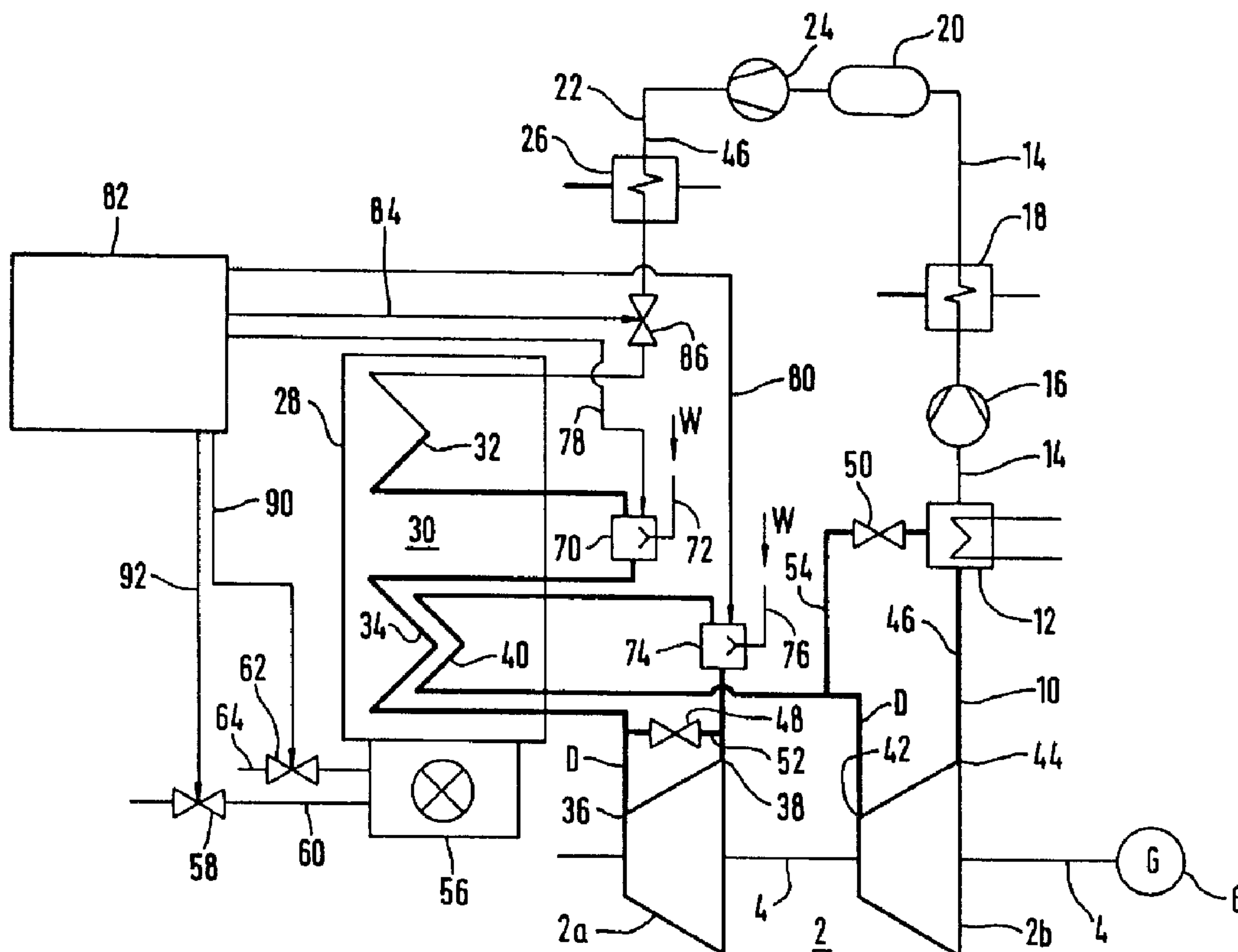




(86) Date de dépôt PCT/PCT Filing Date: 1998/10/28
(87) Date publication PCT/PCT Publication Date: 1999/05/20
(45) Date de délivrance/Issue Date: 2007/02/13
(85) Entrée phase nationale/National Entry: 2000/05/08
(86) N° demande PCT/PCT Application No.: DE 1998/003153
(87) N° publication PCT/PCT Publication No.: 1999/024698
(30) Priorité/Priority: 1997/11/10 (DE197 49 452.8)

