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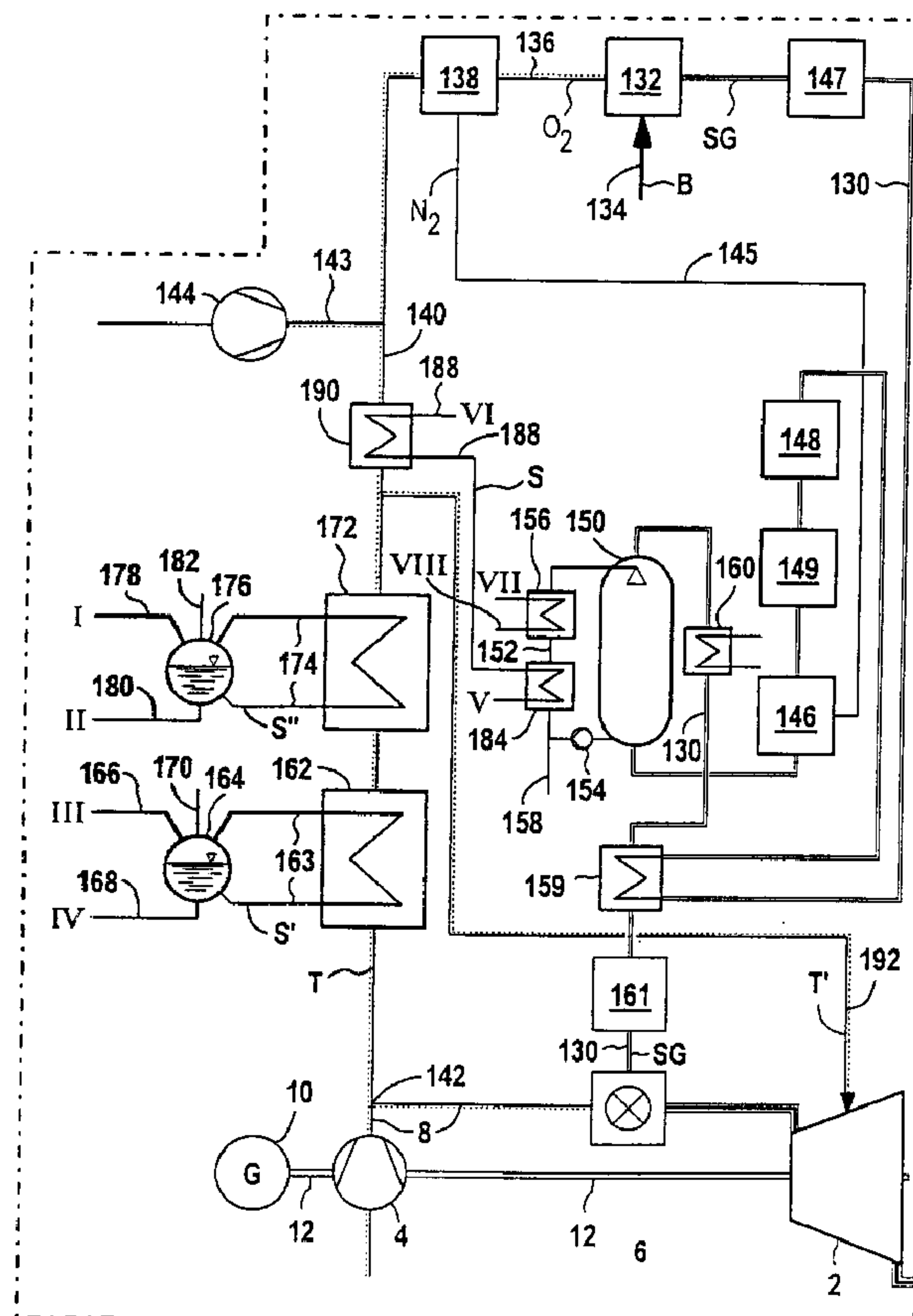
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(54) Titre : INSTALLATION A TURBINE A GAZ ET A VAPEUR

