July 8, 1952 J. D. KUPPENHEIMER 2,602,433

SUPERHEATING AND REHEATING OF VAPOR

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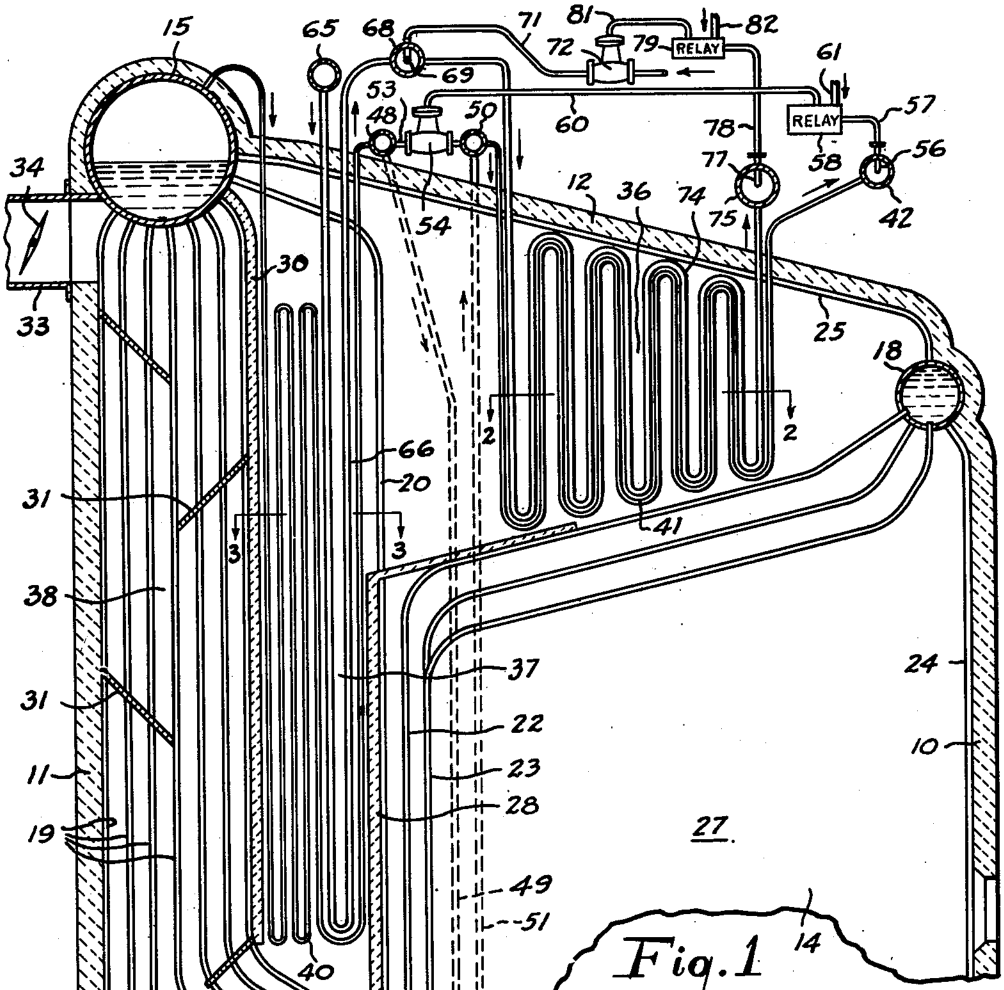

Fig. 1

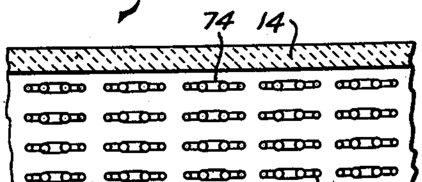

Fig. 2

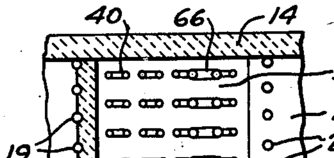

Fig. 3

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SUPERHEATING AND REHEATING OF VAPOR

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1 Claim. (Cl. 122—479)

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This invention relates to the superheating and reheating of vapor, and more particularly to an apparatus whereby vapor, such as steam, may be superheated for use in the high pressure stages of a turbine and then reheated for use in the low pressure stages of the turbine.

