the gases from said tubes.

2. A heating device for extracting heat from high-velocity, hot combustion gases comprising a set of heater tubes increasing diffuser-like in cross section in the direction of their length, inlets on the small ends of said tubes, means for discharging through said inlets relatively hot, high-velocity gases into said tubes in direction of their divergence reducing the velocity of the gases and converting a part of their kinetic energy into increased pressure within said tubes, and means for passing fluid to be heated in heat exchange relation to said tubes abstracting from the flowing gases their residual heat.

3. In a water preheater for a steam generator in which the gases of combustion are driven at high velocity across the heat exchange surfaces, a plurality of heater tubes having inlets for re-

ceiving gas and discharging it through the tubes, said tubes having an increasingly wider cross section in the direction of the gas flow therethrough, means for discharging relatively hot, high-velocity gases from the heat exchange surfaces of said generator through the inlets into said tubes in the direction of their divergence to slow down and compress the gases, and means for passing said feed water for said generator in heat exchange relation to said tubes abstracting from the flowing gases their residual heat.

4. A heating device for extracting heat from hot combustion gases discharged at high velocities from a steam generator, in which combustible charges are subjected to combustion under pressure and the combustion gases are driven by the pressure at high velocity over vaporizer heat exchange surfaces, comprising a set of heater tubes increasing diffuser-like in cross section in the direction of their length, inlet means on the small ends of said tubes and outlet means on the large ends of said tubes arranged to discharge hot, high-velocity gases received from said steam generator through said tubes in direction of their divergence reducing the velocity of the gases and converting a part of their kinetic energy into pressure within said tubes, and means for passing water to said generator in heat exchange relation to said tubes abstracting from the flowing gases their residual heat.

5. A heating device for extracting heat from high-velocity combustion gases, comprising a set of heater tubes increasing diffuser-like in cross section in the direction of their length, inlets at the small ends of said tubes, means for discharging relatively hot combustion gases at velocity of about 200 meters per second through said inlets into said tubes in the direction of their divergence and converting a part of the kinetic energy of the flowing gases into increased pressure of the gases within said tubes, and enclosure means associated with said heater tubes for passing a fluid in heat exchange relation to said heater tubes to heat the fluid by absorbing heat from said gas.

6. A preheater of steam generating fluid for a steam generator in which a compressed combustion charge is subjected in a pressure-proof combustion chamber to combustion under pressure, and the pressure is utilized to impart to the combustion gases a velocity of the order of about 200 meters per second or more through a set of vaporizer tubes surrounded by enclosure means carrying a steam generating fluid heated by said gases to steam generation, comprising a plurality of heater tubes having inlet ends connected to receive from said vaporizer tubes the high velocity gases discharged therefrom and to discharge said gases through said heater tubes, said heater tubes having an increasingly wider cross section in the direction of the gas flow therethrough to slow down the gases and increase their pressure, and enclosure means surrounding said heater for passing said steam generating fluid in heat exchange relation to said heater tubes to preheat the fluid for said generator by absorbing heat from said gas.

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