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(54) **Steam seal header, method of using a steam seal header and steam turbine system incorporating a steam seal header**

(57) A steam turbine system for use in a power plant includes a steam seal header (350) that collects steam from seals (112,114,122) of a high pressure steam turbine (110) and an intermediate pressure steam turbine (120). The collected steam is provided to seals of a low pressure steam turbine (130) to ensure the seals (132) provide an effective seal for the low pressure steam turbine (130). Steam from the low pressure steam turbine (130) is also collected in the steam seal header (350) and it is mixed with the steam collected from the high and intermediate pressure seals (112,114,122). The mixed steam is then provided to drive the low pressure steam turbine (130).

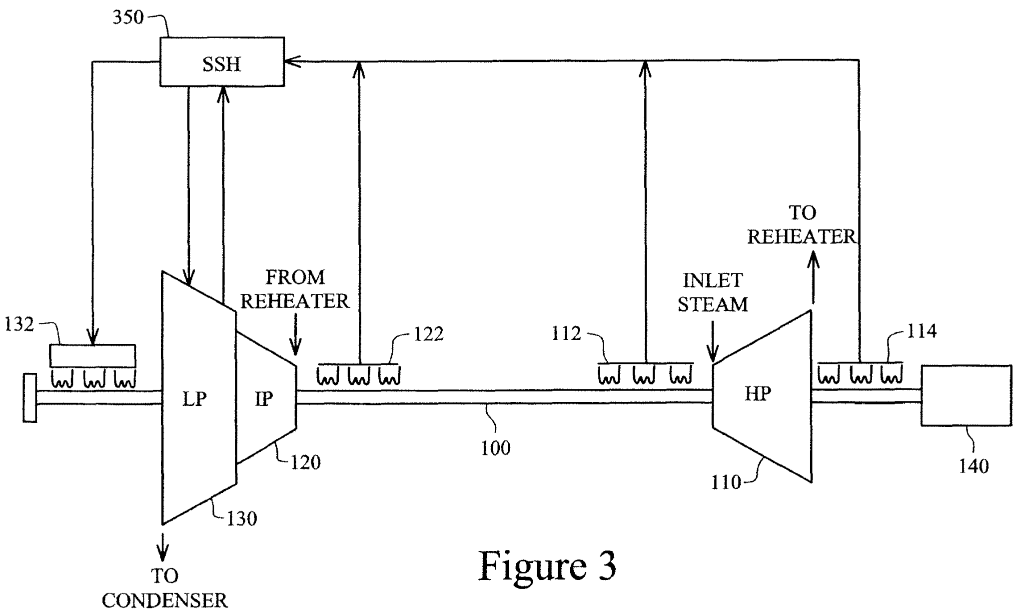

Figure 3

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Description

BACKGROUND OF THE INVENTION

[0001] Steam turbine systems are often an integral portion of a power plant. In some instances, the steam turbines can also be a part of a combined cycle power plant which also includes one or more gas turbines. Thermal energy is used to produce steam which drives the steam turbines. The steam turbines drive a generator which produces electricity.

[0002] The steam turbine system can include a high pressure steam turbine, an intermediate pressure steam turbine and a low pressure steam turbine, all of which are connected to a common rotating shaft that drives a generator. In some instances, the different steam turbines could be coupled to different shafts which drive different generators. Regardless, seals are used to seal the steam turbines to the rotating shaft.

[0003] The seals which seal the steam turbines onto a rotating shaft require a certain amount of steam pressure in order to provide an effective seal. The seals used on high pressure steam turbines and intermediate pressure steam turbines typically receive enough pressure from the associated turbines so that they provide an effective seal. However, in some instances, and under some operating conditions, the low pressure steam turbine may not be capable of providing enough pressure to its seals to ensure an effective seal. As a result, many steam turbine systems are configured so that steam can be routed from the seals used on the high pressure and intermediate pressure steam turbines to the seals used on the low pressure steam turbine so that the low pressure steam turbine seals can provide an effective seal.

[0004] Figure 1 illustrates a typical background art steam turbine system. The steam turbine system includes a high pressure steam turbine 110 attached to a rotating shaft 100. In addition, an intermediate pressure steam turbine 120 and a low pressure steam turbine 130 are also coupled to the same common rotating shaft 100. The high pressure steam turbine 110, intermediate pressure steam turbine 120 and low pressure steam turbine 130 drive a generator 140 which is also connected to the rotating shaft 100.

[0005] Inlet steam is provided to the high pressure steam turbine and is used to generate a motive force. Steam exiting the high pressure steam turbine 110 is routed to a reheater. Steam from the reheater is then routed to the intermediate pressure steam turbine 120. The steam passes through the intermediate pressure turbine 120 and then through the low pressure steam turbine 130, and ultimately exits to a condenser.

[0006] Figure 1 illustrates that high pressure seals 112, 114 are provided on either side of the high pressure steam turbine 110. In addition, intermediate pressure seals 122 are provided to seal the intermediate pressure steam turbine 120. Finally, low pressure seals 132 are provided to seal the low pressure steam turbine 130.

[0007] As explained above, during some operational conditions, the low pressure steam turbine 130 may not be capable of providing sufficient pressure to the low pressure seals 132 to ensure the seals 132 are effective. For this reason, the system also includes a steam seal header 150 which collects steam from the high pressure seals 112, 114 and the intermediate pressures seals 122. The steam routed to the steam seal header 150 is then delivered to the low pressure seals 132 so that the low pressure seals 132 can effectively seal the low pressure steam turbine 130.