Apparatus heretofore provided for this purpose often includes a vapor generator having a combustion chamber within which fuel is burned to produce hot gases. These hot gases are utilized not only for vapor generation but also for the superheating and reheating of the steam. For this purpose there are usually provided a low temperature superheater, a high temperature superheater, and a reheater located between the two superheaters, the arrangement being such that the hot gases will flow in contact with the high temperature superheater, the reheater, and the low temperature superheater, in the order named. Such an apparatus has certain serious disadvantages. For the most efficient generation of power it is desirable that the temperature of the vapor leaving the reheater should be high and approximately the same as the temperature of the vapor leaving the high temperature superheater. However, a considerable reduction in the temperature of the hot gases takes place as they flow in contact with the high temperature superheater, and by the time the gases reach the reheater the heat "head" or difference between the temperature of the hot gases and the temperature of the vapor in the reheater is comparatively low. Consequently it is necessary to provide a relatively large reheater in order that the vapor may be reheated to the required temperature. Such a large reheater is very expensive, it occupies valuable space, and it produces an excessive drop in the pressure of the vapor flowing therethrough. Furthermore, if the size of the high temperature superheater is altered in order to effect an adjustment in the temperature of the vapor leaving the same, this will change the temperature of the gases reaching the reheater and thus alter the temperature of the vapor leaving the reheater, which is undesirable.

It is accordingly one object of the invention to provide a relatively simple, inexpensive, and dependable apparatus for superheating and reheating vapor.

It is a further object of the invention to provide a new and highly advantageous apparatus for utilizing the heat of hot gases to generate vapor, to superheat the vapor, and to reheat the vapor.

With these and other objects in view, as will

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be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claim appended hereto.

Referring to the drawings illustrating one embodiment of the invention, and in which like reference numerals indicate like parts,

Fig. 1 is a longitudinal vertical section through an apparatus for the generation, superheating and reheating of vapor, such as steam;

Fig. 2 is a fragmentary section taken on the line 2—2 of Fig. 1;

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

In Fig. 1 there is shown a boiler setting comprising a front wall 10, a rear wall 11, a roof 12, and two side walls 14 (one only of which appears). A transverse steam-and-water drum 15 is located in the upper rear portion of the setting, and a transverse water drum 16 is spaced a substantial distance below the drum 15. A transverse water drum or header 18 is located in the upper front portion of the setting. A bank of upright water tubes 19 is located immediately in front of the rear wall 11 and connects the drums 15 and 16. These drums are also connected by a row of upright water tubes 20 which are spaced forwardly a substantial distance from the tubes 19. A row of water tubes 22 extend upwardly from the drum 16 in front of the tubes 20 for a portion of the height of the latter tubes and then are bent forwardly to connect with the front drum 18. Other water tubes 23 are located in front of and beneath the tubes 22 and likewise connect at their upper ends with the header 18. A row of water tubes 24 extend upwardly along the front wall 10 and are connected to the front drum 18. A row of water tubes 25 lie directly beneath the roof 12 and connect the drums 15 and 18.

The space 27 behind the front wall 10 provides a combustion chamber in which a suitable fuel, such as oil or pulverized coal, is burned to produce hot gases. In order to direct these gases in a desired manner, certain baffles are provided. A baffle 28 extends upwardly from the lower water drum 16 part way along the water tubes 20 and then forwardly along the tubes 22, this baffle terminating a substantial distance to the rear of the front durm 18. A baffle 30 extends downwardly from the steam-and-water drum 15 along the front row of water tubes 19 and terminates a substantial distance above the lower drum 16. Other baffles 31 extend across the water tubes 19 to direct the gases in a tortuous course. A soot hopper 32 is located behind the lower drum 16, and a gas outlet duct 33 with the usual damper 34 therein is located adjacent the upper drum 15. The space 36 beneath the roof 12 and above the upper forwardly extending portions of the water tubes 22 forms a passage through which hot gases from the combustion chamber 27 may flow in a generally rearward direction. The space 37 between the baffles 28 and 30 forms a passage through which the gases leaving the passage 36 may flow downwardly. The space 38 between the rear wall 11 and the baffle 30 forms a passage through which the gases leaving the lower end of the passage 37 may flow upwardly to the outlet duct 33.

