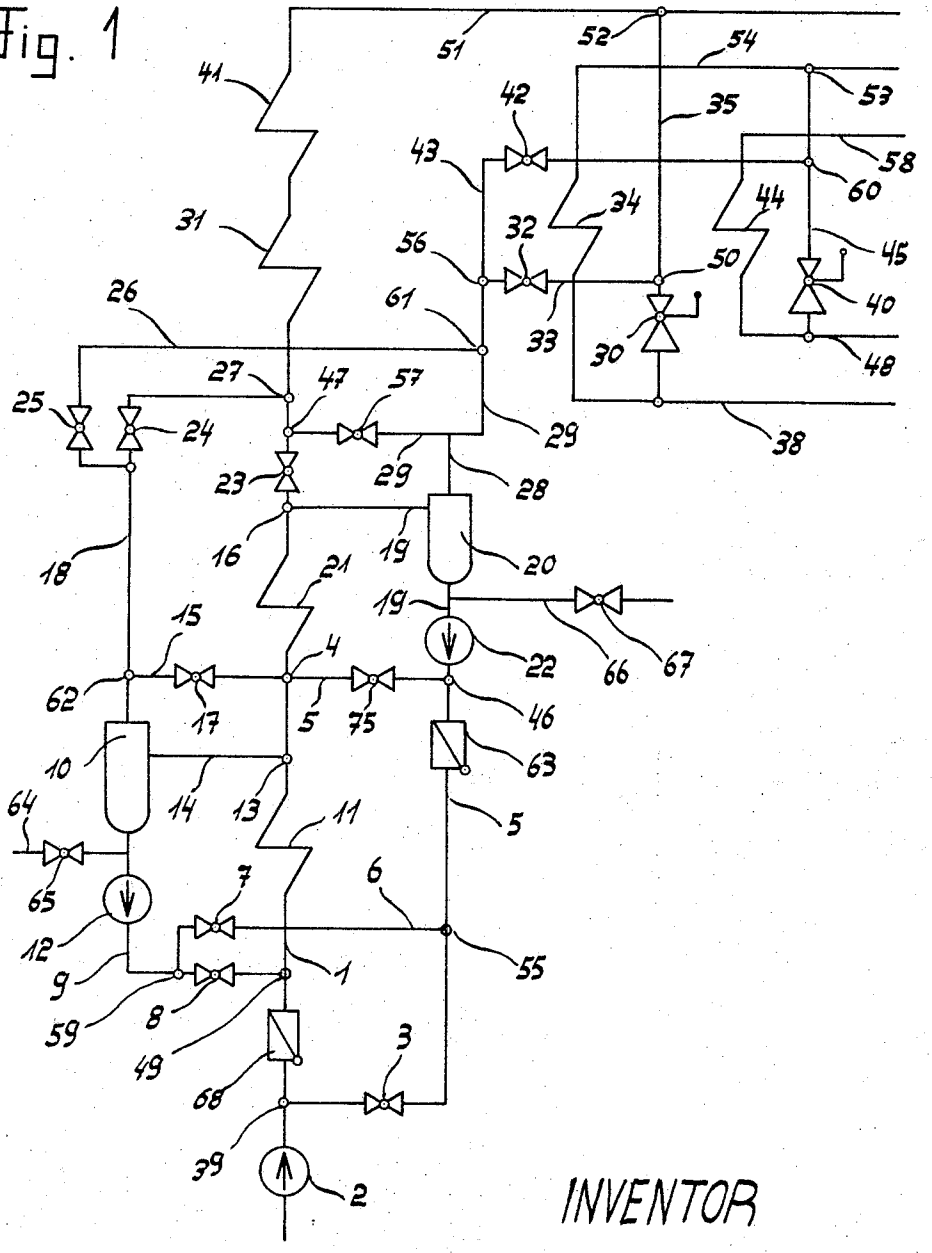
Feb. 13, 1968 K. KNIZIA 3,368,533

METHOD OF STARTING FORCED-FLOW STEAM PRODUCERS

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Fig. 1



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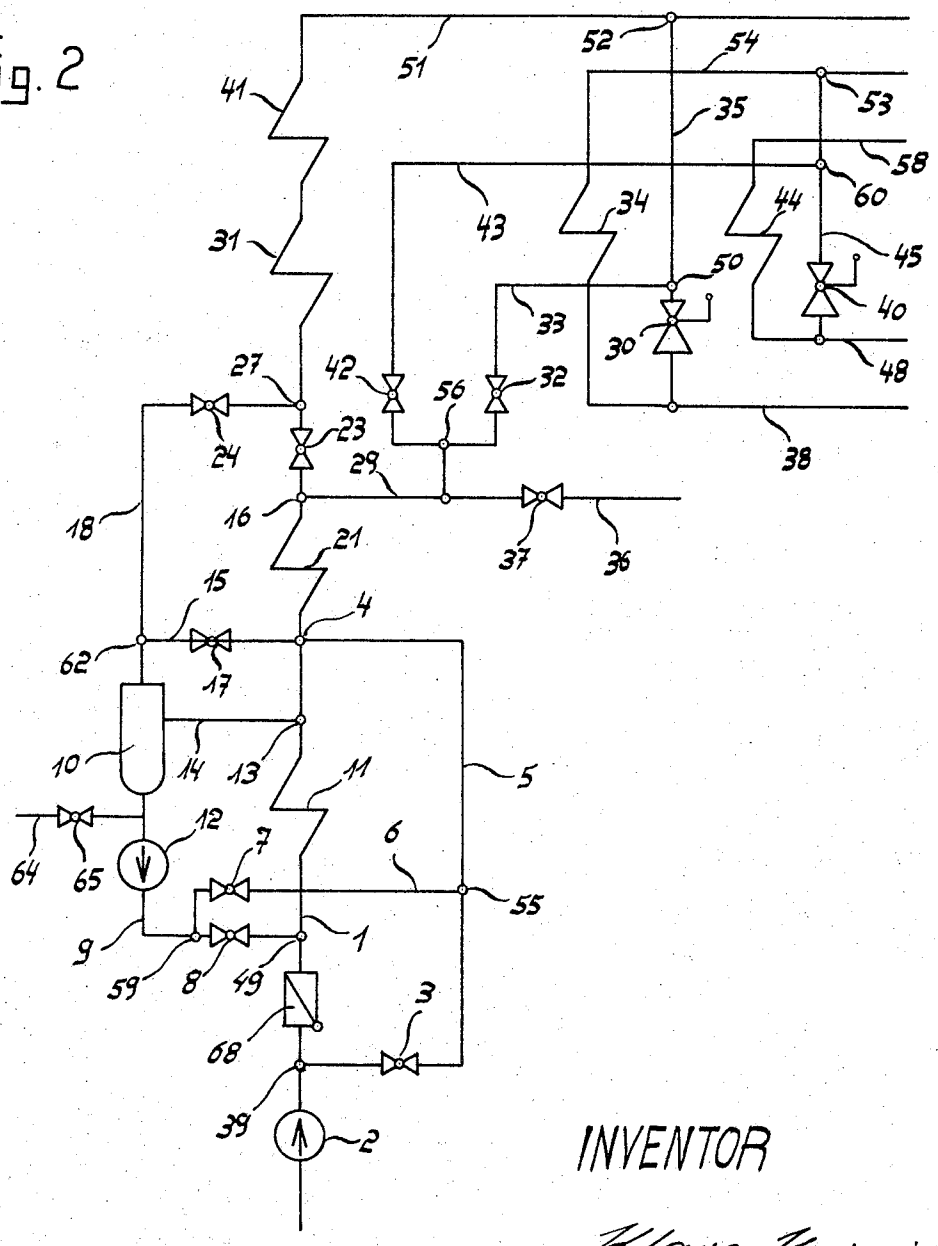
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METHOD OF STARTING FORCED-FLOW STEAM PRODUCERS

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Fig. 2



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United States Patent Office 3,368,533 Patented Feb. 13, 1968