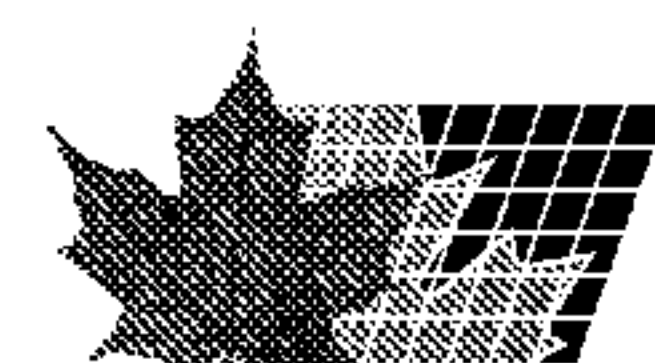
(51) Cl.Int./Int.Cl. *F01K 13/02* (2006.01),
F22G 5/12 (2006.01)
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(54) Titre : PROCEDE PERMETTANT DE REGULER RAPIDEMENT LA PUISSANCE D'UNE CENTRALE THERMIQUE A VAPEUR ET CENTRALE THERMIQUE A VAPEUR
(54) Title: METHOD FOR CLOSED-LOOP OUTPUT CONTROL OF A STEAM POWER PLANT, AND A STEAM POWER PLANT



(57) **Abrégé/Abstract:**

The object of the invention is to ensure a fast, economical and reliable power regulation of a steam generating power plant (1) having a turbo set that comprises a steam turbine (2) and a generator (6) and during the operation of which water (W) is injected



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

into or upstream of an overheater heating surface. According to the disclosed fast power regulating process of the steam generating power plant (1), the injection rate of water (W) is increased to adjust an additional generator output. In a steam generating power plant (1) which is particularly suitable for carrying out the process, an overheater heating surface of a steam generator (28) is provided with a water injector (70, 71) connected to a regulating component (82) for regulating the injection rate of water (W) into the overheater heating surface. The regulating component (82) supplies a regulating signal to the water injector (70, 72) depending on the required additional generator output.



