

Sept. 15, 1942.

E. G. BAILEY

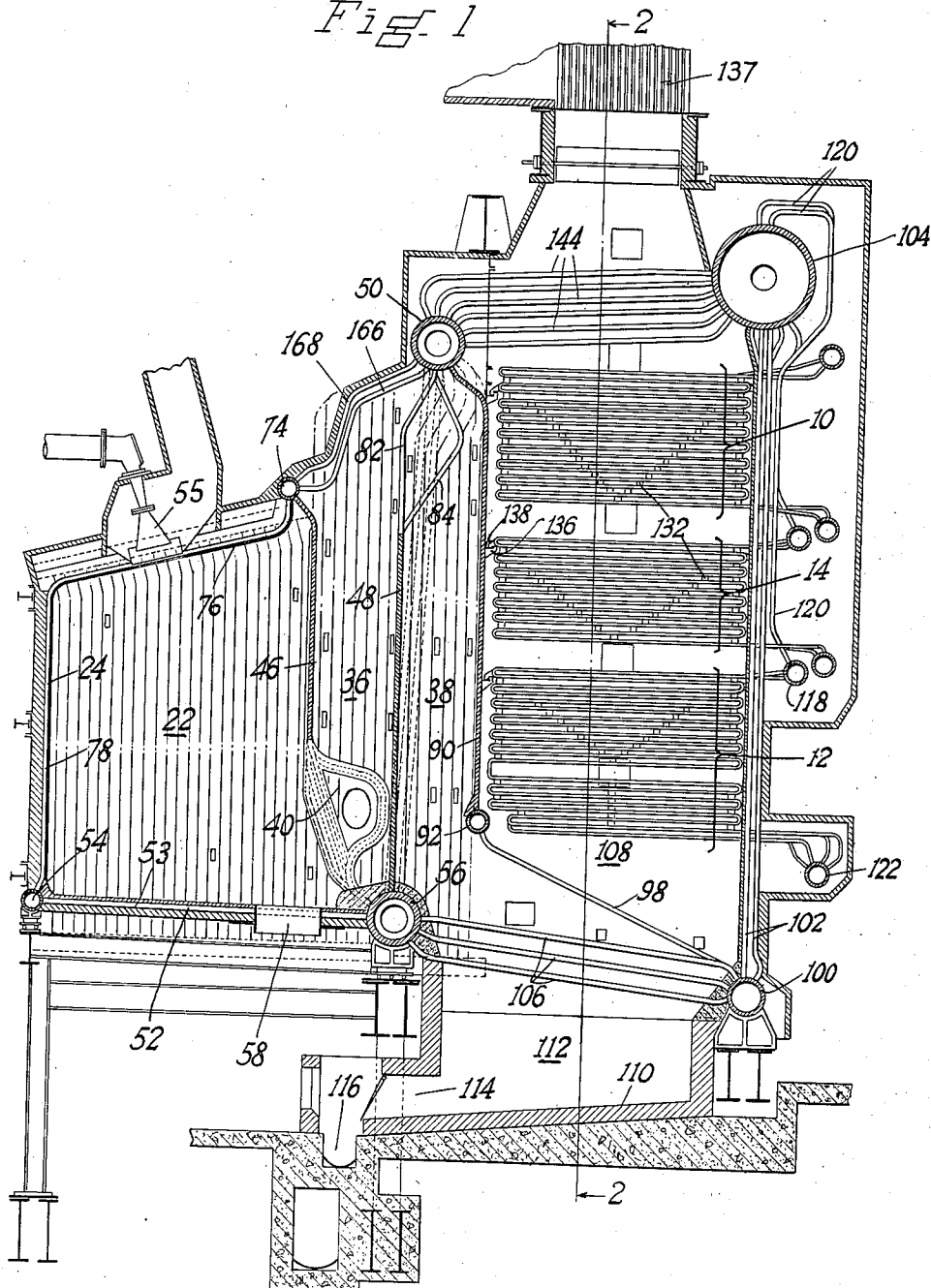
2,295,538

STEAM GENERATOR

Filed March 13, 1940

3 Sheets-Sheet 1

Fig. 1



INVENTOR.

BY *Ervin G. Bailey*

R. M. Holbrook

ATTORNEY.

