

Oct. 8, 1940.

E. H. DONLEY

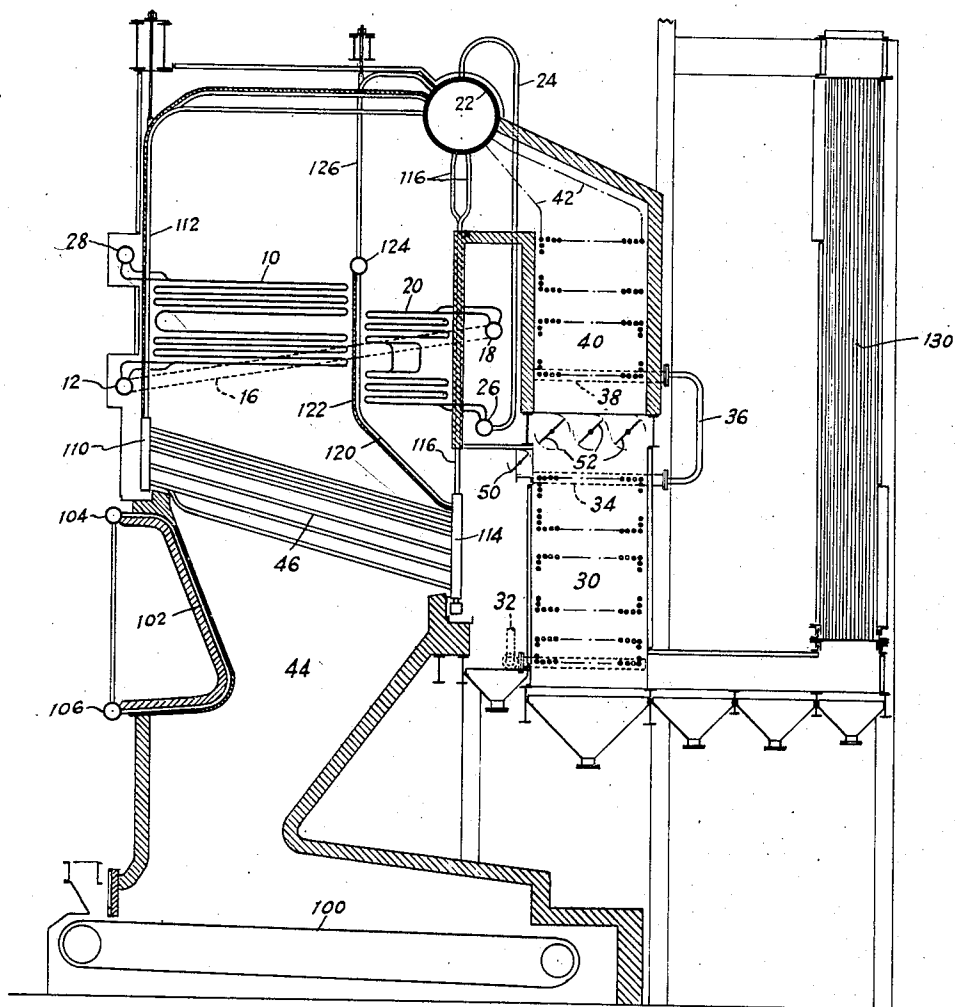
2,217,512

STEAM BOILER

Filed Nov. 13, 1936

2 Sheets-Sheet 1

Fig. 1



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Fig. 2

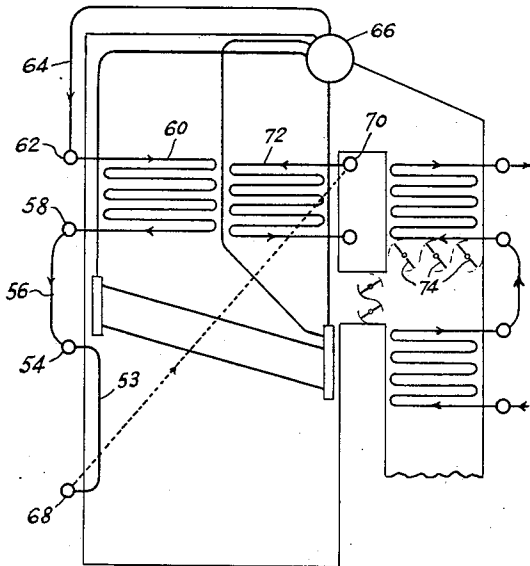


Fig. 3

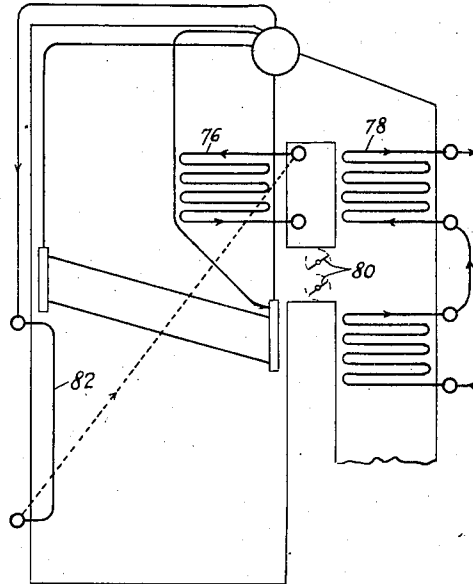
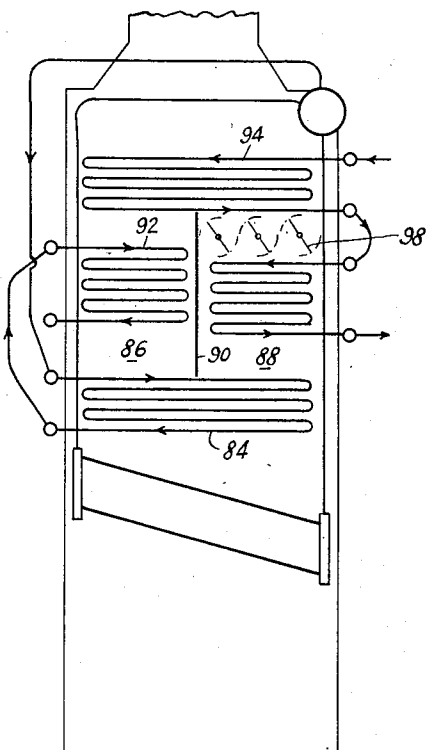


Fig. 4



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STEAM BOILER

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11 Claims. (Cl. 122-477)

This invention is concerned with improvements in steam boilers.

In modern water tube steam boilers and especially in large boilers of the type used in stationary service to supply steam for turbo-electric generators, recent experience has demonstrated clearly that certain conditions are necessary in order that the maximum of practical efficiency may be attained, and many of these conditions are difficult to fulfill. Relatively high steam pressures must be used in the interest of efficiency, and, for turbine use, the steam must not only be superheated to higher temperatures as steam pressures rise, but it is of considerable importance that the total steam temperature shall remain substantially constant over a wide range of boiler loads. This is particularly important in the operation of large central power stations which are subject to daily peak load demands.

For the protection of superheater metal against overheating when steam flow is deficient or absent as, for example, when a boiler is being started up, the superheater must be screened to a considerable extent from furnace radiation. It is therefore, heated mainly by convection from the furnace gases. Such a convection superheater when designed for a safe metal temperature and desired superheat at full boiler load will be deficient in superheating capacity at fractional loads, but the factors which require the desired superheat at full load are still effective at fractional loads. It is an object of this invention to correct this difficulty in a reliable manner.