(54) Title: GAS AND STEAM TURBINE PLANT



(57) **Abrégé/Abstract:**

In a gas and steam turbine plant (1) with a waste-heat steam generator (30) which is located downstream of the gas turbine (2) on the flue-gas side and the heating surfaces of which are connected into the water/steam circuit (24) of the steam turbine (20), for the

(57) Abrégé(suite)/Abstract(continued):

integrated gasification of a fossil fuel (B) a fuel (B) gasification device (132) is located upstream of the combustion chamber (6) of the gas turbine (2) via a fuel line (130). According to the invention, for especially high plant efficiency, a heat exchanger (159) is connected on the primary side into the fuel line (130) between the gasification device (132) and a saturator (150), in addition to a mixing device (146) for admixing nitrogen (N_2), said heat exchanger likewise being connected on the secondary side into the fuel line (130) between the saturator (150) and the combustion chamber (6).

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Abstract

Gas and steam turbine plant

In a gas and steam turbine plant (1) with a waste-heat steam generator (30) which is located downstream of the gas turbine (2) on the flue-gas side and the heating surfaces of which are connected into the water/steam circuit (24) of the steam turbine (20), for the integrated gasification of a fossil fuel (B) a fuel (B) gasification device (132) is located upstream of the combustion chamber (6) of the gas turbine (2) via a fuel line (130). According to the invention, for especially high plant efficiency, a heat exchanger (159) is connected on the primary side into the fuel line (130) between the gasification device (132) and a saturator (150), in addition to a mixing device (146) for admixing nitrogen (N_2), said heat exchanger likewise being connected on the secondary side into the fuel line (130) between the saturator (150) and the combustion chamber (6).

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Description

Gas and steam turbine plant

5 The invention relates to a gas and steam turbine plant with a waste-heat steam generator which is located downstream of a gas turbine on the flue-gas side and the heating surfaces of which are connected into the water/steam circuit of a steam turbine, and
10 with a fuel gasification device located upstream of the combustion chamber of the gas turbine via a fuel line.

 A gas and steam turbine plant with integrated gasification of fossil fuel conventionally comprises a fuel gasification device which is connected on the
15 outlet side to the combustion chamber of the gas turbine via a number of components provided for gas purification. The gas turbine may, in this case, be followed on the flue-gas side by a waste-heat steam generator, the heating surfaces of which are connected
20 into the water/steam circuit of the steam turbine. A plant of this type is known, for example, from GB-A 2 234 984.

 Furthermore, DE 33 31 152 discloses a method for operating a gas turbine plant combined with a fuel
25 gasification plant. There is provision, in this case, for nitrogen to be supplied to the fuel gas directly upstream of the combustion chamber.

 In order to reduce pollutant emission during the combustion of the gasified fossil fuel, in this
30 plant a saturator, in which the gasified fuel is laden with steam, is connected into the fuel line between the gasification device and the combustion chamber of the gas turbine. For this purpose, the gasified fuel flows through the saturator in countercurrent to a water
35 stream which is carried in a water circuit designated as a saturator circuit. In this case, for especially high efficiency, there is provision for feeding heat

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from the water/steam circuit into the saturator circuit.

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By coming into contact with the heated water stream in the saturator, carried in the saturator circuit, the gasified fuel is saturated with steam and to a limited extent undergoes heating. In this case, 5 for thermal and also operational reasons, further heating of the fuel before it is supplied into the combustion chamber of the gas turbine may be necessary.

The object on which the invention is based is to specify a gas and steam turbine plant of the 10 abovementioned type which has especially high plant efficiency.

This object is achieved, according to the invention, in that a heat exchanger is connected on the primary side into the fuel line between the 15 gasification device and the saturator, in addition to a mixing device for admixing nitrogen, and is likewise connected on the secondary side into the fuel line between the saturator and the combustion chamber.