Sept. 15, 1942.

E. G. BAILEY

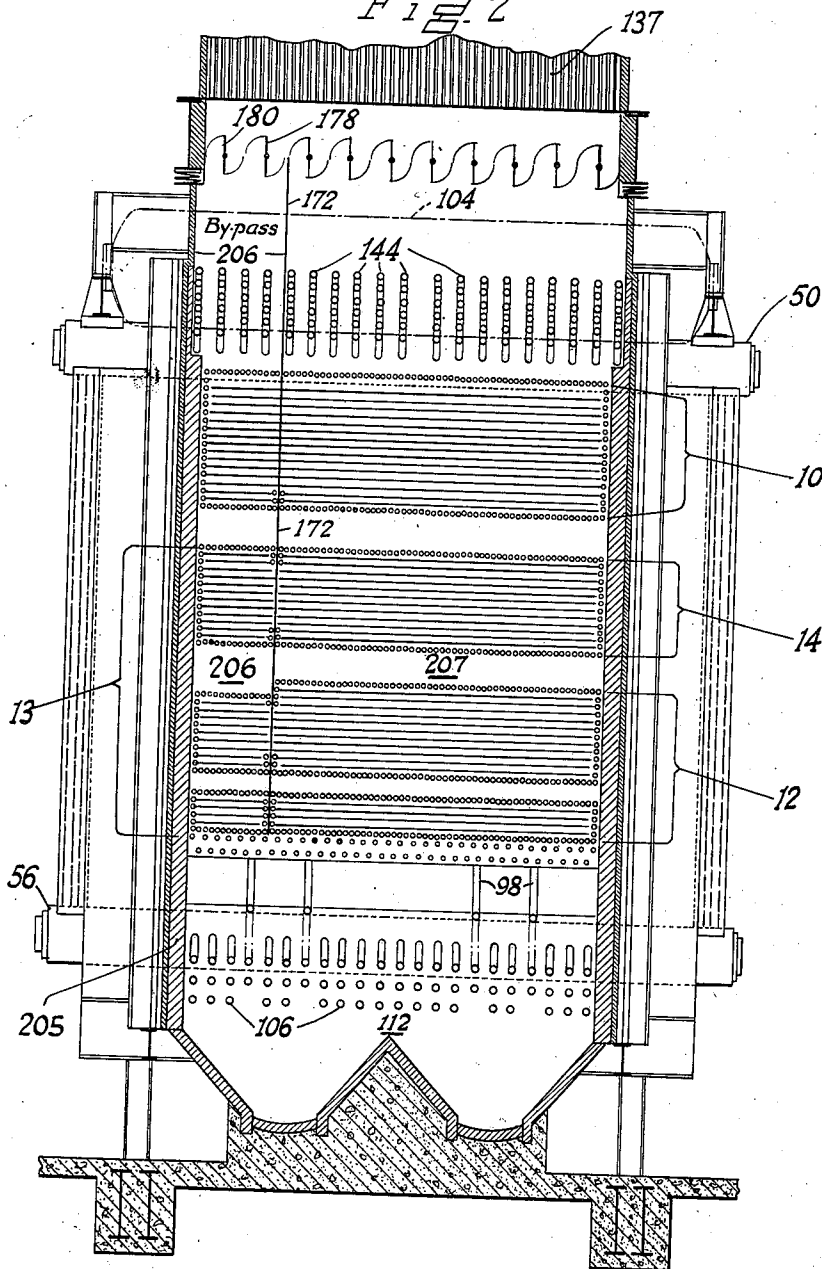
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Fig. 2



INVENTOR.
BY *Ervin G. Bailey*
M. Holbrook
ATTORNEY.

Sept. 15, 1942.