[0008] Any excess steam collected in the steam seal header 150 which is not required by the low pressure seals 132 is routed to the condenser. Unfortunately, routing this excess steam to the condenser essentially wastes the energy present in this high temperature, high pressure steam. The steam collected in the steam seal header 150 still has sufficient thermal energy that it could have been used to produce work. As a result, configuring the steam turbine system as illustrated in Figure 1 results in a less efficient operation that would otherwise be possible.

[0009] Figure 2 illustrates another background art steam turbine system similar to the one illustrated in Figure 1. However, in this embodiment the excess steam collected in the steam seal header 250 which is not needed by the low pressure seals 132 is routed to the low pressure steam turbine 130. This allows the energy in the excess steam collected from the high pressure seals 112, 114 and the intermediate pressure seals 122 to be used to drive the generator 140.

[0010] The steam collected from the high pressure seals 112, 114 and the intermediate pressure seals 122 is at a relatively high temperature and pressure. Often, the temperature and pressure of this collected steam is too high to be directly used in the low pressure steam turbine 130. For this reason, an attemperator 260 is provided between the steam seal header 250 and the low pressure steam turbine 130. The attemperator 260 lowers the temperature and pressure of the steam collected from the high pressure seals 112, 114 and the intermediate pressure seals 122 to a temperature and pressure that is suitable for introduction into the low pressure steam turbine 130.

[0011] Although the configuration illustrated in Figure 2 allows energy in the excess steam to be used to drive the generator 140, the cost of the attemperator 260 is often too high to justify the additional energy which is produced by this configuration.

SUMMARY OF THE INVENTION

[0012] In a first aspect, the invention is embodied in a method of utilizing steam provided by a seal of a high pressure steam turbine or a seal of an intermediate pressure steam turbine includes receiving a first flow of steam from at least one of a seal of a high pressure steam turbine and a seal of an intermediate pressure steam turbine in a steam seal header. A second flow of steam is received from a first location in a low pressure steam turbine in the steam seal header. A third flow of steam is provided from the steam seal header to a second location in the low pressure steam turbine, wherein the third flow of steam comprises a mixture of the first and second flows of steam.

[0013] In a second aspect, the invention is embodied in a steam seal header that includes a main body configured to hold a volume of steam, a first inlet into the main body that is configured to receive a first flow of steam from at least one of a seal of an intermediate pressure steam turbine and a seal of a high pressure steam turbine, and a second inlet into the main body that is configured to receive a second flow of steam from a first location in a low pressure steam turbine. The steam seal header also includes a first outlet from the main body that is configured to output a third flow of steam from the main body to a second location in the low pressure steam turbine, and a second outlet from the main body that is configured to output a fourth flow of steam to a seal of the low pressure steam turbine.

[0014] In a third aspect, the invention is embodied in a steam turbine system. The system includes a high pressure steam turbine, at least one high pressure seal for the high pressure steam turbine, a low pressure steam turbine, and a steam seal header that receives a first flow of steam from the high pressure seal and a second flow of steam from the low pressure steam turbine. The steam seal header outputs a third flow of steam to the low pressure steam turbine, wherein the third flow of steam comprises a mixture of the first and second flows of steam.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Figure 1 is a diagram of a background art steam turbine system;

Figure 2 is a diagram of another background art steam turbine system;

Figure 3 is a diagram of a first steam turbine system embodying the invention;

Figure 4 is a diagram of a second steam turbine system embodying the invention;

Figure 5 is a diagram of a first steam seal header embodying the invention; and

Figure 6 is a diagram of a second steam seal header embodying the invention.

DETAILED DESRIPTION OF THE INVENTION

[0016] Figure 3 is a diagram of a steam turbine system embodying the invention. The configuration illustrated in Figure 3 allows excess steam collected from the high pressure seals and intermediate pressure seals to be utilized to drive a generator. However, this configuration does not require the use of an attemperator.

[0017] The steam turbine system includes a high pressure steam turbine 110 connected to a rotating shaft 100. In addition, an intermediate pressure steam turbine 120 and a low pressure steam turbine 130 are also coupled to the rotating shaft 100. The rotating shaft 100 drives a generator 140.

[0018] High pressure seals 112, 114 are provided to seal the high pressure steam turbine 110. Intermediate pressure seals 122 are provided to seal the intermediate pressure steam turbine 120. Low pressure seals 132 are provided to seal the low pressure steam turbine 130.

[0019] As explained above, under some operating conditions the low pressure steam turbine 130 cannot provide steam at a sufficiently high pressure to the low pressure seals 132 to ensure the seals 132 are effective. For this reason, steam is collected from the high pressure seals 112, 114 and the intermediate pressure seals 112 in a steam seal header 350. The steam seal header 350 provides this collected steam to the low pressure seals 132 so that the low pressure seals 132 provide an effective seal for the low pressure steam turbine 130.