Modern boiler practice has also demonstrated the advantages of the use of economizers to heat the boiler feed water from feed temperature up toward or to the temperature of the saturated steam, and to provide an economizer installation which, in some instances, may also generate some steam. When full advantage is taken of such possibilities of good economizer practice, it is unnecessary to interpose any water tubes of the boiler circulating system between the gas outlet from the superheater and the gas inlet to the economizer. Therefore, any otherwise satisfactory means for keeping the total steam temperature at a substantially constant value must also cooperate with economizers receiving gases directly from the superheater and not impair the operation of the former. It is an object of this invention to provide such means for keeping the total steam temperature at a substantially constant value over a wide range of boiler loads, but maintaining the metal temperature within safe

limits in a water tube boiler in which the gases leaving the superheater pass directly into the economizer.

Other objects of the invention will appear as the description proceeds.

The nature of the invention will be readily understood from the following description when read in connection with the accompanying drawings which illustrate preferred forms of apparatus for attaining the desired results.

In the drawings:

Fig. 1 is a view in the nature of a vertical section of a stoker-fired steam-power installation illustrating the teachings of the invention.

Figs. 2, 3, and 4 are diagrammatic views showing different embodiments of the invention somewhat in vertical section.

The drawings show the superheater tube surface divided into two sections and connected in series as to steam flow. Fig. 1 indicates the primary superheater section 10 receiving steam from an inlet header 12 connected by a conduit 16 to the outlet header 18 of the secondary superheater section 20. The latter receives steam from the boiler drum 22 through the conduit 24 and the inlet header 26. The superheated steam passes from the outlet header 28 to a point of use.

The Fig. 1 embodiment also indicates the economizer tube surface as divided into two sections. They are connected in series as to water flow, and one of the sections may be a steaming economizer section. As shown, the primary economizer section 30 receives feed water through an inlet 32 and discharges the feed water through its outlet header 34 and a conduit 36 to the inlet header 38 of the secondary economizer section 40. From the latter, water, or water and steam passes through the outlet connections 42 to the water space of the drum 22. Both economizer sections are illustrated having a counter flow relation of water flow and gas flow.

These four elements, the two superheater sections and the two economizer sections, are arranged within gas passes in such a manner as to permit variation and regulation of the rate of gas flow over one section of the superheater and one section of the economizer without changing the rate of gas flow over the remaining economizer and superheater sections, and the primary superheater section 10 is shielded from the furnace 44 by a radiant heat screen indicated as a bank of steam generating tubes 46. All of the furnace gases leaving the radiant heat screen flow over the tubes of the superheater section 10 at all times, and all of the furnace gases subse-

quently flow over the tubes of the primary economizer section 30 at all times, that is, at all boiler loads. After the furnace gases have left the primary superheater section 10 they may flow wholly in one of two paths before they reach the second section 30 of the economizer, or they may divide so as to flow partly in one path and partly in the other. In one of these two paths the secondary superheater section 20 is located, and in the other, the secondary section 40 of the economizer is disposed.

When all of the furnace gases flow in one of these two alternate paths intermediate the ends of the entire gas path, they sweep the superheater section 20, and when divided between these two paths some of the gases sweep over the tubes of the economizer section 40 and some over the superheater section 20. In either case the gases are substantially cooled before they reach the economizer section 30.

Regulators 50, only one of which is shown, located at the gas outlet of the superheater section 20, and between that section and the economizer section 30, control the flow of gas over the section 20 while similar regulators 52 control the flow of gas through the gas path in which the economizer section 40 is located. At full boiler load the regulators may be so set as to cause all of the furnace gases to flow over the economizer section 40 and none over the secondary superheater section 20, the surface areas and gas flow rates being so related that the desired total steam temperature is maintained and the temperature of the superheater metal kept within safe limits. When the boiler is operating at a lower load the steam temperature will decrease if the same setting of the regulators is maintained but such a decrease is prevented by changing the setting of the regulators so that a part of the gas stream now passes over the superheater section 20 while the remainder continues to flow over the economizer section 40. Thus, superheat and steam temperature will be controlled by the regulators. Automatic control of regulators in response to changes in total steam temperature and in steam flow may be effected by connecting the regulators with such control apparatus as that indicated in Patent 2,131,058.