3,368,533

METHOD OF STARTING FORCED-FLOW STEAM PRODUCERS

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Filed Feb. 14, 1966, Ser. No. 527,001
Claims priority, application Germany, Feb. 13, 1965, St 23,363
11 Claims. (Cl. 122—406)

ABSTRACT OF THE DISCLOSURE

The present invention relates to a forced-flow steam producer having main conduit means adapted to be connected to a steam consumer and comprising feed water supply means and evaporator heating surface means communicating therewith and also comprising first and second superheater heating surface means in series with each other and with said evaporator heating surface means, and furthermore including first circuit means shunting said evaporator heating surface means and comprising a steam and water separating vessel and a pump while second circuit means lead from a point of said main conduit means between said evaporator heating surface means and said feed water supply means to a point of said main conduit means between said first superheater heating surface means and said evaporator heating surface means. This arrangement is provided with control means which permit operating the two circuits steamwise during the start of the steam producer in parallel arrangement with each other and subsequently with increasing firing of said steam producer to continuously operate the second circuit and the first superheater heating surface means steamwise in series with each other.

The present invention relates to a method of starting forced-flow steam producers, especially steam producers which operate at a high life steam pressure and with one or multiple intermediate superheating stages.

With increasing regenerative preheating and the employment of a single or multiple intermediate superheating stage of high live steam pressure, the proportion of the feed water preheater and evaporator heating surfaces in the boiler is reduced in favor of superheating surfaces. As a result thereof, the high pressure superheater and the heating surfaces of the first intermediate superheater have to extend deeply into the first flue of the boiler.

When starting such a boiler, there exists the necessity of satisfactorily cooling the said superheating surfaces in order to prevent too fast a temperature increase which otherwise, particularly when high heat resistant materials are employed, would cause the formation of tears and cracks. The heretofore known employment of a circulatory system for the evaporator heating surfaces with or without the merging portions, with which subsequently the produced steam passes between the superheater surfaces will not suffice under modern conditions to sufficiently cool the superheater parts.

It is, therefore, an object of the present invention to provide a method of starting forced-flow steam producers, which will overcome the above mentioned drawbacks.

It is another object of this invention to provide a method of starting forced-flow steam producers which while assuring a sufficient cooling of all boiler parts including the evaporator heating surfaces, the adjacent superheater surfaces and the intermediate superheater or superheaters, will while maintaining an admissible temperature gradient, make possible a gradual heating up of said boiler parts,

and a stepwise putting into operation of the heated up boiler parts for the normal boiler operation.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawings, in which:

FIG. 1 is a diagram showing a plurality of circulatory systems on heating surfaces which when in operation are arranged in series with regard to each other.

FIG. 2 shows a diagram illustrating one circulatory system only and a plurality of bypass conduits which permit a liquid cooling of the first superheating surface during the starting of the boiler.

The objects outlined above have been solved according to the present invention by parallelly arranging the evaporator heating surface and the first superheater surfaces during the first starting phase with regard to the conducting away of the steam produced in said two heating surfaces. At the same time, the water separated from a steam water mixture leaving the evaporator heating surface is in a separating vessel conveyed to the first superheater surfaces. When the quantity of steam produced in the evaporator heating surface has reached a certain magnitude and when the evaporation point of the residue in the first superheater surfaces has dropped to approximately the start of the heating surface, the evaporator heating surface is directly connected with the first superheater surfaces so that the steam freed in the separating vessel will now cool all superheater surfaces one after the other. At the same time, a conduit leading from the water side to the first superheater surfaces is closed. The steam freed in the separating vessel will now no longer bypass the first superheater surfaces.