[0020] Excess steam which has been collected from the high pressure seals 112, 114 and the intermediate pressure seals 122 which is not required by the low pressure seals 132 is used to drive the low pressure steam turbine 130. However, in this embodiment steam is withdrawn from a first location within the low pressure steam turbine 130 itself, and this withdrawn steam is mixed with the steam in the steam seal header 350 collected from the high pressure seals 112, 114 and the intermediate pressure seals 122. This creates steam which is at a sufficiently low temperature and pressure that it can be effectively introduced into a second location within the low pressure steam turbine 130 to drive the low pressure steam turbine 130.

[0021] In some embodiments, the steam delivered from the steam seal header 350 into the low pressure steam turbine 130 would be delivered into the low pressure steam turbine 130 at a position downstream from the location where steam was withdrawn from the low pressure steam turbine 130. In alternate embodiments, however, steam delivered from the steam seal header 350 into the low pressure steam turbine 130 is delivered into the low pressure steam turbine 130 at a position upstream from the location where steam was withdrawn from the low pressure steam turbine 130.

[0022] An embodiment as illustrated in Figure 3 allows excess steam collected from the high pressure seals 112, 114 and the intermediate pressure seals 122 to be used to drive the low pressure steam turbine 130. However, this configuration does not require an attemperator. Because the cost of an attemperator is saved, configuring a system as illustrated in Figure 3 results in a more cost effective operation than the background art systems illustrated in Figures 1 and 2.

[0023] Figure 4 illustrates another embodiment of a steam turbine system which operates under similar principles to the system described above in connection with Figure 3. In this embodiment, a high pressure steam turbine 410 is connected to a rotating shaft 400. An intermediate pressure steam turbine 420 is also connected to the rotating shaft 400. Further, a completely separate dual-flow, low pressure steam turbine 430 is also connected to the rotating shaft 400. The dual-flow, low pressure steam turbine 430, the intermediate pressure steam turbine 420 and the high pressure steam turbine 410 all drive a generator 440 which is connected to the rotating shaft 400.

[0024] As illustrated in Figure 4, inlet steam is provided to the high pressure steam turbine 410, and steam exiting the high pressure steam turbine 410 is routed to the inlet of the intermediate pressure steam turbine 420. Steam output from the intermediate pressure steam turbine 420 is routed to a reheater or to a heat recovery steam generator (HRSG). After being reheated, the steam is then delivered from the reheater or the HRSG to the inlet of the dual-flow, low pressure steam turbine 430. Steam exiting the low pressure steam turbine 430 is routed to a condenser.

[0025] High pressure seals 412, 414 are provided to seal the high pressure steam turbine 410 to the rotating shaft 400. Likewise, intermediate pressure seals 422, 424 are provided to seal the intermediate pressure steam turbine 420 to the rotating shaft 400. Further, low pressure seals 432, 434 are provided to seal the low pressure steam turbine 430 to the rotating shaft 400.

[0026] As in the previously-described embodiments, in some operating conditions the dual-flow, low pressure steam turbine 430 cannot provide steam at a sufficiently high pressure to the low pressure seals 432, 434 to provide an effective seal. As a result, steam is collected from the high pressure seals 412, 414 and the intermediate pressure seals 422, 424 in a steam seal header 450. This steam is then provided to the low pressure seals 432, 434 as needed to provide an effective seal for the dual-flow, low pressure steam turbine 430.

[0027] In this embodiment, excess steam collected from the high pressure seals 412, 414 and the intermediate pressure seals 422, 424 is used to drive the dual-flow, low pressure steam turbine 430. As in the previously-described embodiment, a portion of the steam flowing through the low pressure steam turbine 430 is routed to the steam seal header 450. The steam drawn from first location(s) within the low pressure steam turbine 430 is mixed with the steam collected from the high pressure seals 412, 414 and the intermediate pressure seals 422, 424 to provide a flow of steam at an appropriate temperature and pressure that is routed back to second location (s) within the low pressure steam turbine 430.

[0028] The steam seal headers used in the steam turbine systems illustrated in Figures 3 and 4 could take on varying in different forms. In a simple embodiment, as illustrated in Figure 5, the steam seal header 550 includes a main body 551 with four openings. A first inlet 522 receives a first flow of steam from high and/or intermediate pressure seals. A second inlet 556 receives a second flow of steam from a low pressure steam turbine. The first flow of steam received through the first inlet 552 and the second flow of steam received through the second inlet 556 are mixed within the main body 551. The mixture is then output through a first outlet 558 to the low pressure steam turbine, as described above. In addition, the mixture is also output through a second outlet 554 to a low pressure seal of the low pressure steam turbine. Appropriate valves can be provided to adjust the flow rates through the first inlet 552, the second inlet 556, the first outlet 558 and the second outlet 554.

[0029] A steam seal header 550 as illustrated in Figure 5 will generate two flows of steam which are directed to the low pressure steam turbine and to the low pressure seals. However, both flows of steam will be at essentially the same temperature and pressure.

[0030] A second embodiment of a steam seal header 650 is illustrated in Figure 6. This embodiment makes it possible to deliver a first flow of steam at a first temperature and pressure to the low pressure steam turbine, and a second flow of steam at a different temperature and pressure to the low pressure seals of a low pressure steam turbine.

[0031] The steam seal header 650 in Figure 6 includes a main body 651. A first inlet 652 receives a first flow of steam from the seals of a high and/or intermediate pressure steam turbine. A partition 660 separates the interior of the main body 651 into a first chamber 670 and a second chamber 680. As illustrated in Figure 6, the first chamber opens onto the first inlet 652 and a second outlet 654, which is operatively connected to the low pressure seals of a low pressure steam turbine. As a result, the flow of steam received through the first inlet 652 from the high and/or intermediate pressure seals is communicated directly to the low pressure seals through the second outlet 654.