E. G. BAILEY

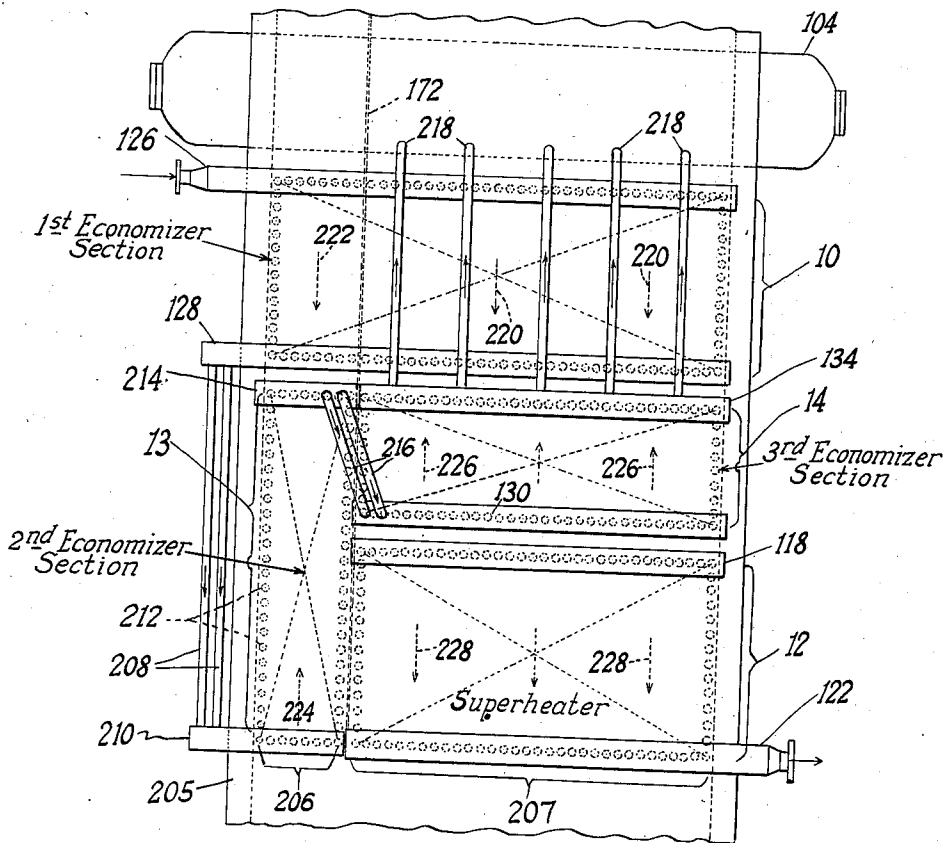
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Fig. 3



INVENTOR.
BY *Ervin G. Bailey*
M. Holbrook
ATTORNEY.

UNITED STATES PATENT OFFICE

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STEAM GENERATOR

Ervin G. Bailey, Easton, Pa., assignor to The
Babcock & Wilcox Company, Newark, N. J., a
corporation of New Jersey

Application March 13, 1940, Serial No. 323,710

13 Claims. (Cl. 122—477)

This invention relates to steam boilers of the high pressure high superheat type and more particularly to those involving a steaming economizer or two stages of evaporation.

In order to attain a high overall thermal efficiency in steam boilers it is necessary to operate at high steam pressures and also at high steam temperatures. High steam temperatures are attained by the use of superheaters which raise the steam temperature from saturated to the desired final or superheat temperature.

The superheating may be accomplished by the use of the radiant type superheater or the convection type, or both in combination, but in each instance it is necessary to subject the superheater to gases of high temperatures. With the convection type of superheater it is, of course, practical to control the heat input by the regulation of gas quantities or gas temperature, while radiant absorption is subject to variation primarily by change in gas temperature. The convection superheater is more flexible in its use and therefore used more extensively, but its use with a bypass for regulating the gas flow thereover introduces complications and difficulties with respect to the construction and operation of other components of the complete boiler unit, and it is the object of this invention to overcome such difficulties.

With a bypass superheater it is in the interest of thermal efficiency to provide water cooled heat absorbing surface in the bypass flue so that the final gas temperature from the flue will be at least as low as the temperature of the gases leaving the superheater pass. Also, in modern boilers of the type utilizing convection superheaters of the horizontal multiple loop tube type, it is in the interest of high absorption capacity and effective space utilization to provide the above mentioned water cooled convection surface in the form of horizontal multiple loop tubes as a part of the economizer whereby it is subject to the forced flow of feed water during normal operation.

It is also the purpose of this invention to so dispose the economizer surface that steam generated therein will have minimum of disturbing reactions in connection with other characteristics of the boiler unit.