According to a further development of the present invention, the method according to the invention will be further improved by providing a further phase which precedes said first phase and according to which the evaporator heating surface and the first superheater surfaces are with regard to the feed water supply and the circulation first arranged parallelly and subsequently serially and in continuous transition. Thus, at the first phase of the starting operation, feed water will be circulated in the circuit which includes the evaporator heating surface, and in the circulatory path which includes the first superheater surfaces. With increasing firing, feed water heated in the boiler is withdrawn from the circulatory circuit which cools the evaporator heating surface, and this feed water is conveyed into the circulatory path for the first superheater surfaces. The water which evaporates in the first as well as in the second circulatory path is replaced by the feed water pump which pumps water into the first circulatory path. After a further increase in the firing, finally the second circulatory path for the superheater surfaces is turned off and the saturated steam or the mixture of liquid and saturated steam derived from the evaporator heating surface is directly employed for cooling the superheater surfaces adjacent the evaporator. Instead of being circulated in a circulatory path including the first superheater surfaces, the water after having been circulated in the circulatory path of the evaporator may also be passed separately through the first superheater section. If one of the two circulatory pumps should break down, the system may also be started with one circulatory pump only. If the circulatory pump in the evaporator circuit remained inoperable, the starting of the system is effected with one circuit in which similar to the heretofore known manner the evaporator is cooled and all of the steam freed in the separating vessel is passed into the superheater surface following the evaporator. If, on the other hand, the circulatory system which includes the first superheater surface remained operable, a circu-

latory path through the evaporator and the superheater heating surface is employed while the circulatory system for the evaporator is turned off.

When installing intermediate superheater heating surfaces which during the starting of the boiler have to be cooled, the steam produced in the evaporator heating surface and in the first superheater surfaces may partially be conveyed directly to the intermediate superheater or superheaters for purposes of cooling while said steam partially bypasses the high pressure superheater. By varying the way in which the steam flow is split up, it is possible in combination with the customary injection to heat up all superheater surfaces at a maximum temperature gradient.

The method according to the present invention permits on one hand to control the temperature increase in the boiler heating surfaces which are arranged in the combustion chamber and in the firebox whereby the arrangement will also be suitable for an automatic starting of steam producers, and on the other hand, in view of the cooling of the flue gases on the first large heating surfaces which are passed through by liquid, the superheating surfaces which are cooled to a lesser degree during the phase of the starting operation will be subjected to less stress.

Referring now to the drawings in detail, both circuits show the possibility of serially arranging heating surfaces which were first arranged in parallel with regard to each other, and to effect said arrangement in series continuously and without a temperature jump.

Referring first to the diagram of FIG. 1, feed water is conveyed by a feeding pump 2 through a feeding conduit 1 into the evaporator part 11. The evaporator heating surface 11 is followed by the first superheater heating surfaces 21. From here the steam passes through the subsequent superheater heating surfaces 31 and 41 to the main steam conduit 51 which leads to a turbine. From said turbine a conduit 38 passes to the first intermediate reheater 34 while a further conduit 54 leads back to the turbine. Another conduit 48 leads from the turbine to the second intermediate reheater 44 from which a conduit 58 leads back to the turbine. Behind the evaporator heating surface 11, at point 13, there is branched off a circulating conduit 14 which leads to a separating vessel 10. Water is withdrawn from vessel 10 through a conduit 9 which at 49 leads back to the main conduit 1. The circulating conduit 14, 9 has interposed therein the separating vessel 10 and a circulatory pump 12 and a control valve 8 arranged between circulatory pump 12 and point 49. The separated steam is conveyed from separating vessel 10 through a conduit 18 and a control valve 24 behind the superheating surfaces 21 to the main conduit 1 at point 27.