The hot gases heat the various water tubes and generate steam therein, this steam being released in the steam-and-water drum 15. This will be saturated steam, its temperature being the temperature of boiling water corresponding to the pressure within the drum. If this pressure is say 1050 pounds per square inch, the steam temperature will be 552 degrees Fahrenheit. Before such steam can be used efficiently for the generation of power in a steam turbine, it is necessary to superheat the steam to a comparatively high temperature, such as 1000 degrees F. This superheating is preferably done in two separate stages. For this purpose a low temperature superheater 40 is mounted within the passage 37 and arranged to receive steam directly from the drum 15, and a high temperature superheater 41 is mounted within the passage 36. The superheater 41 is arranged to receive steam from the superheater 40 and to deliver the steam to a header 42 from which it may flow to a steam turbine (not shown) for the production of power. Each of the superheaters 40 and 41 comprises a plurality of tubes spaced apart laterally and each bent into sinuous form to provide a plurality of upright loops lying in a vertical plane.

It is important to maintain the temperature of the steam in the header 42 as closely as possible to the desired value of 1000 degrees. For this purpose the superheaters 40 and 41 are made large enough to heat the steam to a somewhat higher temperature under most conditions, and means is provided to desuperheat the steam slightly after it leaves the superheater 40 and before it enters the superheater 41. The particular means illustrated comprises a desuperheater 44 immersed in the boiler water in the lower drum 16 and having an inlet header 45 and an outlet header 46. The low temperature superheater 40 is provided with an outlet header 48 which is connected to the desuperheater inlet header 45 by a pipe 49. The high temperature superheater 41 is provided with an inlet header 50 which is connected to the desuperheater outlet header 46 by a pipe 51. The headers 48 and 50 are connected to one another by a pipe 53 having a diaphragm actuated valve 54 of well-known type therein to control the flow.

The valve 54 is controlled in response to variations in the temperature of the steam within the superheater outlet header 42, in order to minimize such variations. This may be brought about by apparatus of a well-known type comprising a temperature responsive bulb 56 located within the header 42 and connected by a tube 57 to a relay 58 which in turn is connected by a tube 60 to the diaphragm chamber of the valve 54. Air or other suitable fluid under pressure is supplied to the relay 58 through a tube 61. These parts are so constructed and arranged that if the temperature of the steam reaching the header 42 should increase and slightly exceed the desired value of 1000 degrees, the bulb 56 will respond to such increase and cause the relay 58 to transmit a slightly increased fluid pressure to the diaphragm chamber of the valve 54, thereby closing this valve slightly and causing a larger portion of the steam from the header 48 to flow through the pipe 49, the desuperheater 44, and the pipe 51 to the header 50. This will reduce the temperature of the steam entering the high temperature superheater 41, and thereby reduce the temperature of the steam reaching the outlet header 42. Similarly, upon a slight reduction in temperature within the header 42, the relay 58 will open the valve 54 slightly and cause a smaller proportion of the steam to pass through the desuperheater 44, thereby raising the temperature of the steam entering the high temperature superheater 41. Thus the steam temperature at the outlet header 42 is maintained at the desired value, and at no point in the system is the steam heated to a temperature exceeding the maximum temperature desired at the said header 42. Because of the resistance to steam flow through the superheaters and the desuperheaters, the pressure of the steam at the header 42 may be approximately 1000 pounds, i. e., 50 pounds less than the pressure in the drum 15.

The steam from the header 42 is delivered to the high pressure stages of a steam turbine (not shown), where power is produced in known manner. By the time the steam has passed through these stages, its pressure will have been reduced to say 500 pounds, and its temperature will have dropped to say 500 degrees. This is somewhat above the saturation temperature for this pressure, so that the steam will be dry. Before this steam enters the low pressure stages of the turbine it is desirable to reheat the steam and thereby prevent, or at least minimize, condensation within the turbine. Preferably the steam is reheated to approximately the same temperature as that to which it was originally superheated, i. e. 1000 degrees F.