It is also to be understood that the apparatus described herein may be so operated that the gases may be divided so as to flow partly over the economizer section 40 and partly over the superheater section 20 at full boiler load, superheat control at lower boiler loads being secured by diverting a larger fraction of the furnace gases over the superheater section 20.

Referring to the embodiment indicated in Fig. 2 of the drawings, one of the superheater sections includes a radiant superheater 53 of the wall tube type. It is shown as receiving its steam from an inlet header 54 and the conduit 56 connected to the outlet header 58 of the superheater section 60. The latter receives its steam from an inlet header 52 and the conduit 64 connected to the steam space of the boiler drum 66. Steam flows from the outlet header 68 of the superheater 52 to the inlet header 70 of a third superheater section 72 from which the steam is transmitted to a point of use. The gas flow in the embodiment of invention illustrated in Fig. 2 is the same as that described in reference to the Fig. 1 embodiment and the regulators and economizer sections are similarly arranged.

The Fig. 3 embodiment of the invention eliminates such elements as the regulators 74 of the

Fig. 2 embodiment and also eliminates any superheater corresponding to the superheater section 60, the superheat being controlled by proportioning gas flow between the gas pass of the superheater section 76 and the economizer section 78, the latter having sufficient tube area so that when the regulators 80 are open that section of the economizer imposes a greater resistance to gas flow than that imposed by the superheater section 76. The superheater section 76 and the radiant superheater section 82 of this embodiment are connected in a manner similar to the manner in which the sections 52 and 72 of the Fig. 2 embodiment are connected.

In the Fig. 4 embodiment of the invention the primary superheater section 84 extends across parallel gas passes 86 and 88 which are divided by the wall 90. The secondary superheater section 92 receives its steam from the section 84 and the former is disposed within the gas pass 86. One economizer section 94 is disposed across the entire gas flow, extending across the outlets of the gas passes 86 and 88, as shown. The second economizer section is located within the gas pass 88 and superheat is controlled by regulators 98 arranged at the outlet of the gas pass 88.

It will be understood that the furnace installation shown in Fig. 1 of the drawings is merely representative, and that the invention is not limited thereto. Other furnaces, such as slag tap furnaces may be used. Fig. 1 indicates a stoker fired furnace including a chain grate stoker 100, and one of the walls of the furnace may be cooled by the wall tubes 102. These tubes are shown as connected to headers 104 and 106 which may be appropriately connected in the boiler circulatory system.

Whereas the boilers indicated in the drawings are sectional header boilers in which horizontally inclined steam generating tubes are included, it is to be appreciated that the invention is not limited thereto but that it may apply to other tubes or boilers such as bent-tube boilers. The particular sectional header boiler shown in Fig. 1 includes the uptake headers 110 connected by circulators 112 to the drum 22. At the opposite ends of the steam generating tubes 46 are the downtake headers 114 connected at their upper ends to the water space of the drum 22 by the downtakes 116.

The boiler indicated in Fig. 1 also includes circulators 120 which support the wall 122 separating the gas pass of the superheater section 10 from the gas pass of section 20. The tubes 120 are connected at their upper ends to a header 124 supported by circulators 126 which establish communication between the drum 22 and the header 124. Fig. 1 also discloses an air heater 130 through which the furnace gases pass from the economizer section 30 on their way to the final outlet flue.

Under some operative conditions and with certain proportioning of the tube surfaces in the parallel gas passes of the middle superheat control zone the illustrative apparatus may, at low loads, be so used as to prevent corrosion of economizer tubes resulting from excessively low gas temperatures at the outlet of the economizer. For instance, the secondary superheater section may be such that it abstracts less heat from the gases than the secondary economizer section. If, under these conditions, the secondary economizer section is by-passed by the gases there will be an increased gas temperature at the outlet of the economizer. Such operation may

be employed to prevent the cooling of the furnace gases below the dew point when moisture deposits on the economizer tubes and takes part in chemical reactions which cause tube damage.