At point 39 of feeding conduit 1 there branches off a conduit 5 which while bypassing the evaporator heating surface 11 leads into main conduit 1 at point 4 ahead of the superheating surfaces 21. Conduit 5 may by means of a control valve 3 selectively be shut off. Behind the superheating surfaces 21 at point 16 there branches off a circulating conduit 19 which at point 46 leads into the bypass conduit 5. The circulating conduit 19 has interposed therein a separating vessel 20 and a circulatory pump 22. The steam separated in the separating vessel 20 is through conduit 28 and conduit 29 likewise conveyed to the main conduit 1 into which it leads at point 47. This connecting conduit has interposed therein a control valve 57. Thus, the system comprises a first circulating circuit composed of feeding conduit 1, evaporator heating surface 11, conduit 14, separating vessel 10, circulating conduit 9, and circulatory pump 12. The second circulating circuit comprises the first superheater heating surfaces 21, the circulating conduit 19, the separating vessel 20, the circulatory pump 22, and a portion of the feeding conduit 5. Both circulating circuits are completely separated from each other and may be operated separately from each other. The separated steam is in conformity with the above described circuit passed from both circulating circuits to the main conduit 1 ahead of the superheater heating surfaces 31. At point 59, a connecting conduit 6 branches off from circulating conduit 9, which conduit 6 leads at 55 into the branch conduit 5. Conduit 6 has interposed therein a control valve 7. The water withdrawn from the separating vessel 10 can thus through said conduit 6 in a controlled manner be conveyed to feeding conduit 5 and thus to the first superheater heating surfaces 21.

Conduit 1 also comprises a check valve 63 which is arranged ahead of the point where circulating conduit 9 leads into conduit 1 but ahead of point 49. Another check valve 63 is arranged in conduit 5. A shut-off valve 23 is adapted to separate the first superheater heating surfaces 21 from the second superheater heating surfaces 31. This valve 23 is arranged behind the shut-off point 16 of the circulating conduit 19 but ahead of point 47 where conduit 29 leads into the main conduit 1. Finally, the steam conduit 18 communicates with main conduit 1 through a conduit 15 having interposed therein a shut-off valve 17 and branching off from conduit 18 at point 62. Conduit 15 leads into main conduit 1 at point 4.

A conduit 35 branches off main conduit 51 at point 52. Conduit 35 establishes communication between conduit 51 and conduit 38 through the intervention of a control valve 30, conduit 38 leading to the first intermediate reheater 34. A conduit 54 leads from the first intermediate superheater 34 to the above mentioned turbine while at point 53 a conduit 45 branches off from conduit 54 and establishes communication between conduit 54 and a conduit 48 leading from the turbine to the second intermediate reheater 44, a control valve 40 being interposed in conduit 45. A conduit 26 branches off from conduit 18 and has a shut-off valve 25 interposed therein. Conduit 26 leads at point 61 into conduit 29 which latter behind point 61 at point 56 branches into two conduits 33 and 43 each of which has a control valve 32, 42 respectively arranged therein. The first conduit 33 leads at point 50 into the branch conduit 35, whereas the second conduit leads at point 60 into the branch conduit 45. By means of these two conduits, conduit 18 communicates with the intermediate reheaters 34 and 44 so that the steam separated in the separating vessel 10 is able to cool these intermediate superheaters. Through conduits 28 and 29 steam from the separating vessel 20 may be conveyed to the intermediate superheaters 34 and 44.

With the diagram according to FIG. 1, during the starting phase, first the feeding pump 2 fills the circulating system for the evaporator heating surfaces 11 and the circulatory system for the superheating surfaces 21. Prior to firing the boiler, also the pumps 12 and 22 are started, and a separate circulating operation is started. At this point, the evaporator heating surfaces 11 with the circulating circuit 14–10–9–12 are in parallel with the superheating surfaces 21 with the circulating circuit 19–20–22–5, while feeding water is continuously conveyed through feeding conduit 1 to the first circuit and to the second circuit. The steam produced in the circulating system of the evaporator heating surface 11 is separated in separating vessel 10 and through conduit 18 and control valve 24 is conveyed to the second superheater heating surfaces 31 which are located behind the superheater heating surfaces 21 cooled by the second circulating system.

The increase in the evaporator heating surface 11 according to this diagram by the heating surface of the first superheater 21 which in this phase of the starting operation acts as evaporator, not only produces a sufficient cooling for these heating surfaces 21 but also brings about that at an early stage a sufficiently large quantity of steam will be obtained for cooling the successive superheaters 31, 41, and reheaters 34 and 44.