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WELTORGANISATION FÜR GEISTIGES EIGENTUM
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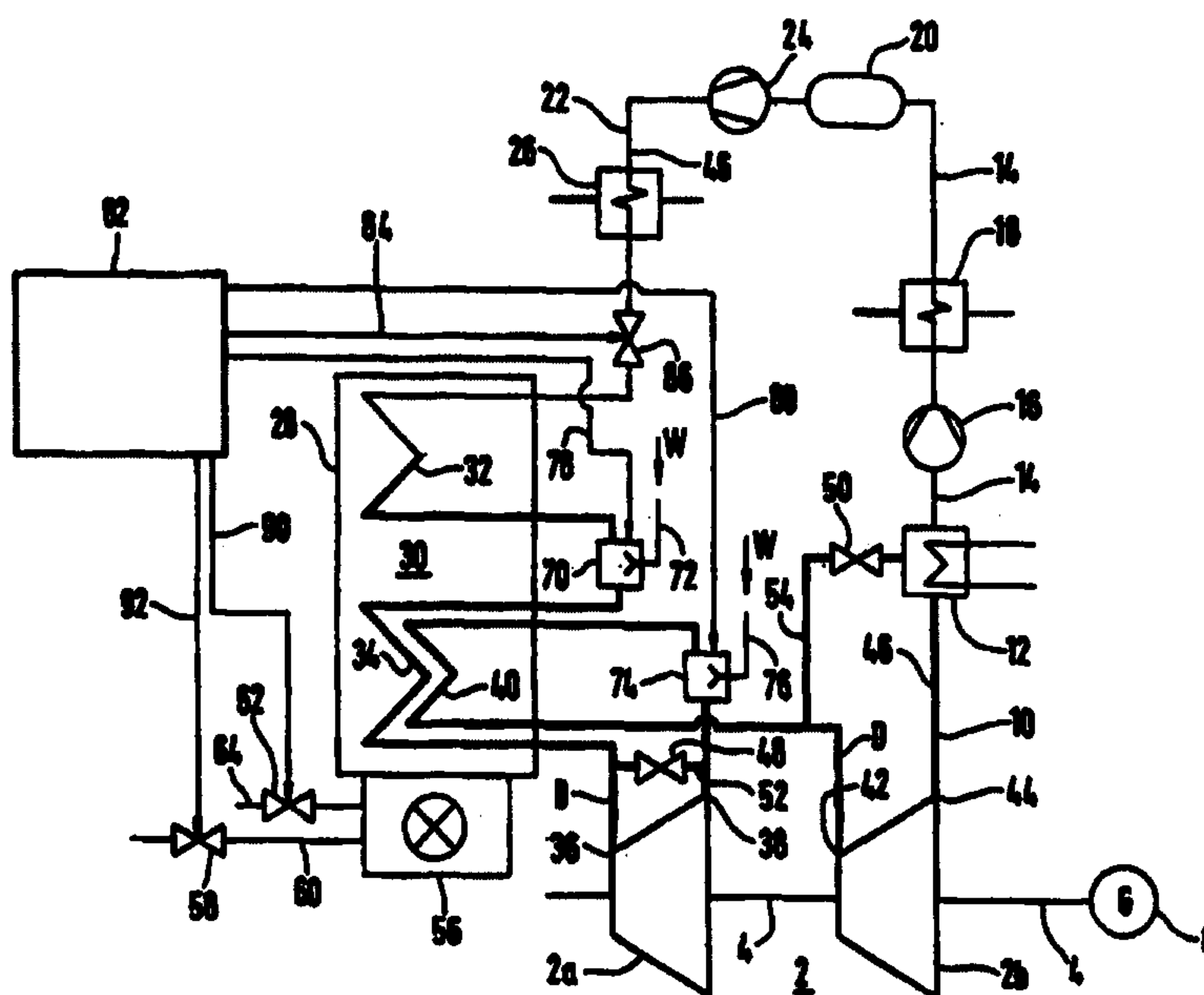
(51) Internationale Patentklassifikation ⁶ : F01K 13/02, F22G 5/12	A1	(11) Internationale Veröffentlichungsnummer: WO 99/24698 (43) Internationales Veröffentlichungsdatum: 20. Mai 1999 (20.05.99)
(21) Internationales Aktenzeichen: PCT/DE98/03153 (22) Internationales Anmeldedatum: 28. Oktober 1998 (28.10.98) (30) Prioritätsdaten: 197 49 452.8 10. November 1997 (10.11.97) DE (71) Anmelder (für alle Bestimmungsstaaten ausser US): SIEMENS AKTIENGESELLSCHAFT [DE/DE]; Wittelsbacherplatz 2, D-80333 München (DE). (72) Erfinder; und (75) Erfinder/Anmelder (nur für US): KALLINA, Günter [DE/DE]; Vogesenstrasse 8, D-76337 Waldbronn (DE). KRAL, Rudolf [DE/DE]; Weinhofer Strasse 27, D-90518 Altdorf (DE). WITTCHOW, Eberhard [DE/DE]; Schronfeld 96, D-91054 Erlangen (DE). (74) Gemeinsamer Vertreter: SIEMENS AG; Postfach 22 16 34, D-80506 München (DE).		(81) Bestimmungsstaaten: CA, CN, ID, JP, KR, KZ, RU, UA, US, europäisches Patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Veröffentlicht <i>Mit internationalem Recherchenbericht. Vor Ablauf der für Änderungen der Ansprüche zugelassenen Frist; Veröffentlichung wird wiederholt falls Änderungen eintreffen.</i>