In a plant of this type, the admixing of 20 nitrogen to the gasified fossil fuel, also designated as synthesis gas, is intended for maintaining particularly low NO_x limit values in the combustion of the synthesis gas. The mixing device provided for admixing the nitrogen is connected into the fuel line 25 upstream of the saturator on the fuel side. The heat exchanger is, in this case, connected into the fuel line upstream of the mixer and saturator on the primary side and downstream of the saturator on the secondary side. Said heat exchanger thus transmits heat from the 30 synthesis gas, also designated as crude gas, flowing into the saturator into the synthesis gas, also designated as mixed gas, flowing out of the saturator. The heat exchanger, also designated as a crude-gas/mixed-gas heat exchanger, thus gives rise to 35 an at least partial heat-side bypass of the saturator, so that, due to the heating of the synthesis gas by the crude gas, the thermodynamic losses of the overall process are kept particularly low. The fuel-side

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arrangement of the mixing device upstream of the
saturation at the same time ensures

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that the crude-gas/mixed-gas heat exchanger transmits the heat from the crude gas to a particularly large mass stream. Thus, by virtue of an arrangement of this type, a particularly favorable heat exchange can be achieved, since, under the boundary condition of a constant final temperature, a comparatively large quantity of heat can be transmitted to the mixed gas flowing out of the saturator.

For especially high plant efficiency, in an advantageous development, the crude-gas/mixed-gas heat exchanger is preceded in the fuel line by a crude-gas waste-heat steam generator upstream of the saturator. By means of the crude-gas waste-heat steam generator, precooling of the synthesis gas or crude gas generated in the gasification device is possible, this precooling being beneficial for material reasons. At the same time, the heat extracted from the crude gas can be utilized in an especially beneficial way for steam generation. In this case, in a plant designed for the gasification of coal as fossil fuel, a so-called gas quench may be provided, in which so-called quench gas, branched off from the fuel line at a point between the crude-gas/mixed-gas heat exchanger and the saturator, is supplied to the synthesis gas before the latter enters the crude-gas waste-heat steam generator. In an arrangement of this type, the crude-gas mass flow is approximately comparable to the mixed-gas mass flow, so that the mixed gas can be preheated by heat exchange with the crude gas to temperatures of well above 300°C under customary operation conditions.

Expediently, a further heat exchanger, which is heated, for example, by means of medium-pressure feedwater, is connected on the secondary side into the fuel line between the saturator and the combustion chamber. In an arrangement of this type, even in the case of only limited cooling of the crude gas, for example because of boundary conditions set by a crude-gas dedusting device, reliable preheating of the

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mixed gas, along with especially high plant efficiency,
is ensured. A concept of this type for mixed-gas
preheating is also

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particularly suitable for a plant which is designed for the gasification of coal as fossil fuel and in which gas quench is not provided or for a plant designed for the gasification of oil as fossil fuel. Particularly in the case of a plant designed for the gasification of coal and without gas quench, the crude-gas mass flow is usually approximately half the mixed-gas mass flow, so that mixed-gas preheating by the crude-gas/mixed-gas heat exchanger is limited to a temperature range of about 200°C to 230°C. In a plant of this type, therefore, additional mixed-gas preheating via a further heat exchanger heated, for example, by means of high-pressure feedwater is especially beneficial.

Advantages achieved by means of the invention are, in particular, that the crude-gas/mixed-gas heat exchanger, provided in addition to the mixing device connected into the fuel line upstream of the saturator, makes it possible, by bypassing the saturator, to have an especially favorable transmission of heat from the crude gas flowing into the saturator to the mixed gas flowing out of the saturator. Thermodynamically unfavorable cooling and reheating of the synthesis gas are therefore necessary only to a limited extent, so that the efficiency of the gas and steam turbine plant is especially high.

An exemplary embodiment of the invention is explained in more detail with reference to a drawing in which the figure shows a gas and steam turbine plant diagrammatically.

The gas and steam turbine plant 1 according to the figure comprises a gas turbine plant 1a and a steam turbine plant 1b. The gas turbine plant 1a comprises a gas turbine 2 with a coupled air compressor 4 and a combustion chamber 6 which is located upstream of the gas turbine 2 and which is connected to a compressed-air line 8 of the compressor 4. The gas turbine 2 and the air compressor 4 and also a generator 10 are seated on a common shaft 12.