With increasing firing, valves 3 and 8 are throttled, and valve 7 is opened in a corresponding manner. As a result thereof, the proportion of the evaporated water which is replaced by the feeding pump will gradually alone be in communication with the evaporator heating surface

11. The superheater heating surfaces 21 are to an ever increasing extent supplied with the water which is withdrawn by pump 12 in boiling condition from the separating vessel 10 and which is then through control valve 7 and conduit 6 conveyed to conduit 5. However, if desired, vessel 10 may from the very start, with control valve 3 of the circulating circuit of the heating surfaces 21 closed, be filled through valve 7 and conduit 6 and be charged during the starting operation so that as far as the water flow is concerned arrangement in series is maintained.

With further increasing firing, the quantity of steam freed in separating vessel 10 will eventually become so great that it will be sufficient to properly cool the superheater heating surfaces 21 and all of the subsequent heating surfaces. The steam freed in vessel 10 will then no longer be passed to the superheaters 31, 41, and reheaters 34, 44 through control valves 24 and 25 but will through control valve 17 and conduit 15 be conveyed to the start of the superheater heating surfaces 21. At this time the circulating system 19–20–22–5 of the first superheater heating surfaces 21 is taken out of operation. No temperature shock will occur at the feed-in point to said heating surfaces 21 because the water in boiling condition is replaced by saturated steam of the same temperature. From this time on, the starting operation of the steam producer will take its course as is customary with the systems with circulation.

When the circulating system of the evaporator circuit 11 has dropped out due to a disorder, it is also possible to start the steam producer through the intervention of the circulating system of the superheater heating surface 21 by blocking the check valve flap 63 so as to maintain the same in open position. In these circumstances, a circulating circuit is obtained via the heating surfaces 11 and 21 and the circulating system 19–20–22–5 and control valve 3 back to feeding conduit 1.

Referring now to FIG. 2, this figure shows an arrangement which is based on the same principle as the system of FIG. 1 with the exception that the second circulating system of FIG. 1 is modified over that of the arrangement of FIG. 2. According to FIG. 2, the circulating system 14–10–9–11 of the evaporator is filled and brought into operation through feeding conduit 1. A portion of the feeding water passes through control valve 3 and conduit 5 to superheater heating surfaces 21. While valve 23 is closed, said feeding water passes through conduit 29 and control valve 37 as well as conduit 36 into the open or into a starting expander. The first superheater heating surfaces 21 may also be filled through valve 7 and conduit 6, 5. With increasing firing, the proportion of the cold feeding water is reduced through valve 3 and conduit 5 to the superheater 21 so that eventually through valve 7 and conduit 6 only boiling water will be conveyed to the heating surfaces where it will be evaporated.

It is also possible from the very start to press all of the water supply by the feeding pump into the evaporator heating surface 11 and to supply the heating surfaces 21 solely through valve 7 and conduit 6 from the circulating system of the evaporator heating surface. When the heat absorption in the heating surfaces 21 is so great that the water entering the same evaporates, valve 37 is closed, and steam is conveyed through valve 23 to the intermediate high pressure superheaters or as the case may be through valves 32 and 42 to the intermediate superheaters for purposes of cooling. The steam separated in separating vessel 10 of the circulating system is from the very start through conduit 18 and valve 24 conveyed to the subsequent superheaters for cooling purposes. A corresponding splitting up of this steam to the high pressure and the intermediate superheaters is not shown in FIG. 2, but can be realized in a manner analogous to that shown in FIG. 1. From a certain starting condition on, valve 7 will be closed and the circulating operation is started through valve 8 into the feeding conduit and the evapoartor heating surface as is customary with heretofore known circulating methods. The steam freed in the separating vessel is no longer through conduit 18 and valve 24 conveyed to the superheater behind the superheating surface 21 but through valve 17 and conduit 15 also the heating surfaces 21 are enclosed into the cooling by said saturated steam. From this time on, the starting of the steam producer is continued as it is customary with boilers having a circulating system.

It is, of course, to be understood that the present invention is, by no means, limited to the methods set forth above but also comprises any modifications within the scope of the appended claims. In this connection it should be noted that the circuits set forth above can also in an analogous manner be employed for stopping the steam producer.

