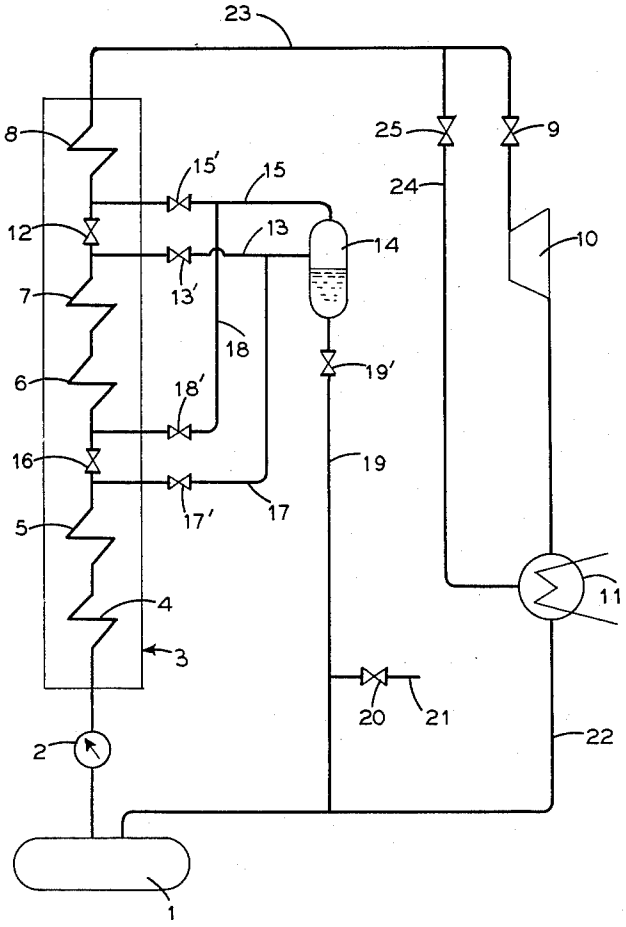
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DEVICE FOR LOW LOAD OPERATION OF ONCE-THROUGH BOILERS

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DEVICE FOR LOW LOAD OPERATION OF ONCE-THROUGH BOILERS

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This invention relates generally to improvements in the construction and operation of power plants having forced circulation vapor generating units of the once-through type with vapor generating and superheating sections, and particularly to improved provisions for starting up and operating vapor generating units of this type at low output rates while adequately protecting the vapor superheating section of the unit.

This invention is an improvement of the arrangement shown in U.S. Patent 2,989,038, issued June 20, 1961, to Ottmar Schwarz. As shown in the patent, the starting up of a once-through vapor generating unit has been improved and while the present invention utilizes the starting up procedure of the patent, the system arrangement of the present invention additionally permits low load operation of the unit without the hazards heretofore present in the operation of such units.

In the usual operation of a once-through vapor generating or boiler unit the transition zone wherein the conversion of water to steam will generally occur within the intermediate portion of the unit, the location varying with changes in the operating rate of the unit. During low load operation however, while the transition zone will normally move toward the water inlet portion of the unit thereby increasing the proportionate amount of heating surface of the superheating section and so tend to maintain a desired steam temperature at reduced output, the net result may not cause the transition zone to shift enough to provide the steam superheat temperatures desired. These difficulties can be overcome, as disclosed in the present invention, without subjecting the steam superheating and generating sections of the unit to overheating.

In accordance with the invention a once-through boiler or steam generating unit of the type described can be operated at a low operating rate or load while maintaining the steam temperature and pressure at desired values consistent with efficient steam turbine performance. This is accomplished by closing a cut-off valve intermediate the steam generating and steam heating sections of the unit whereby the pressurized, heated fluid is diverted from the steam generating section of the unit through a pressure reducing valve, with the flashing fluid discharging into a vessel where the water and steam are separated. The separated water is returned to the water heating and/or steam generating section of the unit from the low pressure vessel, while the separated steam is passed through the steam superheating section wherein it is superheated to a desired value and delivered to the turbine. When using the present invention, the fuel delivery rate to the furnace of the unit is controlled in direct response to the steam temperature leaving the unit.