(54) Title: FAST POWER REGULATING PROCESS FOR A STEAM GENERATING POWER PLANT AND STEAM GENERATING POWER PLANT

(54) Bezeichnung: VERFAHREN ZUR SCHNELLEN LEISTUNGSREGELUNG EINER DAMPFKRAFTANLAGE SOWIE DAMPFKRAFTANLAGE

(57) Abstract

The object of the invention is to ensure a fast, economical and reliable power regulation of a steam generating power plant (1) having a turbo set that comprises a steam turbine (2) and a generator (6) and during the operation of which water (W) is injected into or upstream of an overheater heating surface. According to the disclosed fast power regulating process of the steam generating power plant (1), the injection rate of water (W) is increased to adjust an additional generator output. In a steam generating power plant (1) which is particularly suitable for carrying out the process, an overheater heating surface of a steam generator (28) is provided with a water injector (70, 71) connected to a regulating component (82) for regulating the injection rate of water (W) into the overheater heating surface. The regulating component (82) supplies a regulating signal to the water injector (70, 72) depending on the required additional generator output.



(57) Zusammenfassung

Bei einer Dampfkraftanlage (1) mit einem eine Dampfturbine (2) und einen Generator (6) aufweisenden Turbosatz, bei deren Betrieb eine Einspritzung von Wasser (W) in oder vor eine Überhitzerheizfläche erfolgt, soll eine zuverlässige Schnelle Leistungsregelung mit besonders geringem Aufwand gewährleistet sein. Dazu wird bei einem Verfahren zur Schnellen Leistungsregelung der Dampfkraftanlage (1) erfindungsgemäß zwecks Einstellung einer Generator-Mehrleistung eine Erhöhung der Einspritzrate des Wassers (W) vorgenommen. Bei einer zur Durchführung des Verfahrens besonders geeigneten Dampfkraftanlage (1) ist eine Überhitzerheizfläche eines Dampferzeugers (28) mit einem Wasserinjektor (70, 72) versehen, der zur Einstellung einer Einspritzrate von Wasser (W) in die Überhitzerheizfläche mit einem Reglerbaustein (82) verbunden ist, wobei der Reglerbaustein (82) ein Stellsignal für den Wasserinjektor (70, 72) in Abhängigkeit von einer angeforderten Generator-Mehrleistung vorgibt.

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Description

Method for closed-loop output control of a steam power plant, and a steam power plant

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The invention relates to a method for closed-loop output control of a steam power plant with a turbo-generator set having a steam turbine and a generator, in the case of the operation of which plant
10 water is injected into or upstream of a superheater heating surface. It also relates to a steam power plant suitable for carrying out the method.

Such a method and such a plant are disclosed, for example, in FR-A-23 81 172.

15

Reliable power supply in an electric power supply system presupposes careful balancing between the generation of electrical power by a number of power units and the tapping of this power by a number of consumers in an electricity distribution network. If
20 the generation and tapping of the electrical power are equal, the system frequency, which is an important parameter in an electricity network, is constant. Its nominal value is, for example, 50 Hz in the European interconnected network. A frequency deviation which
25 occurs, for example, owing to the failure of a power unit and to the connection or disconnection of a consumer, can be regarded as a measure of an increase or decrease in the generator output.

Alongside the correction of frequency
30 deviations within a power supply system, a further task consists in maintaining a prescribed interchange power at coupling points to subnetworks from which the distribution network (interconnected network or separate network) is assembled. One requirement is
35 therefore that a fast increase in the output

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- of a power unit should be available within seconds. It can be required in this case, for example, that a sudden load increase of approximately 3 to 5%, referred to full load, should be possible within 30 seconds.
- 5 However, the plant disclosed in FR-A-23 81 172 is neither designed nor suitable for providing such a fast output reserve.