What I claim is:

1. In a circuit for facilitating the starting of a forced-flow steam producer: feed water supply means, main conduit means adapted to be connected with a steam consumer and to communicate with said feed water supply means, evaporator heating surface means interposed in said main conduit means, first superheater heating surface means likewise interposed in said main conduit means and arranged in series with and behind said evaporator heating surface means when looking in the direction of flow of fluid through said main conduit means, second superheater heating surface means also interposed in said main conduit means in series with and behind said first superheater heating surface means when looking in the direction of flow of fluid through said main conduit means, first circuit means shunting said evaporator heating surface means and leading from said main conduit means at a point between said evaporator heating surface means and said first superheater heating surface means to a point between said feed water supply means and the adjacent side of said evaporator heating surface means, said first circuit means including a separating vessel adapted to separate steam and water from each other and also including a circulating pump, second circuit means connected to said main conduit means at a point between said evaporator heating surface means and said first superheater heating surface means and also connected to said main conduit means at a point between said feed water supply means and said evaporator heating surface means, and control valve means respectively located in said first and second circuit means for controlling the same.

2. A circuit according to claim 1, in which said second circuit means shunts said first superheater heating surface means and includes a separating vessel for separating steam and water from each other and also includes a circulating pump.

3. A circuit according to claim 1, which includes valve means adapted selectively to be closed and opened and located between said first and second circuit means on one hand and said second superheater heating surface means on the other hand.

4. A circuit according to claim 1, which includes first auxiliary conduit means leading from said separating vessel to said second superheater heating surface means while bypassing said first superheater heating surface means and said second circuit means, and valve means interposed in said auxiliary conduit means and adapted selectively to be opened and closed.

5. A circuit according to claim 4, which includes second auxiliary conduit means leading from said first auxiliary conduit means to said first superheater heating surface means, and valve means interposed in said second auxiliary conduit means and adapted selectively to be opened and closed.

6. A circuit according to claim 4, which includes reheater means, and which also includes additional conduit means leading from said first auxiliary conduit means to

said reheater means, and valve means interposed in said additional conduit means for controlling the same.

7. A circuit according to claim 2, which includes reheater means, and which also includes: third conduit means branching off from the pressure side of the circulating pump in said second circuit means and communicating with said main conduit means at a point between said evaporator heating surface means and said first superheater heating surface means, fourth conduit means leading from said separating vessel in said second circuit means to said reheater means, and valve means interposed in said third conduit means for controlling the same.

8. A circuit according to claim 2, which includes two branch lines respectively branching off from said first and second circuit means between the respective separating vessel and pump pertaining thereto.

9. A circuit according to claim 1, which includes conduit means connected to that end of said first superheater heating surface means which is remote from said evaporator heating surface means, said last mentioned conduit means being adapted selectively to be connected to a starting expander or to the outside of said steam producer.

10. A circuit according to claim 1, which includes first and second reheater means, high pressure conduit means connected to the output side of said second superheater heating surface means, a first feeding line for said first reheater means connected to said high pressure conduit means, a second feeding line for said second reheater means connected to the outlet side of said first reheater means, pressure reducing valve means respectively interposed in said first and second feeding lines, and conduit means adapted to communicate with said first and second circuit means and respectively leading into said first and second feeding lines.

11. In a method of starting a forced-flow steam producer having main conduit means adapted to be connected to a steam consumer and comprising feed water supply means and evaporator heating surface means communicating therewith, and first and second superheater heating surface means in series with each other and with said evaporator heating surface means, said steam producer also including first circuit means shunting said evaporator heating surface means and comprising a steam and water separating vessel and a pump and also including second circuit means leading from a point of said main conduit means between said feed water supply means and said evaporator heating surface means to a point of said main conduit means between said first superheater heating surface means and said evaporator heating surface means, which includes the steps of: during the start of said steam producer operating said two circuits steamwise in parallel arrangement with regard to each other, and subsequently with increasing firing said steam producer continuously operating said second circuit means and said first superheater heating surface means steamwise in series with regard to each other.

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