The invention involves an arrangement of convection superheating and water heating surface between which the heating gas flow can be divided or proportioned as indicated in the interest of superheat or superheater tube temperature requirements. The invention provides an arrange-

ment of economizer surface a portion of which may generate steam under certain operating conditions without becoming steam-bound.

It has been found that a preferable arrangement for the use of a multiple loop horizontal tube economizer in a steaming gas pass in parallel with a gas pass flue of a high temperature superheater is one in which the feed water is first heated by a non-steaming section located in the gas path above the superheater and above the steaming economizer, and with the feed water subsequently passing to the upflow steaming section located in whole or in part in the damper controlled bypass flue. With such an arrangement the extent of internal economizer tube volume between the zone where the economizer is first contacted with hot gases and the discharge connection to the boiler drum is limited, and changes in steam volume in the steaming section will have a minimum effect in disturbing water levels in the steam and water drum.

The invention will be described with reference to the accompanying drawings, and other objects of the invention will appear as the description proceeds.

In the drawings:

Fig. 1 is a sectional elevation of a steam boiler constructed in accordance with the teachings of this invention;

Fig. 2 is a vertical section on the line 2—2 of Fig. 1, illustrating the arrangement of tubes and the provisions for superheat control in the convection section of the boiler; and

Fig. 3 is a diagrammatic view in the nature of an elevation showing the arrangement of the economizer parts and the superheater, with their headers.

The boiler illustrated in Fig. 1 includes banks of tubes extending across the path of the furnace gases. Some of these tubes carry steam which is being superheated and they are represented in Fig. 1 as the tubes of the superheater 12. Other banks of similarly positioned tubes form the first and second economizer sections 10 and 13, respectively.

The superheater and the economizer are subject to furnace gases originating in the combustion chamber 22 the walls of which present non-metallic refractory faces to the burning fuel, the refractory material being maintained on wall tubes 24 by metallic studs welded to the tubes.

Beyond the combustion chamber 22, I provide means for lowering the temperature of the gases flowing from that chamber to such banks of tubes as those forming the superheater 12 and the sec-

ond economizer section 13, a predominant amount of the heat absorbed between the superheater and the combustion chamber 22 being transmitted to the walls of the intervening passages 36 and 38 by gaseous radiation, the walls of these passages being defined by tubes connected into the boiler circulation.

The outlet 40 through which the furnace gases pass from the combustion chamber 22 into the gas pass 36 is at the bottom of that chamber where it is crossed by refractory covered screen structures formed by bending the tubes of the wall 46. At the bottom of the combustion chamber 22, I provide a furnace floor 53 cooled by the floor tubes 52 directly communicating with the header 54 and a drum 56, and connected by the latter into the fluid circulation of the boiler. When pulverized fuel is utilized by the burners 55 the floor tubes 52 are covered with refractory material so that slag may be maintained on the bottom of the furnace. The collected slag is discharged through a slag opening 58 to a subjacent slag pit (not shown).

The tubes defining the wall 46 and the gas mixing screen extending across the outlet 40 of the combustion chamber 22 are shown to communicate at their lower ends with the drum 56 and at their upper ends with the header 74. Other furnace wall tubes directly connect the headers 74 and 54 and extend along the roof 76 and the wall 78 of the combustion chamber.

The other wall 48 of the passage 36 includes tubes 82 and 84 directly connecting the drums 50 and 56, the tubes 84 being bent out of their wall-forming alignment at their upper ends so as to reduce draft loss as the gases pass into the chamber 38.

The wall 90 of the passage 38 may be of a construction similar to that of the wall 48 and it includes tubes directly connecting the drum 50 and the header 92. The latter may be supported by the tubes of the wall 90 which are suspended from a part of the setting. Water is supplied to the header 92 by the tubes 98 which communicate at their lower ends with the header 100. The latter is connected by a number of downtake tubes 102 with the water space of the drum 104 and circulatory connection between the header 100 and the drum 56 is formed by the tubes 106 which extend beneath the downflow passage 38 and the up-pass 108. The tubes 106 will act upon all ash particles coming in contact therewith to cool them so that they may be accumulated for removal upon the inclined floor 110 of the hopper 112. Such accumulations of ash may be continuously or periodically removed by causing them to pass through the outlet 114 to the sluiceway 116.