[0032] An aperture 662 is provided in the partition 660 so that at least a portion of the flow of steam received through the first inlet 652 can be communicated into the second chamber 680. A second inlet 656 opens into the second chamber 680. The second inlet 656 would be operatively connected to a low pressure steam turbine so that steam can be received from the low pressure steam turbine into the second chamber 680. A first outlet 658 also opens into the second chamber 680. The first outlet 658 is operatively connected to the low pressure steam turbine so that steam from within the second chamber 680 can be communicated to the low pressure steam turbine.

[0033] The second chamber 680 is used to create a mixture of the first flow of steam received through the first inlet 652 and the second flow of steam received through the second inlet 656. This mixture is then provided to the low pressure steam turbine through the first outlet 658.

[0034] The embodiment illustrated in Figure 6 can deliver a first flow of steam to the low pressure seals of a low pressure steam turbine at a first temperature and pressure, and also deliver a second flow of steam to a low pressure steam turbine at a second temperature and pressure different from the first temperature and pressure. Typically, the flow of steam delivered to the low pressure steam turbine through the first outlet 658 should be at lower temperature and pressure than the first flow of steam received from the high and/or intermediate pressure seals. Mixing that flow of steam with steam from the low pressure steam turbine in the second chamber 680 makes this possible. However, this configuration also makes it possible to deliver a flow of steam at a higher temperature and pressure to the low pressure seals of a low pressure steam turbine.

[0035] In some embodiments, the steam seal header 650 could also include a valve 664 connected to the aperture 662 to control the amount of steam that is routed into the second chamber 680. In some embodiments this valve 664 could be an expansion valve, which would cause the steam moving from the first chamber 670 into the second chamber 680 to enter the second chamber 680 at a lower pressure than exists within the first chamber 670.

[0036] While the invention has been described in connection with what is presently considered to be the most practical and preferred embodiment, it is to be understood that the invention is not to be limited to the disclosed embodiment, but on the contrary, is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.

[0037] Various aspects and embodiments of the present invention are defined by the following numbered clauses:

1. A steam turbine system for use in a power plant, comprising:

   a high pressure steam turbine;
   at least one high pressure seal for the high pressure steam turbine;
   a low pressure steam turbine;
   a steam seal header that receives a first flow of steam from the high pressure seal and a second flow of steam from the low pressure steam turbine, and that outputs a third flow of steam to the low pressure steam turbine, wherein the third flow of steam comprises a mixture of the first and second flows of steam.

2. The steam turbine system of clause 1, further comprising a low pressure seal for the low pressure steam turbine, wherein the steam seal header outputs a fourth flow of steam to the low pressure seal.

3. The steam turbine system of clause 2, wherein the steam seal header is configured such that the third and fourth flows of steam output by the steam seal header are at substantially the same temperature and pressure.

4. The steam turbine system of clause 1 or 2, wherein the steam seal header is configured such that the third flow of steam is at a different temperature and pressure than the fourth flow of steam.

5. The steam turbine system of clause 4, wherein the fourth flow of steam is at substantially the same temperature and pressure as the first flow of steam.

6. The steam turbine system of clause 5, wherein the steam seal header is configured such that the third flow of steam comprises a mixture of at least a portion of first flow of steam and at least a portion of the second flow of steam.

7. The steam turbine system of any of clauses 1 to 6, further comprising:

   an intermediate pressure steam turbine; and
   an intermediate seal for the intermediate pressure steam turbine, wherein the first flow of steam received by the steam seal header comprises a mixture of steam from the high pressure seal and steam from the intermediate pressure seal.

Claims

1. A method of utilizing steam provided by a seal of a high pressure steam turbine (110,410) or a seal of an intermediate pressure steam turbine (120,420), comprising:

   receiving a first flow of steam from at least one of a seal (112,114,412,414) of a high pressure steam turbine (110,410) and a seal (122,422,424) of an intermediate pressure stream turbine (120,420) in a steam seal header (350,450);
   receiving a second flow of steam from a first location in a low pressure steam turbine (130,430) in the steam seal (350,450) header; and
   providing a third flow of steam from the steam seal header (350,450) to a second location in the low pressure steam turbine (130,430), wherein the third flow of steam comprises a mixture of the first and second flows of steam.

2. The method of claim 1, wherein the first flow of steam comprises steam from a seal (122,422,424) of an intermediate steam turbine (120,420) and steam from a seal (112,114,412,414) of a high pressure steam turbine (110,410).

3. The method of claim 1 or 2, wherein the first flow of steam and the second flow of steam mix together in the steam seal header (350,450) to form the third flow of steam.

4. The method of any of claims 1 to 3, further comprising providing a fourth flow of steam from the steam seal header (350,450) to a seal (132,432,434) of the low pressure steam turbine (130,430).

5. The method of claim 4, wherein the fourth flow of steam is at substantially the same temperature and pressure as the third flow of steam.

6. The method of claim 4, wherein the fourth flow of steam is at a different temperature and pressure than the third flow of steam.