While the use of a reducing valve and the resultant low pressure zone provides steam for the superheating section of the unit and ultimately to the turbine at a pressure substantially lower than that of the water delivered to the unit, it is sometimes desirable to increase the pressure of the water delivered to the unit at low load so that the pressure of the steam delivered to the turbine will be at a value comparable with the steam delivered to the turbine under normal operating conditions. In other words, the present invention includes the concept of increasing the pressure of the water delivered

to the unit to compensate at least in part for the pressure drop involved in passing the water from the unit through the pressure reducing valve, the low pressure zone and thence to the steam heating section.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawing and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

The drawing illustrates diagrammatically a once-through steam boiler constructed and arranged in accordance with the invention.

In the system illustrated, boiler feed water is withdrawn from a hot well or feed water reservoir 1 at a suitable temperature and is forced under a substantial positive pressure by a feed water pump 2 through the tubes forming serially connected water heating or steam generating sections 4, 5 and 6 and steam superheating sections 7 and 8. The water heating sections are preferably located mainly in a radiant heat absorbing section of the furnace and boiler setting 3. The steam superheating sections 7 and 8 are preferably located in a relatively low gas temperature convection heating section of the boiler. The firing rate of the boiler is regulated to produce the desired superheated steam temperature, with the steam flow path being through a conduit 23 and a valve 9, into the turbine 10 and to a condenser 11. The condensate from the condenser 11 is pumped through the conduit 22 to the hot well 1. A by-pass steam line 24 for use during start up and equipped with a valve 25 connects the conduit 23 with the condenser 13, thus by-passing the turbine 10.

As disclosed in Patent 2,989,038 a normally open cut-off valve 12 is located in the once-through boiler between the primary superheater 7 and the steam generating section 6 for use during start up. In the present arrangement the cut-off valve 12 is positioned between the superheating sections 7 and 8. A pipe 13 having a valve 13' connects the upstream side of the valve 12 with a low pressure flash tank 14. Another pipe 15 with flow control valve 15' connects the steam space of the flash tank 14 with the downstream side of the valve 12. The lower portion of the flash tank 14 is provided with a water discharge pipe 19 having a valve 19' therein for conveying water from the flash tank 14 into the condensate return pipe 22 and thence to the hot well 1.

As shown in the drawing, the cut-off valve 12 is closed during start-up of the once-through boiler with the fluid being pumped through the heat exchange members 4, 5, 6 and 7, then passing through the valve 13' into the flash tank 14. The valve 13' is a pressure reducing valve, so that the heated fluid delivered to the tank 14 through the valve 13' has flashed at least a portion thereof into saturated steam. The steam from the tank 14 upon passing through the pipe 15 and its associated valve 15', is introduced into the superheating portion of the once through boiler system to be superheated in the secondary superheater 8. With this arrangement, the flow through that portion of the unit upstream of valve 12 will protect the heat absorbing surfaces. The tubes of the secondary superheater 8 are protected by the steam supplied from the flash tank 14. As is also disclosed in said patent, the water level in the tank 14 is maintained substantially uniform during the start up period of boiler operation by withdrawing water through the valve 19' for return to the hot well 1. During start up steam discharged through the conduit may by-pass the turbine through the conduit 24, with the steam condensed in the condenser 11 returned to the hot well 1 through conduit 22.

As the flow through the once-through boiler is increased during start up it is desirable to pass steam through the valve 9 to the turbine to warm up the turbine. As the flow through the once-through boiler is gradually increased to a predetermined rate the valve 12 will be opened with the simultaneous closing of valves 13' and 15', all of the steam thereafter passing through the conduit 23 and valve 9, to the turbine 10 for normal capacity operation.

In accordance with the present invention, low load operation may cause an operating condition wherein steam superheating portions of the unit may become overheated by reason of the movement of the transition point upstream from the normal transition zone to the vicinity of or even upstream of, the water heating and evaporating portion 6. Under these conditions it has been found highly desirable to utilize a cut-off valve 16 positioned between the heat absorbing sections 5 and 6 to divert heated water, or a steam and water mixture, to a low pressure zone such as previously described in connection with the known start up system, to insure the presence of adequate amounts of water in the heat absorbing tubes disposed within the hotter portions of the furnace. The precise location of the valve 16, which may be further upstream or downstream than here shown in a once-through boiler circuit depends on the location of the transition zone for the particular unit design under consideration at the desired low load operation rate. Alternately more than one valve 16 may be positioned in the intermediate portion of the unit for selective operation within the system in accordance with the hereinafter described operation of the valve 16.