Other characteristics of the steam generator are described in my co-pending application 88,285, filed on July 1, 1936, and issued as Patent 2,196,889, dated April 9, 1940. The present application is a continuation-in-part thereof.

The superheater and economizer sections 10, 12, and 14 are of the continuous tube type. As shown, the superheater 12 has an inlet header 118 connected by tubes 120 to the steam space of the drum 104. From the header 118 the superheater tubes extend back and forth across a part of the gas pass 108 and are connected at their outlet ends to the header 122.

An illustrative arrangement of the economizer sections and the superheater sections may be regarded as particularly shown in Figs. 2 and 3 of the drawings. As here shown, the second

economizer section 13 is located in the superheat control bypass 206 formed by the setting wall 205 and the division wall 172.

Feed water enters the economizer inlet header 126 (Fig. 3) and flows through the tubes of the economizer section 10 to the header 128. From one end of the latter the flow is through the downtakes 208 to the header 210 for the second economizer section or auxiliary economizer section 13. From this header the flow is upward through the looped tubes 212 to the header 214 and thence through the tubes 216 to the header 130 of the third economizer section 14. From the header 130 water, or a mixture of water and steam, flows upwardly through the tubes of the economizer section 14 to the header 134 and thence to the drum 104 by way of the uptake tubes 218. In the particular embodiment shown the headers 214 and 134 are structurally defined by a transverse diaphragm in a single long header.

At low loads the amount of gases sweeping the tubes of the economizer section 13 and that part of the economizer section 10 in the bypass 206 is decreased, sufficient active economizer circuits being provided by the third economizer section 14 and that part of the economizer section 10 contacted by the furnace gases in the main part of the gas pass 108, in which the superheater 12 is disposed.

The arrows 220 and 222 indicate the downflow of water in the economizer section 10 and the arrow 224 indicates an upflow of water in the economizer section 13. Similarly, the arrows 226 indicate an upflow of water in the economizer section 14.

As indicated in Fig. 3 of the drawings the header 122 is the outlet header of the superheater, the flow of steam being downward as indicated by the arrows 228.

Both the superheater tubes and the economizer tubes are of small diameter and they are also arranged in closely spaced relationship. For example, 2" O. D. tubes may be arranged on a center to center spacing transversely of the gas pass, of the order of 3". The tube leg spacing longitudinally of gas flow may be somewhat greater but is preferably not more than 4".

The successive loops of the superheater tubes and the economizer tubes are preferably united by metallic struts 132. Such struts may be used in the lower temperature zones but between the successive economizer tubes and superheater tubes in the higher temperature zones the successive tubes are preferably connected by slip hanger constructions to compensate for the greater degree of expansion and contraction of these tubes. Such slip hanger constructions are illustrated in the United States patent to Gilg 2,134,713, granted November 1, 1936. In any event, the successive loops of the economizer section and the superheater are so joined that they form vertically arranged flat coils. These coils may be supported by lugs welded to the tubes 102 at one side of the gas pass and by the lugs 136 welded to the tubes of the wall 90, at the other side of the gas pass. Co-operating lugs 138 are welded to the coils. The furnace gases after passing across the economizer and the superheater proceed across the circulators 144 which directly connect the drums 50 and 104. The gases then flow between the dampers arranged at the top of the gas pass 108 and thence to the air heater 137.

The drum 50 is directly connected to the head-

er 74 by an inner row of tubes 166 and an outer row 168 and the spaces between the tubes 168 may be closed by stud tube and refractory constructions similar to those employed in the walls of the combustion chamber 22. Some of these spaces are however left open so as to provide for the operation of lance bars to remove slag which may unduly accumulate on the tubes 82 and 84.

Preferably the baffle or division wall 172 separating the superheater bypass 206 from the gas pass 207 is so positioned that the major part of the gases pass through the latter. Preferably, this baffle is so arranged that the superheater bypass 206 is about one-fourth the flow area of the gas pass 207. The superheat is controlled by regulating the end dampers 178 and 180 directly at the outlet of the bypass 206, and these dampers are intended to be open at full load so that the maximum amount of furnace gases will then pass over the second economizer section or auxiliary economizer section 13, and as the load decreases the dampers 178 and 180 will be moved toward their closed positions.