7. A steam seal header (350,450,550,650), comprising:

a main body (551,651) configured to hold a volume of steam;
a first inlet (552,652) into the main body (551,651) that is configured to receive a first flow of steam from at least one of a seal (122,422,424) of an intermediate pressure steam turbine (120,420) and a seal (112,114,412,414) of a high pressure steam turbine (110,410);
a second inlet (556,656) into the main body (551,651) that is configured to receive a second flow of steam from a first location in a low pressure steam turbine (130,430);
a first outlet (558,658) from the main body (551,651) that is configured to output a third flow of steam from the main body (551,651) to a second location in the low pressure steam turbine (130,430); and
a second outlet (554,654) from the main body (551,651) that is configured to output a fourth flow of steam to a seal (132,432,434) of the low pressure steam turbine (130,430).

8. The steam seal header of claim 7, wherein the main body (551,651) is configured to mix at least portions of the first and second flows of steam to create the third flow of steam.

9. The steam seal header of claim 7 or 8, further comprising a partition member (660) located in the main body (551,651) , wherein the partition member (660) separates the main body (551,651) into a first chamber (670) that holds only the first flow of steam and a second chamber (680) that holds a mixture of the first and second flows of steam.

10. The steam seal header of claim 9, wherein the first inlet (552,652) and the second outlet (554,654) open into the first chamber (670) and wherein the second inlet (556,656) and the first outlet (558,658) open into the second chamber (680) of the main body.

11. The steam seal header of claim 10, further comprising an aperture (662) in the partition (660) that allows at least a portion of the first flow of steam received through the first inlet (556,652) to pass from the first chamber (670) into the second chamber (680).

12. The steam seal header of claim 11, further comprising a valve (664) that is operatively coupled to the aperture (662) in the partition (660), wherein the valve (664) controls an amount of the first flow of steam that passes from the first chamber (670) into the second chamber (680).

13. The steam seal turbine of claim 12, wherein the valve (664) is an expansion valve.

14. A steam turbine system for use in a power plant, comprising:

a high pressure steam turbine (110,410);
at least one high pressure seal (112,114,412,416) for the high pressure steam turbine (110,410);
a low pressure steam turbine (130,430); and
a steam seal header (350,450,550,650) as recited in any of claims 7 to 13.