Referring once more to the drawings, it will be seen that a header 65 is provided to receive the steam to be reheated, and the tubes 66 of a low temperature reheater are connected to this header to receive steam therefrom. These tubes 66 are bent into the form of upright loops located within the downflow gas passage 37, and they deliver the steam into a desuperheater 68 of the well-known spray type having a spray pipe 69 therein. The spray pipe 69 receives substantially pure water, such as condensate, at a suitable pressure from a pipe 71 under the control of a diaphragm valve 72. From the desuperheater 68 the steam enters a high temperature reheater 74 located within the gas passage 36 and arranged to deliver the reheated steam to an outlet header 75 from which it may flow to the low pressure stages of the turbine. The reheater 74 comprises a plurality of tubes spaced apart laterally and each bent into sinuous form to provide a plurality of upright loops lying in a vertical plane.

The temperature of the steam in the outlet header 75 is preferably maintained substantially constant and approximately equal to that of the steam within the header 42, i. e. 1000 degrees F. For this purpose a temperature responsive bulb 77 is located within the header 75 and connected by a tube 78 to a relay 79 which in turn is connected by a tube 81 to the diaphragm chamber of the valve 72. Air or other suitable fluid under pressure is supplied to the relay 79 through a tube 82. These parts are so arranged that upon a slight increase in the steam temperature within the header 75, the bulb 77 will cause the relay 79 to transmit a slightly decreased fluid pressure to the diaphragm chamber of the valve 72, thereby causing this valve to open slightly and admit more water to the spray pipe 69 in the desuperheater 68. This will immediately lower the temperature of the steam entering the reheater 74, and thereby lower the temperature of the steam reaching the header 75. Similarly, a slight reduction in the temperature within the header 75, below the desired value, will cause the relay 79 to close the valve 72 slightly and reduce the rate at which water is sprayed into the desuperheater 69, until the desired temperature is restored in the header 75. At no point in the system is it necessary to reheat the steam to a temperature above that desired in the header 75.

The high temperature superheater 41 and the high temperature reheater 74 are located within a common gas passage 36 and subjected to heat from a common gas stream. Thus they are subjected to substantially the same heat head or temperature difference. Preferably the elements of these two heat exchangers are closely intermingled, so as to minimize the effect of any differences in the gas temperature across the passage. As shown in Figs. 1 and 2, each reheater tube 74 may be located in a common vertical plane with an adjacent superheater tube 41, the loops intermeshing within these planes. The flow of the steam through the superheater 41 and through the reheater 74 is in a generally forward direction toward the front drum 18 and opposite to the generally rearward direction of flow of the hot gases in the passage 36. Thus the flow of the steam and the flow of the gases are opposite, providing efficient transfer of heat. Also, the high temperature portions of the reheater and of the superheater are adjacent to one another and are equally exposed to the high temperatures of the gases entering the passage 36 at perhaps 1800 degrees F. Hence considerably less total heating surface will be required for the reheater than with prior constructions in which the reheater is located behind the superheater. Because of the reduced size of the reheater, the pressure loss in the steam flowing

therethrough will be less than with prior constructions. The weight of the steam flowing through the reheater 74 per hour will ordinarily be substantially the same as the weight of the steam flowing through the superheater 41 per hour, since only a small quantity of water will be added at the desuperheater 68. However, the pressure within the reheater will be considerably less, and the volume of the steam flowing therethrough per hour will accordingly be greater than in the case of the superheater. Hence it will ordinarily be desirable to make the reheater tubes 74 somewhat larger in diameter than the superheater tubes 41, to avoid too great a pressure drop through the reheater.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

Apparatus for superheating and reheating vapor comprising means providing a passage for the flow of hot gas in a stream extending throughout the entire width of the passage, a superheater for vapor under pressure having a plurality of separate elements distributed substantially uniformly across the entire width of the passage, and a reheater for vapor under a somewhat lower pressure having a plurality of elements which are intermingled substantially uniformly with the superheater elements across the entire width of the passage so that all the superheater elements and all reheater elements will be subjected to the heat of gas at substantially the same temperature, each superheater element comprising a tube bent into sinuous form to provide a series of loops lying in a common plane, and each reheater element likewise comprises a tube bent into sinuous form to provide a series of loops lying in a common plane, all of said planes extending parallel with the general direction of the gas flow in the passage, and each reheater tube lies in a common plane with one of the superheater tubes, the loops of the tubes being intermeshed.

JOHN D. KUPPENHEIMER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,952,542	Ehlinger	Mar. 27, 1934
2,035,763	Robinson	Mar. 31, 1936
2,477,950	Bailey	Aug. 2, 1949