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The steam turbine plant 1b comprises a steam turbine 20 with a coupled generator 22 and, in a water/steam circuit 24, a condenser 26 located downstream of the steam turbine 20 and also a waste-heat steam generator 30. The steam turbine 20 consists of a first pressure stage or high-pressure part 20a, of a second pressure stage or medium-pressure part 20b and of a third pressure stage or low-pressure part 20c, which drive the generator 22 via a common shaft 32.

In order to supply working medium AM or flue gas, expanded in the gas turbine 2, into the waste-heat steam generator 30, an exhaust-gas line 34 is connected to an inlet 30a of the waste-heat steam generator 30. The expanded working medium AM from the gas turbine 2 leaves the waste-heat steam generator 30 via its outlet 30b in the direction of a chimney which is not illustrated in any more detail.

The waste-heat steam generator 30 comprises a condensate preheater 40 which can be fed on the inlet side with condensate K from the condenser 26 via a condensate line 42, into which a condensate pump unit 44 is connected. The condensate preheater 40 is connected on the outlet side to a feedwater tank 46 via a line 45. Moreover, in order to bypass the condensate preheater 40, as required, the condensate line 42 can be connected directly to the feedwater tank 46 via a bypass line which is not illustrated. The feedwater tank 46 is connected via a line 47 to a high-pressure feed pump 48 with medium-pressure extraction.

The high-pressure feed pump 48 brings the feedwater S flowing out of the feedwater tank 46 to a pressure level suitable for a high-pressure stage 50 of the water/steam circuit 24, said high-pressure stage being assigned to the high-pressure part of the steam turbine 20. The feedwater S, which is under high pressure, can be supplied to the high-pressure stage 50

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via a feedwater preheater 52 which is connected on the outlet side to a high-pressure drum 58 via a feedwater line 56 capable of being shut off by means of a valve 54.

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The high-pressure drum 58 is connected to a high-pressure evaporator 60 arranged in the waste-heat steam generator 30, in order to form a water/steam cycle 62. For the discharge of fresh steam F, the high-pressure drum 58 is connected to a high-pressure superheater 64 which is arranged in the waste-heat steam generator 30 and which is connected on the outlet side to the steam inlet 66 of the high-pressure part 20a of the steam turbine 20.

10 The steam outlet 68 of the high-pressure part 20a of the steam turbine 20 is connected via a reheater 70 to the steam inlet 72 of the medium-pressure part 20b of the steam turbine 20. Its steam outlet 74 is connected via an overflow line 76 to the steam inlet 78
15 of the low-pressure part 20c for the steam turbine 20. The steam outlet 80 of the low-pressure part 20c of the steam turbine 20 is connected via a steam line 82 to the condenser 26, so that a closed water/steam circuit 24 is obtained.

20 Moreover, a branch line 84 branches off from the high-pressure feed pump 48 at an extraction point at which the condensate K has reached a medium pressure. This branch line is connected via a further feedwater preheater 86 or medium-pressure economizer to
25 a medium-pressure stage 90 of the water/steam circuit, said medium-pressure stage being assigned to the medium-pressure part 20b of the steam turbine 20. For this purpose, the second feedwater preheater 86 is connected on the outlet side to a medium-pressure drum
30 96 of the medium-pressure stage 90 via a feedwater line 94 capable of being shut off by means of a valve 92. The medium-pressure drum 96 is connected to a heating surface 98 arranged in the waste-heat steam generator 30 and designed as a medium-pressure evaporator, in
35 order to form a water/steam cycle 100. For the discharge of medium-pressure fresh steam F', the medium-pressure drum 96 is connected via a steam line 102 to the reheater 70 and therefore to the steam inlet

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72 of the medium-pressure part 20b of the steam turbine
20.