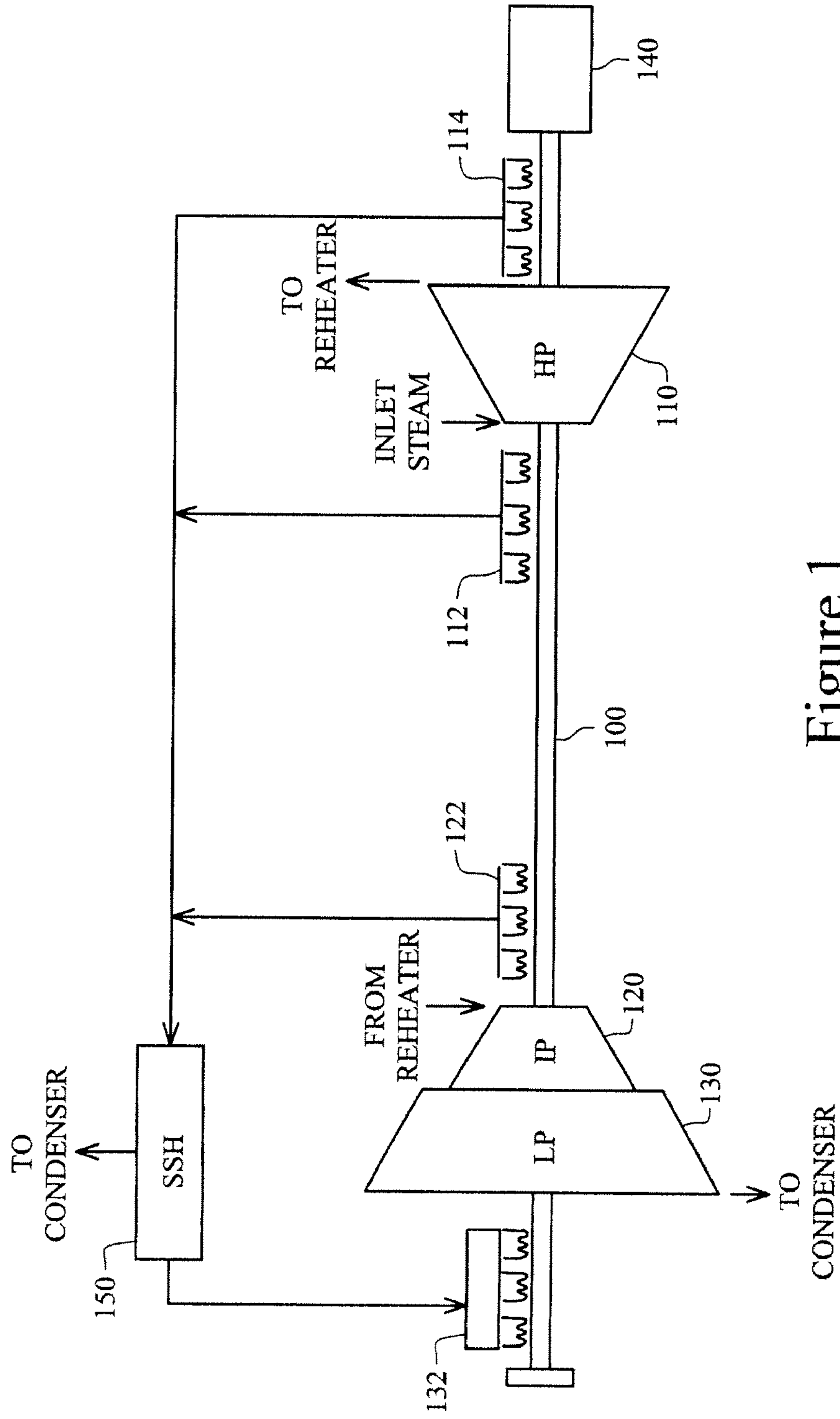

Figure 1
BACKGROUND ART

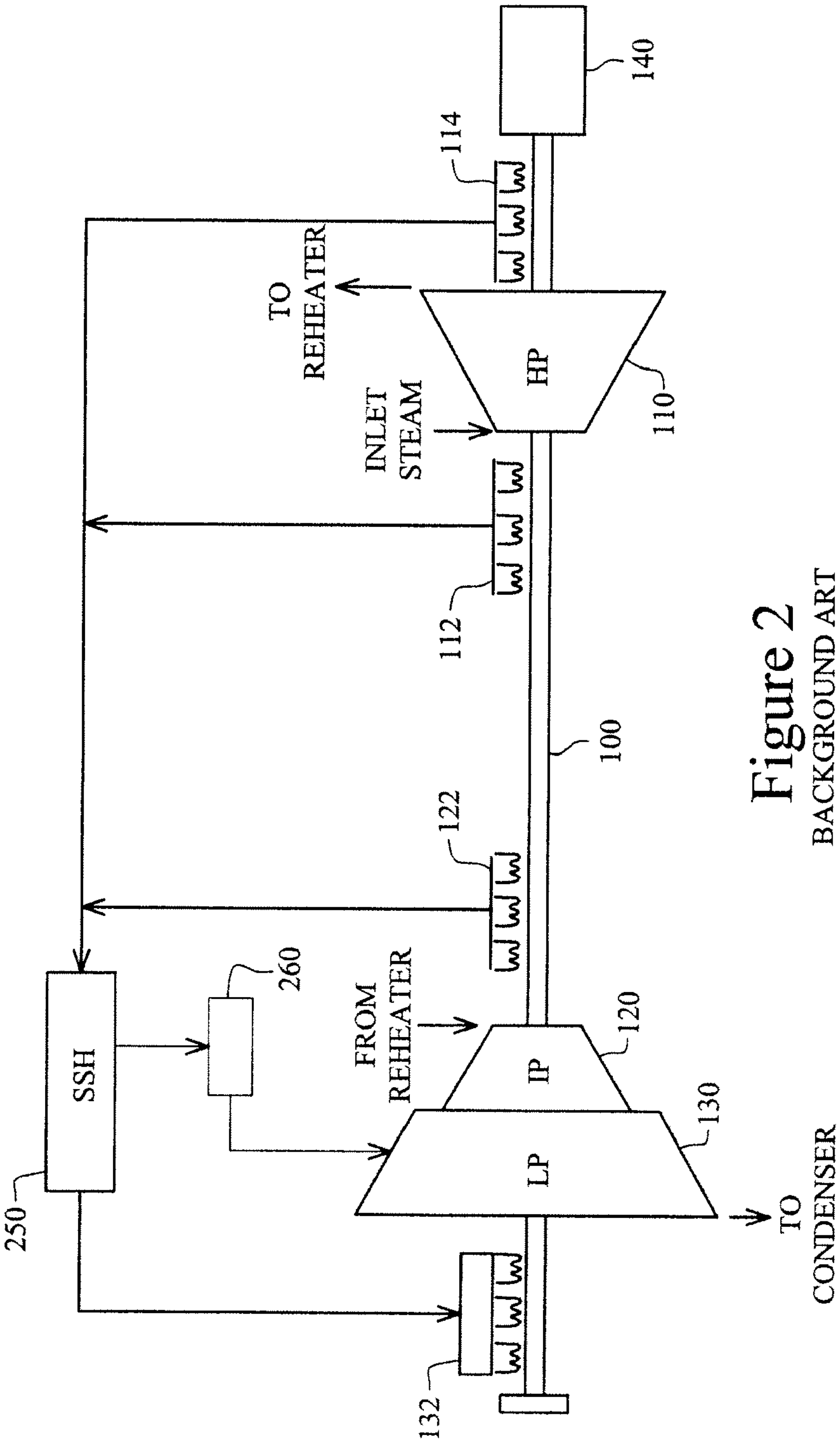

Figure 2
BACKGROUND ART