The liquid cooled heat transfer surface in the bypass flue 206 consisting of a portion of the first economizer section 10 and the second economizer section 13 provides for cooling the flue gases passing therethrough, to a degree substantially corresponding to the cooling of the gases flowing through the main flue 207, as effected by the superheater 12, the third economizer section 14, and the portion of the first economizer 10 which is included therein.

It is also to be noted that the convection heat absorbing surface provided in the two passes is of the horizontal multiple loop tube type, and the elements, whether superheater or economizer elements, are of corresponding lengths and general shape. This arrangement is advantageous in permitting more flexible design and lower cost construction in that the two sets of elements can both be supported on the same set of water cooled elements by similar devices, such as supports 136 and 138.

In this manner heat absorption in the specific surfaces, such as superheating and boiler heating surfaces, are controlled to the end that the total steam superheat temperature is maintained at the desired figure without a sacrifice of thermal efficiency. At the same time the fluid flow path is so arranged that good economizer flow conditions are maintained.

While I have described my invention with reference to a specific embodiment thereof, it is to be appreciated that the method is not to be limited to all of the details of that embodiment. It is rather to be considered as of the scope indicated by the subjoined claims.

I claim:

1. In a steam generator, a furnace, steam generating tubes exposed to heat from the furnace, means forming a furnace gas outlet for the generator, means defining two parallel gas passes between the furnace and the gas outlet, an inlet economizer section extending across both passes, a superheater in one pass, means whereby steam from said tubes passes to the superheater, a second economizer section in the other pass, means connecting the economizer sections to the generator for water flow thereto, damper means to effect distribution of gas flow between the two passes, the second economizer section having an upflow of water and an upflow of heating gas thereover.

2. In a steam generating installation; a fur-

nace operating at high temperatures; steam generating tubes subject to the heat of the furnace; and a convection section including closely spaced tubes subjected to the gases from the furnace; the convection section including a superheater, means forming a superheater gas pass and an economizer gas pass for receiving varying proportions of the total furnace gases passing over parts of the convection section; the economizer gas pass constituting a superheater by-pass, means whereby steam from the generating tubes passes to the superheater; a high temperature economizer section positioned in the bypass so that the high temperature of the gases contacting it causes that section to act as a steaming economizer under certain load conditions, a parallel flow secondary economizer section positioned over the superheater, a counter-flow primary economizer section extending over both the economizer gas pass (superheater bypass) and the superheater gas pass and beyond the superheater and the other economizer sections relative to gas flow; means connecting the economizer sections in series as to water flow; and connections between an economizer section and the generator whereby fluid from the economizer sections flows to the generator.

3. In a steam generator; a furnace operating at high temperatures; steam generating tubes subject to the heat of the furnace; and a convection section including closely spaced tubes subjected to the gases from the furnace; the convection section including a superheater, connections whereby steam from the generating tubes passes to the superheater, means forming a superheater gas pass and an economizer gas pass for receiving varying proportions of the total furnace gases, a parallel flow high temperature economizer section positioned in the economizer gas pass so that the high temperature of the gases contacting it causes that section to act as a steaming economizer under certain load conditions, a parallel flow secondary economizer section positioned in the superheater gas pass, a counterflow primary economizer section extending over both the economizer gas pass (superheater bypass) and the superheater gas pass beyond the superheater and the other economizer sections relative to gas flow, and connections between the economizer sections and the generator for fluid flow through said sections to the generator.

4. In a steam generator; a furnace operating at high temperatures; steam generating tubes subject to the heat of the furnace; a convection section including closely spaced tubes subjected to the gases from the furnace; the convection section including a superheater, steam connections between the outlets of the steam generating tubes and the superheater, means forming a superheater gas pass and an economizer gas pass arranged in parallel and receiving varying proportions of the total furnace gases, a high temperature economizer section so positioned in advance of other economizer surface in the economizer gas pass that the high temperature of the gases contacting it causes that section to act as a steaming economizer under certain load conditions, a separate secondary economizer section positioned in the superheater gas pass and beyond the superheater relative to gas flow, a counter-flow primary economizer section extending across the path of furnace gases in both the economizer gas pass (superheater bypass) and the superheater gas pass so that its elements

are subject to the lowest gas temperatures in said passes, connections between the economizer sections for series flow of water therethrough, and other connections between the secondary economizer section and the inlets of the steam generating tubes.