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A further line 110 provided with a low-pressure feed pump 107 and capable of being shut off by means of a valve 108 branches off from the line 47 and is connected to a low-pressure stage 120 of the water/steam circuit 24, said low-pressure stage being assigned to the low-pressure part 20c of the steam turbine 20. The low-pressure stage 120 comprises a low-pressure drum 122 which is connected to a heating surface 124, arranged in the waste-heat steam generator 30 and designed as a low-pressure evaporator, in order to form a water/steam cycle 126. In order to discharge low-pressure fresh steam F'', the low-pressure drum 122 is connected to the overflow line 76 via a steam line 128, into which a low-pressure superheater 129 is connected. The water/steam circuit 24 of the gas and steam turbine plant 1 thus comprises three pressure stages 50, 90, 120 in the exemplary embodiment. Alternatively, however, fewer, in particular two, pressure stages may also be provided.

The gas turbine plant 1a is designed to operate with a gasified synthesis gas SG which is generated by the gasification of a fossil fuel B. The synthesis gas provided may be, for example, gasified coal or gasified oil. For this purpose, the combustion chamber 6 of the gas turbine 2 is connected on the inlet side to a gasification device 132 via a fuel line 130. Coal or oil can be supplied as fossil fuel B to the gasification device 132 via a charging system 134.

In order to provide the oxygen O₂ required for gasifying the fossil fuel B, the gasification device 132 is preceded via an oxygen line 136 by an air separation plant 138. The air separation plant 138 is capable of being loaded on the inlet side with a part stream T of the air compressed in the air compressor 4. For this purpose, the air separation plant 138 is connected on the inlet side to an extraction air line 140 which branches off from the compressed-air line 8 at a branch point 142. Moreover, a further air line

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143, into which an additional air compressor 144 is connected, issues into the extraction air line 140.

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In the exemplary embodiment, therefore, the entire air stream L flowing into the air separation plant 138 is composed of the part stream T branched off from the compressed-air line 8 and of the air stream conveyed from the additional air compressor 144. A connection concept of this type is also designated as a partly integrated plant concept. In an alternative embodiment, the so-called fully integrated plant concept, the further air line 143, along with the additional air compressor 144, may also be dispensed with, so that the air separation plant 138 is fed with air completely via the part stream T extracted from the compressed-air line 8.

The nitrogen N_2 obtained additionally to the oxygen O_2 in the air separation plant 138 during the separation of the air stream L is supplied, via a nitrogen line 145 connected to the air separation plant 138, to a mixing device 146 and is admixed with the synthesis gas SG there. In this case, the mixing device 146 is designed for particularly uniform and strand-free mixing of the nitrogen N_2 with the synthesis gas SG.

The synthesis gas SG flowing out from the gasification device 132 first passes via the fuel line 130 into a crude-gas waste-heat steam generator 147, in which cooling of the synthesis gas SG takes place by heat exchange with a flow medium. High-pressure steam generated during this heat exchange is supplied to the high-pressure stage 50 of the water/steam circuit 24 in a way not illustrated in any more detail.

A dedusting device 148 for the synthesis gas SG and a desulfurating plant 149 are connected into the fuel line 130 downstream of the crude-gas waste-heat steam generator 147 and upstream of the mixing device 146, as seen in the direction of flow of the synthesis gas SG. In an alternative embodiment, instead of the dedusting device 148, a soot scrubber device may also be provided, particularly

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when the gasified fuel is oil.

For especially low pollutant emission during the combustion of the gasified fuel in the combustion chamber 6, there is provision for loading the gasified fuel with steam prior to entry into the combustion chamber 6. This may be carried out in a saturator system in a way which is especially advantageous in thermal terms. For this purpose, a saturator 150, in which the gasified fuel is carried in countercurrent to the heated saturator water, is connected into the fuel line 130. In this case, the saturator water circulates in a saturator circuit 152 which is connected to the saturator 150 and into which a circulating pump 154 and, for preheating the saturator water, a heat exchanger 156 are connected. In this case, the heat exchanger 156 is loaded on the primary side with preheated feedwater from the medium-pressure stage 90 of the water/steam circuit 24. In order to compensate for the losses of saturator water which occur during the saturation of the gasified fuel, a feed line 158 is connected to the saturator circuit 152.