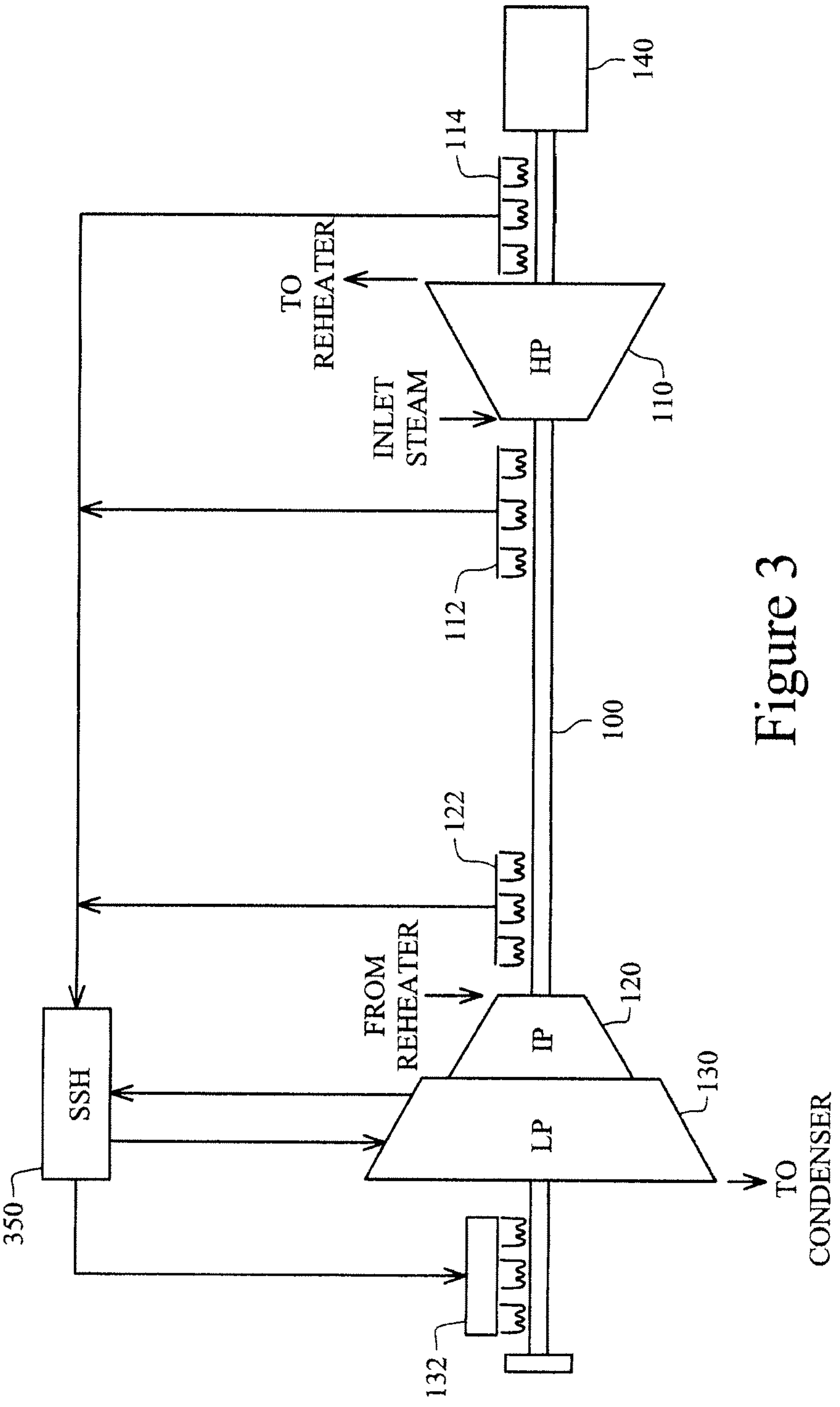
140
114
TO
REHEATER
HP
110
INLET
STEAM
112
100
122
FROM
REHEATER
IP
120
130
SSH
LP
350
TO
CONDENSER
132