3 Without proper control of furnace gas temperatures such damage frequently occurs at low boiler loads.

It is to be understood that the invention is not necessarily limited to boilers which include economizers, nor is it limited to superheaters which are shielded from furnace radiation. In some instances, water tubes of the boiler circulating system may replace the economizer tubes in whole or in part without changing the effectiveness of the control of superheat. Effective control of superheat may also be obtained when the first section of the superheater is partly or wholly directly exposed to furnace radiation. It is also to be understood that the relative positions of the different sections of the heating surfaces may be widely varied so long as the illustrative sequential flow conditions are maintained. The invention is also applicable to the maintenance of superheat control under various circumstances. For instance, the invention may be employed to compensate for a decrease in superheat capacity caused by tube deposits resulting from long continued operation, or from undesirable feed water conditions.

30 I claim:

1. In a steam boiler, a furnace, a steam generating section including a bank of tubes exposed to the heat of the furnace, a primary superheater in a position which is remote from the steam generating section, a primary economizer section, means providing a plurality of gas passes arranged in parallel between said superheater and said economizer section, a secondary economizer section in one of said parallel gas passes, a secondary superheater in another of said parallel gas passes, and means for proportioning the total gas flow between said parallel gas passes for maintaining a predetermined superheat over a wide range of boiler loads.

2. In a steam boiler, a furnace, a steam generating section including tubes extending across a primary gas pass leading from the furnace, a primary superheater section including tubes also extending across the primary gas pass, a primary economizer section, means providing a plurality of secondary gas passes arranged in parallel between said superheater and said economizer section, a secondary economizer section in one of said parallel gas passes, a secondary superheater in another of said parallel gas passes, means for proportioning the total gas flow between said parallel gas passes, and means for connecting the superheaters so that steam flows from the primary superheater to the secondary superheater.

3. In a steam boiler, a steam generating section including a bank of tubes extending across a gas pass, a primary superheater including tubes beyond the steam generating section, a primary economizer section, means providing a plurality of gas passes arranged in parallel between said superheater and said economizer section, a secondary economizer section in one of said parallel gas passes, a secondary superheater in another of said parallel gas passes, means for proportioning the total gas flow between said parallel gas passes, means connecting the superheaters for the series flow of steam therethrough, and means similarly connecting the economizers for the series flow of water therethrough to the steam generating section.

4. In a steam boiler, a steam generating section including tubes extending across a gas pass, a primary superheater including tubes beyond the steam generating section, a primary economizer section, means providing a plurality of gas passes arranged in parallel between said superheater and said economizer section, a second economizer section in one of said parallel gas passes, a second superheater in another of said parallel gas passes, and regulators at the gas inlets of the primary economizer for proportioning the total gas flow between said parallel gas passes in order that the superheat may be maintained at substantially the same values over a wide range of boiler load variation.

5. In a steam boiler, a steam generating section including tubes extending across a gas pass, a primary superheater including tubes beyond the steam generating section, a primary economizer section, means providing a plurality of gas passes arranged in parallel between said superheater and said economizer section, a second economizer section in one of said parallel gas passes, a second superheater in another of said parallel gas passes, and regulators at the outlet of each of the parallel gas passes for proportioning the total gas flow between said parallel gas passes to compensate for changes in the boiler load and maintain a desired superheat.