A heat exchanger 159 acting as a crude-gas/mixed-gas heat exchanger is connected on the secondary side into the fuel line 130 downstream of the saturator 150, as seen in the direction of flow of the synthesis gas SG. In this case, the heat exchanger 159 is likewise connected into the fuel line 130 on the primary side at a point upstream of the dedusting plant 148, so that the synthesis SG flowing into the dedusting plant 148 transmits part of its heat to the synthesis gas SG flowing out of the saturator 150. The routing of the synthesis gas SG via the heat exchanger 159 prior to entry into the desulfurating plant 149 may also be provided, in this case, with regard to a connection concept which is modified in terms of the other components. Particularly when a soot scrubber device is incorporated, the heat exchanger may be

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arranged preferably on the crude-gas side downstream of the soot scrubber device.

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A further heat exchanger 160, which on the primary side may be feedwater-heated or else steam-heated, is connected on the secondary side into the fuel line 130 between the saturator 150 and the heat exchanger 159. In this case, the heat exchanger 159, designed as a crude-gas/pure-gas heat exchanger, and the heat exchanger 160 ensure particularly reliable preheating of the synthesis gas SG flowing into the combustion chamber 6 of the gas turbine 2, even when the gas and steam turbine plant 1 is in different operating states.

Furthermore, in order to load the synthesis gas SG flowing into the combustion chamber 6 with steam, as required, the fuel line 130 has connected into it a further mixing device 161, to which medium-pressure steam can be supplied via a steam line, not illustrated in any more detail, in particular in order to ensure that the gas turbine operates reliably in the event of operational incidents.

In order to cool the part stream T of compressed air to be supplied to the air separation plant 138 and also designated as extraction air, the extraction air line 140 has connected into it on the primary side a heat exchanger 162 which is designed on the secondary side as a medium-pressure evaporator for a flow medium S'. The heat exchanger 162 is connected, to form an evaporator cycle 163, to a water/steam drum 164 designed as a medium-pressure drum. The water-steam drum 164 is connected via lines 166, 168 to the medium-pressure drum 96 assigned to the water/steam cycle 100. Alternatively, however, the heat exchanger 162 may also be connected directly on the secondary side to the medium-pressure drum 96. In the exemplary embodiment, therefore, the water/steam drum 164 is connected indirectly to the heating surface 98 designed as a medium-pressure evaporator. Moreover, a feedwater line 170 is connected to the water/steam drum 164 for the refeed of evaporated flow medium S'.

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Connected into the extraction air line 140 downstream of the heat exchanger 162, as seen in the direction of flow of the part stream T of compressed air, is a further heat exchanger 172 which is designed on the secondary side as a low-pressure evaporator for a flow medium S''. In this case, to form an evaporator cycle 174, the heat exchanger 172 is connected to a water/steam drum 176 designed as a low-pressure drum. In the exemplary embodiment, the water/steam drum 176 is connected via lines 178, 180 to the low-pressure drum 122 assigned to the water/steam cycle 126 and is thus connected indirectly to the heating surface 124 which is designed as a low-pressure evaporator. Alternatively, however, the water/steam drum 176 may also be connected in another suitable way, the steam extracted from the water/steam drum 176 being capable of being supplied as process steam and/or as heating steam to a secondary consumer. In a further alternative embodiment, the heat exchanger 172 may also be connected directly on the secondary side to the low-pressure drum 122. Moreover, the water/steam drum 176 is connected to a feedwater line 182.

The evaporator cycles 163, 174 may in each case be designed as a positive cycle, the cycle of the flow medium S' or S'' being ensured by a circulating pump, and the flow medium S', S'' at least partially evaporating in the heat exchanger 162 or 172 designed as an evaporator. In the exemplary embodiment, however, both the evaporator cycle 163 and the evaporator cycle 174 are each designed as a natural cycle, the cycle of the flow medium S' or S'' being ensured by the pressure differences established during the evaporation process and/or by the geodetic arrangement of the respective heat exchanger 162 or 172 and of the respective water/steam drum 164 or 176. In this embodiment, in each case only one circulating pump (not illustrated) of comparatively small dimension is connected into the evaporation cycle 163 or into the evaporator cycle 174

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for the purpose of starting up the system.