A pressure reducing valve 17' is installed in the conduit 17 which connects the once-through boiler upstream of the cut-off valve 16 with the conduit 13 leading to the flash tank 14. In a similar manner the conduit 18 connects the steam space of the flash tank 14 through conduit 15 with the downstream portion of the once-through boiler immediately downstream of the valve 16.

In operation, the valve 12 will be open and valves 13' and 15' closed, the valve 16 may be closed at low load operating rates, with heated water or fluid passing through the pressure reducing valve 17' to the flash tank 14. The steam separated in tank 14 is passed back to the once-through boiler through the conduits 15 and 18. With this arrangement only water or steam-water mixture passes through the heat exchange sections 4 and 5 with steam only passed through the sections 6, 7 and 8. The excess water separated in the tank 14 is returned through the conduit 19 and valve 19' and conduit 22 to the hot well 1 as hereinbefore described in connection with the start up procedure of the boiler.

It will be noted that the pressure drop in passing fluid through the heat exchange sections 4 and 5, the pressure reducing valve 17, through the flash tank 14 and the conduits 15 and 18 will result in a considerable reduction in the pressure of the steam delivered to the superheating sections 6, 7 and 8 and turbine 10 as compared to operation excluding the pressure reducing system from the flow path. If desired, for turbine operating purposes, it is possible to increase the pressure of the water delivered by the pump 2 to compensate for the pressure loss in passing the steam and water flow through the circuit including the flash tank 14 so that the steam delivered to the turbine 10 may be at any desirable pressure for efficient operation of the turbine.

Whenever necessary to compensate for system losses, make-up water may be added through the conduit 21, and its control valve 20. Such make-up water will mix with the condensate within the hot well 1, so that the temperature of the water delivered to the boiler by the pump 2 will be generally uniform in temperature.

The present invention is particularly useful in the operation of a once-through boiler, since it will permit efficient and safe operation throughout an increased range of operating rates.

While in accordance with the provisions of the statutes I have illustrated and described herein the best form and mode of operation of the invention now known to me, those skilled in the art will understand that changes may be made in the form of the apparatus disclosed without departing from the spirit of the invention covered by my claims, and that certain features of my invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. In a forced flow once-through type steam boiler having serially connected steam generating and superheating sections with the transition zone being located between said sections at normal operating loads, means for supplying feed water to said steam boiler, means for adjusting the location of said transition zone to alter the effective superheating surface in correspondence with a selected load on said boiler comprising at least two cut-off valves, one of said valves being positioned in said steam generating section and the other being positioned in said steam superheating section, a flash drum having a steam space and a water space and being maintained at a pressure substantially below the pressure in said steam generating section, conduits associated with each of said cut-off valves with a first conduit connecting the section immediately upstream of each of said cut-off valves to said flash drum and each arranged to convey the entire discharge from said section to said flash drum when the corresponding cut-off valve is closed, a pressure reducing valve in each of said first conduits arranged to cause water discharged from the corresponding section to flash into steam, and valve controlled second conduits associated with each of said cut-off valves and connecting the steam space of said flash drum to said sections immediately downstream of the corresponding cut-off valve for supplying the flashed steam to said section to superheat said flashed steam.

2. In a forced flow once-through type steam boiler having serially connected steam generating and super-heating sections with the transition zone being located between said sections at normal operating loads, means for supplying feed water to said steam boiler, means for adjusting the location of the transition zone to protect the generating and superheating sections of said boiler comprising at least two cut-off valves spaced apart in said boiler, one of said valves being positioned in said steam generating section to increase the effective superheating surface during low load operation and the other being positioned in said steam superheating section to flood an upstream portion of said superheating section during initial heating of said once-through boiler, a flash drum having a steam space and a water space and being maintained at a pressure substantially below the pressure in said steam generating section, conduits associated with each of said cut-off valves with a first conduit connecting the section immediately upstream of each of said cut-off valves to said flash drum and each arranged to convey the entire discharge from said section to said flash drum when the corresponding cut-off valve is closed, a pressure reducing valve in each of said first conduits arranged to cause water discharged from the corresponding section to flash into steam, and valve controlled second conduits associated with each of said cut-off valves and connecting the steam space of said flash drum to said sections immediately downstream of the corresponding cut-off valve for supplying the flashed steam to said section to superheat said flashed steam.

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