6. A water tube boiler having a primary superheater subjected to the heat of furnace gases in a relatively high temperature zone, a secondary superheater subjected to the heat of furnace gases but located in a zone of relatively low gas temperatures, means for connecting the superheaters in series with reference to steam flow, means to direct all of the furnace gases across the primary superheater, means whereby the furnace gases leaving the primary superheater are divided so as to flow in the same direction through parallel gas passes in one of which the secondary superheater is located, an economizer section in another of said parallel gas passes, means contacted by the gases adjacent the ends of the parallel gas passes for proportioning the flow of furnace gases between said parallel gas passes according to the load imposed on the boiler, and another economizer section receiving the flow of all of the furnace gases after they have passed through one or both of said parallel gas passes.

7. A water tube boiler having a primary superheater subjected to the heat of furnace gases in a relatively high temperature zone, a secondary superheater subjected to the heat of furnace gases but located in a zone of relatively low gas temperatures, means for connecting the superheaters in series with reference to steam flow, means to direct all of the furnace gases across the primary superheater, means whereby the furnace gases leaving the primary superheater are divided so as to flow in the same direction through parallel gas passes in one of which the secondary superheater is located, an economizer section in another of said parallel gas passes, means for proportioning the flow of furnace gases between said parallel gas passes, and another economizer section receiving the flow of all of the furnace gases after they have passed through one or both of said parallel gas passes.

8. In a water tube steam boiler, a steam generating section subjected to the heat of furnace gases, means for establishing three separate fluid heating zones arranged serially in the direction of gas flow, the first and last of said zones being undivided while the second zone is divided into a

plurality of parallel gas passes, a primary superheater section in the first zone, a primary economizer having tubes arranged in the last zone and across the gas flow from both of said passes, 5 the secondary superheater section arranged in one of the gas passes of the second zone, an economizer arranged in the other gas pass of the second zone, and regulators arranged forwardly of the third zone for controlling the proportioning of the gas flows in the parallel paths 10 of the second zone to control superheater and economizer operation.

9. The method of operating a steam boiler and associated superheater and economizer which 15 comprises effecting heat exchange between high temperature furnace gases and water flowing in restricted and separated paths across the path of said furnace gases, causing said furnace gases to superheat steam flowing in restricted paths 20 across the path of said gases beyond said restricted water flows (with reference to gas flow) and through a superheating zone, utilizing radiant heat of the furnace gases approaching the steam generating zone to further 25 superheat the steam flowing in restricted paths from the first superheating zone, dividing the furnace gases beyond said superheating zone so that they flow in a plurality of paths, effecting further superheating of the steam by the gases 30 flowing in one of said paths, causing absorption of heat by feed water flowing in restricted paths across another of said paths, effecting a further absorption of heat by the feed water after the furnace gases flowing through said paths have 35 been reunited, and counter-acting variations from a desired superheat temperature by apportioning the percentages of the total amount of

gases passing through said gas paths in response to said variations and steam flow.

10. In the superheating of steam, causing a first absorption of heat from high temperature furnace gases by steam flowing in restricted paths, 5 subsequently dividing the stream of furnace gases so that it flows in a plurality of parallel gas paths, effecting a further superheating of the superheated steam in one of said parallel gas paths, causing an absorption of heat by feed water 10 flowing in restricted paths across the path of the furnace gases in another of said parallel paths, apportioning the percentages of the total amount of gas flow through said parallel paths in response to variations of superheat from a de- 15 sired value, and causing all of the gases from said parallel paths to pass over feed water of a lower temperature than that in one of the parallel paths, said lower temperature feedwater flowing through the combined gases and thence 20 to the above mentioned restricted feedwater paths.

11. In a water tube steam boiler, steam generating tubes, a primary superheater section, a secondary superheater section in series with the 25 primary section as to both steam and gas flow, a primary economizer section, a secondary economizer section in parallel with the secondary superheater section as to gas flow and in series with the primary economizer section as to water- 30 flow, and means whereby at a given boiler load the gas flow over the secondary superheater section and the secondary economizer section is simultaneously controlled or varied while the gas flow over the primary superheater section and 35 primary economizer section remains constant.

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