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For feeding heat into the saturator circuit 152, there is provided, in addition to the heat exchanger 156 which is capable of being loaded with heated feedwater branched off downstream of the feedwater preheater 86, a saturator water heat exchanger 184 which is capable of being loaded on the primary side with feedwater S from the feedwater tank 46. For this purpose, the saturator water heat exchanger 184 is connected on the primary side to the branch line 84 via a line 186 on the inlet side and to the feedwater tank 46 via a line 188 on the outlet side. For reheating the cooled feedwater S flowing out of the saturator water heat exchanger 184, an additional heat exchanger 190 is connected into the line 188 and on the primary side is located downstream of the heat exchanger 172 in the extraction air line 140. By virtue of an arrangement of this type, especially high heat recovery from the extraction air and therefore especially high efficiency of the gas and steam turbine plant 1 can be achieved.

A cooling-air line 192 branches off from the extraction air line 140 between the heat exchanger 172 and the heat exchanger 190, as seen in the direction of flow of the part stream T, and a part quantity T' of the cooled part stream T is capable of being supplied to the gas turbine 2 via said cooling-air line as cooling air for cooling the blades.

The arrangement of the mixing device 146 on the fuel side upstream of the saturator 150 makes it possible, in the heat exchanger 159, to have especially favorable heat transmission from the synthesis gas SG flowing into the saturator 150 and also designated as crude gas to the synthesis gas SG flowing out of the saturator 150 and also designated as mixed gas. In this case, heat exchange is promoted, in particular, in that the heat exchanger 159 transmits the heat from the crude gas to a particularly high mass flow of the mixed gas. Thus, even in the case of a limited final

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temperature, a comparatively large amount of heat can be transmitted to the mixed gas flowing out of the saturator 150. The gas and steam turbine plant 1 therefore has especially high plant efficiency.

5 In accordance with this invention, there is provided a gas and steam turbine plane (1) with a waste-heat steam generator (30) which is located downstream of a gas turbine (2) on the flue-gas side and the heating surfaces of which are connected into the water/steam circuit (24) of a
10 steam turbine (20), and with a fuel (B) gasification device (132) located upstream of the combustion chamber (6) of the gas turbine (2) via a fuel line (130), a heat exchanger (159) being connected on the primary side into the fuel line (130) between the gasification device (132) and a saturator
15 (150), in addition to a mixing device (146) for admixing nitrogen (N_2), said heat exchanger likewise being connected on the secondary side into the fuel line (130) between the saturator (150) and the combustion chamber (6).

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Patent claims

1. A gas and steam turbine plant (1) with a waste-heat steam generator (30) which is located downstream of a gas turbine (2) on the flue-gas side and the heating surfaces of which are connected into the water/steam circuit (24) of a steam turbine (20), and with a fuel (B) gasification device (132) located upstream of the combustion chamber (6) of the gas turbine (2) via a fuel line (130), a heat exchanger (159) being connected on the primary side into the fuel line (130) between the gasification device (132) and a saturator (150), in addition to a mixing device (146) for admixing nitrogen (N_2), said heat exchanger likewise being connected on the secondary side into the fuel line (130) between the saturator (150) and the combustion chamber (6).

2. The gas and steam turbine plant (1) as claimed in claim 1, wherein the heat exchanger (159) is preceded in the fuel line (130) by a crude-gas waste-heat steam generator (147) upstream of the saturator (150).

3. The gas and steam turbine plant (1) as claimed in claim 1 or 2, wherein a further heat exchanger (160) is connected on the secondary side into the fuel line (130) between the saturator (150) and the combustion chamber (6).