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The printed publication "VGB Kraftwerks-technik", Issue 1, January 1980, pages 18 to 23 describes possibilities for fast closed-loop output control and frequency back-up control. Whereas there
5 are a plurality of possibilities of intervention which can be carried out simultaneously or alternatively for a fast change in output in the range of seconds (seconds reserve), it is necessary to change the supply of fuel for a permanent change in the output of a power
10 unit. In a fossil-fired steam power plant, it is therefore usual for the purpose of bridging delay times within the first seconds for control valves, held in advance in a throttled position, of the steam turbine to be opened, and thereby for available steam
15 accumulators to be activated and discharged virtually without delay. Such a mode of operation of the steam power plant in the throttled state leads, however, to a high proper heat consumption, and is thus economical only to a qualified extent.

20 In addition to an increase in output due to the cancellation of the throttling of control valves of the steam turbine, it is also possible to shut down feed heaters which are provided in the water-steam circuit of the steam turbine and are heated by means of
25 extraction steam from the steam turbine. A condensate flow guided simultaneously through the low-pressure feed heater can be stopped within a few seconds and increased again. This measure for fast closed-loop output control in fossil-fired power units by shutting
30 down the feed heaters accompanied by stoppage of condensate is also described, for example, in German Patent DE-C 33 04 292.

It is customary to use a governing system to subject the fast seconds reserve to closed-loop and/or
35 open-loop control, that is to say closed-loop control of the loading of steam flows to regenerative feed heaters and/or heating condensers as well as of the process steam and the condensate in the water-steam circuit of the steam turbine of a power unit.

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For fast closed-loop output control, that is to say activating the seconds reserve, this entails throttling the steam supply to the feed heaters, throttling the process steam and/or throttling the condensate. In this case, desired setting values for control valves at the turbine bleed points, and for regulating units for setting condensate are formed so as to produce a required extra generator output. However, it is disadvantageous here that the configuration of a steam turbine suitable for this purpose is relatively complicated. The said closed-loop control mechanism is, however, complex and therefore vulnerable, with the result that such a system is reliable for fast closed-loop output control only to a qualified extent.

It is therefore the object of the invention to specify a method for closed-loop output control of a steam power plant of the abovementioned type, which ensures reliable fast closed-loop output control with a particularly low outlay. In addition, the aim is to provide a steam power plant which is particularly suitable for carrying out the method.

With regard to the method, this object is achieved according to the invention by an extra generator output of approximately 3 to 5% referred to full load being set within a reaction time of up to approximately 30 seconds by increasing the water injection rate.

In this regard, the invention proceeds from the consideration that the expensive activation of steam accumulators in the water-steam circuit of the steam turbine should be dispensed with for reliable fast closed-loop output control in conjunction with a particularly low outlay with regard to the components used. It is possible by dispensing with the activation of steam accumulators to achieve a relatively fast increase in the output of the steam turbine by means of a short-term increase in the steam mass flow to be fed to the steam turbine.

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Such an increase is performed by additionally injecting water into or upstream of the superheater heating surface.

5 The additional injection of water into the region of the superheater heating surface has the effect in this case of generating an additional steam flow which effects an increase in the output of the steam turbine even after a short time. The increase in the water injection rate firstly decreases the steam
10 temperature in the superheater heating surface. The decrease in the steam temperature leads to an increase in the temperature difference between the superheater heating surface and the steam, which is decisive for the level of the heat transfer. In this way,
15 accumulator heat can be extracted from the superheater heating surface and, in addition, more heat can be extracted from the flue gas, with the result that the heat transferred in the steam generator onto the superheater heating surface temporarily increases.

20 For the purpose of setting the extra generator output, the water injection rate into a high-pressure superheater and/or a reheater is expediently increased.