Figure 3

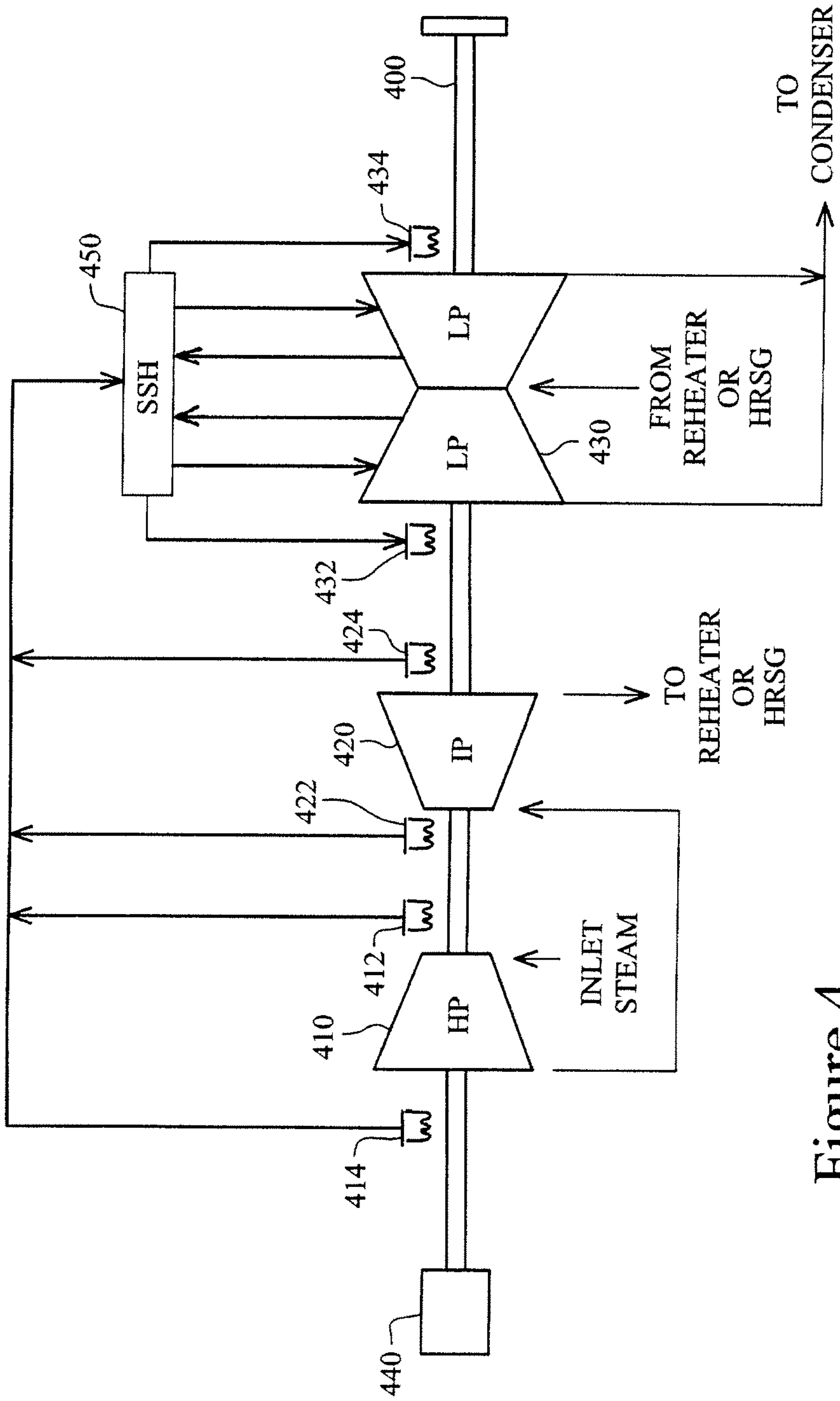
400
434
450
SSH
LP
LP
430
FROM REHEATER OR HRSG
TO CONDENSER
432
424
422
420
IP
TO REHEATER OR HRSG
412
HP
410
INLET STEAM
414
440

Figure 4

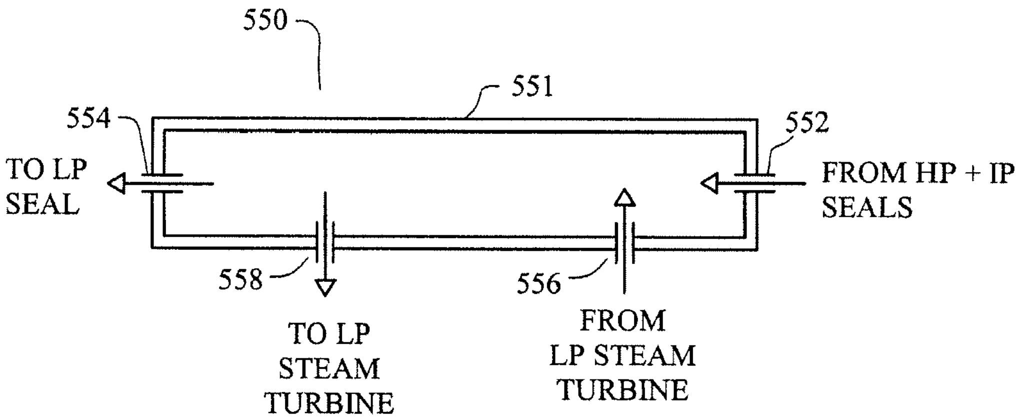

Figure 5

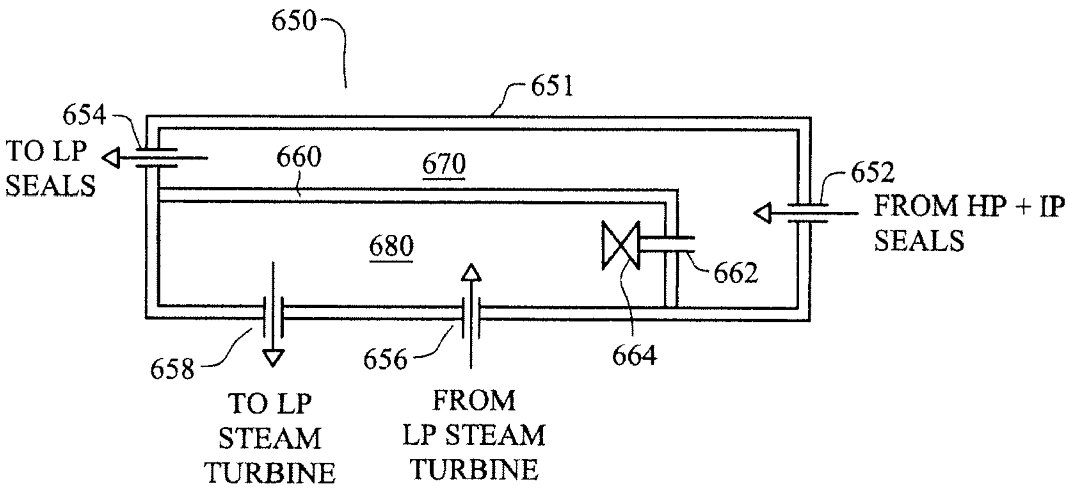

Figure 6