4. The gas and steam turbine plant (1) as claimed in claim 3, the further heat exchanger (160) of which is capable of being heated by feedwater (S).

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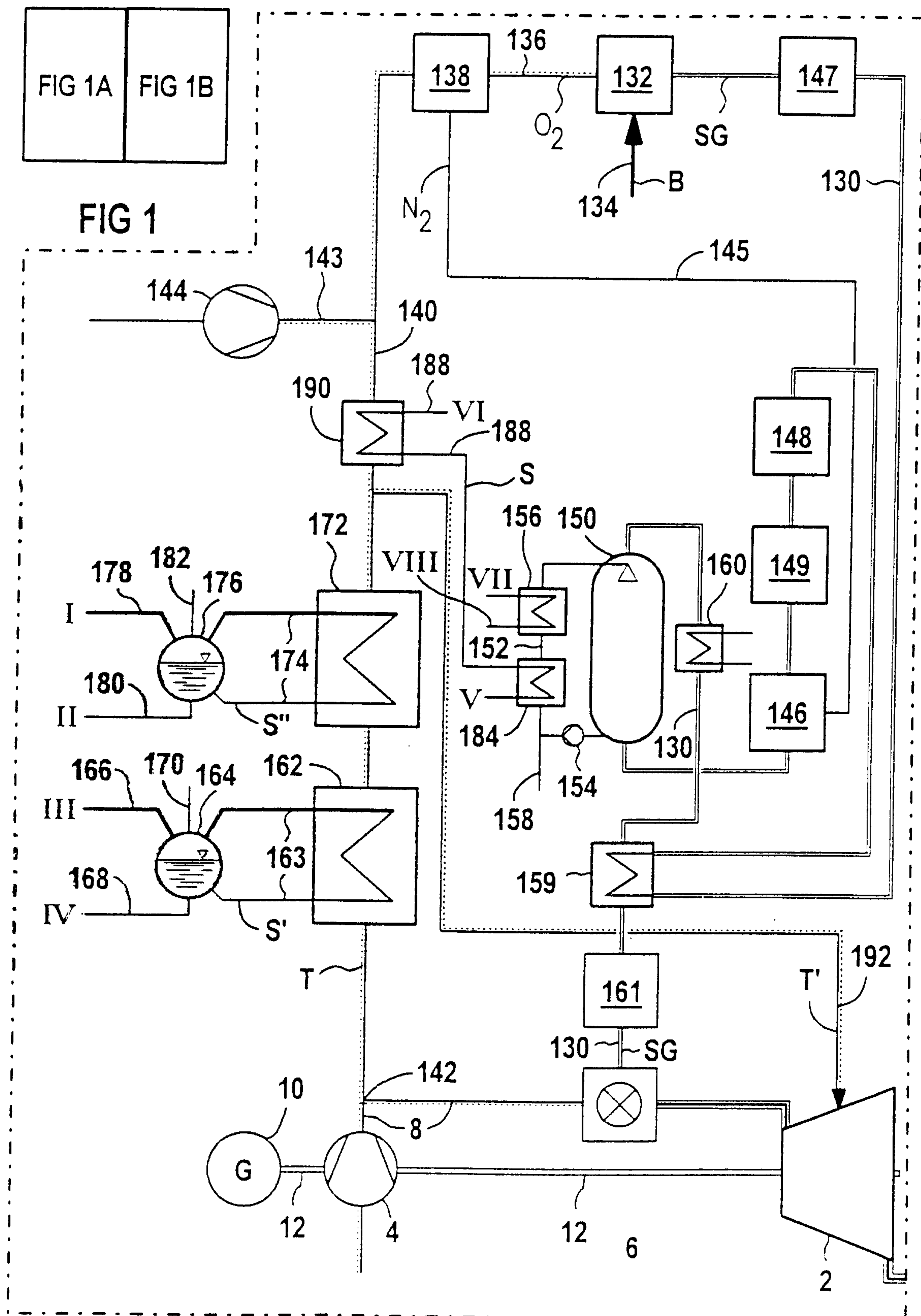


FIG 1A

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