In order to avoid an undesired decline in the output of the steam turbine, it is expedient that at
25 the latest after a waiting time of approximately one minute, calculated from the increase in the water injection rate, the desired value for the temperature of the steam flowing out from the superheater heating surface is lowered by a prescribable amount.
30 Specifically, it has emerged that the steam temperature in the superheater heating surface drops because of the increased water injection rate after approximately 60 s, and in the case of temperature-controlled closed-loop control, this could lead to a reduction in the
35 water injection rate, and thus to a decline in the output of the steam turbine. This is reliably avoided given a well-timed reduction in the desired value for the temperature of the steam flowing out from the superheater

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heating surface.

It is advantageously the case that in parallel with increasing the water injection rate as quickly as possible, that is to say simultaneously with or
5 directly after the increasing of the water injection rate, the fuel supply to a combustion chamber heated by fossil fuel and assigned to the steam generator of the steam power plant is increased by a value matched to the required extra generator output. The increase in
10 the fuel supply can, for example, become effective in the case of a coal-fired steam generator after a time of approximately 2 to 4 minutes in the form of the rise in the electric output of the steam turbine. To the extent that the electric output of the steam turbine
15 rises because of the increase in the fuel supply, the water injection rate can be reduced to its original value, and the closed-loop control of the steam temperature provided for continuous operation can be reactivated.

20 With regard to the steam power plant with a turbo-generator set having a steam turbine and a generator, and with a steam generator whose heating surfaces are connected into the water-steam circuit of the steam turbine, a superheater heating surface of the
25 steam generator being provided with a water injector which is connected to a controller module for the purpose of setting a water injection rate into the superheater heating surface, the said object is achieved according to the invention by virtue of the
30 fact that the controller module prescribes an actuating signal for the water injector, for the purpose of increasing the injection rate, as a function of an extra generator output, required within a reaction time of up to approximately 30 seconds, of approximately 3
35 to 5% referred to full load.

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The controller module is thus designed in such a way that an extra generator output required in the short term is undertaken by means of increasing the water injection rate into the superheater heating

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surface. The injection valves arranged on the water injector, on which the controller module acts, are expediently provided with quickly operating drives. Moreover, the controller module is designed in such a way that the opening pulse and the closing pulse for the drives of these injection valves are provided by the closed-loop output control of the steam power plant and not by the closed-loop temperature control of the steam power plant.

It is advantageously the case that the controller module is connected on the output side via a signal line to a control valve provided for setting the feedwater supply into the steam generator and/or that the controller module is connected on the output side via a signal line to a control valve provided for setting the fuel supply into a combustion chamber assigned to the steam generator. Thus, the controller module can be used, on the one hand, in the short term to activate an output reserve by increasing the water injection rate, and on the other hand in the medium or long term, to activate an increase in the continuous output by varying the fuel supply to the combustion chamber.

The advantages achieved with the invention consist, in particular, in rendering it possible to set an extra generator output by means of increasing the water injection rate with particularly simple means and without additional requirements placed on the components used. In particular, there is no need for expensive measures to adapt the steam turbine to the requirements of the fast closed-loop output control. It follows that the concept of fast closed-loop output control is particularly suitable also for steam turbines of normal design which can be operated in the entire load range with a particularly low heat consumption. In the case of such fast closed-loop output control, the steam turbine is subjected to only a slight load, with the result that even frequent repetition of such fast closed-loop output control does not entail damage to the steam turbine.

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An exemplary embodiment of the invention is explained in more detail with the aid of a drawing, in which the figure shows a steam power plant in a diagrammatic fashion.

5 The steam power plant 1 in accordance with the figure comprises a steam turbine 2 which is connected to a generator 6 via a turbine shaft 4. In the exemplary embodiment, the steam turbine 2 comprises a high-pressure section 2a and a low-pressure section 2b.
10 The steam turbine 2 is thus of two-stage design. Alternatively, the steam turbine 2 can, however, also comprise only one or a plurality of, in particular three, pressure stages.