5. In a steam generating installation; a furnace operating at high temperatures; steam generating tubes subject to the heat of the furnace; a convection section including closely spaced tubes subjected to the gases from the furnace; and means forming a transition zone through which the gases pass from the furnace to the convection section; the convection section including a superheater, means connecting the superheater to the outlets of the steam generating tubes, means forming a superheater bypass for varying proportions of the total furnace gases, a high temperature economizer section positioned in the bypass so that the high temperature of the gases contacting it causes that section to act as a steaming economizer under certain load conditions, a parallel flow secondary economizer section positioned over the superheater, a counter-flow primary economizer section extending over both the economizer gas pass (superheater bypass) and the superheater gas pass and beyond the superheater and the other economizer sections relative to gas flow, means connecting the outlet of the secondary economizer section to the inlets of the steam generating tubes, and water flow connections between said economizer sections.

6. In a steam generator, a furnace, steam generating tubes subject to the heat of the furnace gases, a steam and water separator, the steam generating tubes being connected to the separator, means forming first and second gas passes arranged for parallel flow, a superheater having tubes positioned in a zone of high gas temperature in the first gas pass, means connecting the superheater tubes to said separator, a high temperature economizer section having at least some of its tubes disposed in the second pass and in a zone of gas temperatures of the same order as the zone of the superheater, a low temperature economizer section having heating elements disposed in both gas passes beyond the high temperature economizer section and beyond the superheater relative to gas flow, connections whereby water flows first through the low temperature economizer section and then through the other economizer section, water flow connections between the outlet of the high temperature economizer section and the separator, and flow control means for proportioning the flow of furnace gases between said gas passes.

7. In a steam generator, a furnace, means for burning fuel in the furnace, steam generating tubes exposed to the heat of the furnace gases, a superheater including spaced tubes extending across the path of the furnace gases, connections between the superheater tubes and the outlets

of the steam generating tubes, a bypass baffle dividing the flow of gases at the position of the superheater, a main economizer section having tubes extending across the entire flow of the furnace gases on opposite sides of said baffle, a secondary economizer section disposed in the bypass at the side of the baffle opposite the superheater, water flow connections between said economizer sections, connections between the inlets of the steam generating tubes and the secondary economizer section, and means for controlling and inversely varying the amount of gas flow over the superheater and the secondary economizer in order that superheat may be maintained constant over a wide range of boiler load variations.

8. In a steam generator, a furnace, means forming a furnace gas outlet for the generator, steam generating tubes exposed to the heat of the furnace, means defining two parallel gas passes between the furnace and the gas outlet, an inlet economizer section extending across both passes, a superheater in one pass, a second economizer section in the other pass, means connecting the economizer sections for water flow there-through, a connection between the inlets of the steam generating tubes and the second economizer section, and damper means to effect distribution of gas flow between the two passes, the said superheater and the said second economizer being similarly formed of a plurality of similarly supported multiple loop tubes.

9. In a steam generator, a furnace, means forming a gas outlet for the generator, means defining two parallel gas passes between the furnace and the gas outlet, steam generating tubes subject to the heat of the furnace, counter-flow feed water heating means in the two passes positioned adjacent the outlet, a superheater in one pass, inlet connections between the outlets of the steam generating tubes and the superheater, a parallel flow economizer in the other pass, series flow water connections between the economizer and said heating means, a connection between the economizer and the inlets of the steam generating tubes and control means to effect a distribution of gas flow between the two passes.

10. In a steam generator, a furnace, means forming a gas outlet for the generator, means defining two parallel gas passes between the furnace and the gas outlet, a steam and water drum, steam generating tubes connected to the drum, feed water heater means in the two passes and positioned below the steam and water drum, a superheater in one pass, a steam flow connection between the drum and the superheater, an up-flow economizer in the other pass, means connecting the outlet of the heater means to the inlet of the economizer, means connecting the outlet of the economizer to the steam and water drum, and control means to effect distribution of gas flow between the two passes.

ERVIN G. BAILEY.