 The steam turbine 2 is connected on the output
15 side to a condenser 12 via a steam pipe 10. The condenser 12 is connected via a conduit 14, into which a condensate pump 16 and a steam-heated feed heater 18 are connected, to a feedwater tank 20. The feedwater tank 20 is connected on the output side via a supply
20 conduit 22, into which a feedwater pump 24 and a steam-heated feed heater 26 are connected, to a heating surface arrangement 30 arranged in a steam generator 28.

 The heating surface arrangement 30 comprises an
25 evaporator heating surface 32. The evaporator heating surface 32 can in this case be constructed as a through-flow evaporator heating surface, or as a natural-circulation evaporator heating surface. For this purpose, the evaporator heating surface can be
30 connected in a known way to a steam-and-water drum (not represented in the exemplary embodiment) for forming a circuit.

 The evaporator heating surface 32 is connected to a high-pressure superheater 34, which is likewise
35 arranged in the steam generator 28 and is connected on the output side to the steam inlet 36 of the high-pressure section 2a of the steam turbine 2. The steam outlet 38

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of the high-pressure section 2a of the steam turbine 2 is connected via a reheater 40 to the steam inlet 42 of the low-pressure section 2b of the steam turbine 2. Its steam outlet 44 is connected via the steam pipe 10 to the condenser 12, thus producing a closed water-steam circuit 46.

The water-steam circuit 46 represented in the figure is constructed from only two pressure stages. However, it can also be constructed from only one or from a plurality of, in particular three, pressure stages, further heating surfaces being arranged in a known way in the steam generator 28.

Both the high-pressure section 2a and the low-pressure section 2b of the steam turbine 2 can in each case be bypassed via a bypass conduit 52 or 54, respectively, which can be shut off by a valve 48 or 50, respectively. The bypass conduit 54 assigned to the low-pressure section 2b of the steam turbine 2 opens in this case directly into the condenser 12 on the output side.

The steam generator 28 is assigned a fossil-fired combustion chamber 56. The combustion chamber 56 can be supplied with fuel via a fuel supply line 60, which can be shut off by a valve 58, and can be supplied with combustion air via a conduit 62, which can be shut off by a valve 62.

The high-pressure superheater 34 is assigned a water injector 70 which can be supplied with water W via a supply line 72. The reheater 40 is similarly assigned a water injector 74, which can likewise be supplied with water W via a supply conduit 76. In order to set the water W injection rate into the high-pressure superheater 34 and into the reheater 40, the water injector 70 and the water injector 74 are respectively connected to a controller module 82 via a signal line 78, 80, respectively. In continuous operation of the

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steam power plant 1, the controller module 82 acts on the water injector 70 and the water injector 74 in such a way that the temperature of the steam D flowing out from the high-pressure superheater 34 or from the reheater 40 is
5 constant in a prescribable tolerance band. For this purpose, the controller module 82 is connected (in a way not shown in more detail) to suitably arranged temperature sensors.

The controller module 82 is designed in such a
10 way that it is possible for the purpose of fast closed-loop output control to set an extra generator output by means of increasing the water W injection rate into the high-pressure superheater 34 and/or into the reheater 40. For this purpose, in the case of a required extra
15 generator output the temperature-controlled closed-loop control of the controller module 82 is deactivated and replaced by an output-based controller principle. The controller module 82 in this case uses signals, sent to the water injector 70 and the water injector 74, to
20 increase the water W injection rate into the high-pressure superheater 34 or into the reheater 40, in such a way that the output of the steam turbine 2 is increased because of the increased steam mass flows.

The controller module 82 is, moreover, connected
25 on the output side via a signal line 84 to a control valve 86 connected into the supply conduit 22. It is therefore possible to set the feedwater supply rate to the steam generator 28 via the controller module 82.

Furthermore, the controller module 82 is
30 connected to the valve 62 via a signal line 90, and to the control valve 58 via a signal line 92. It is therefore possible to use the controller module 82 to set the air supply and also the fuel supply to the combustion chamber 56. The controller module 82 is designed in this
35 case in such a way that the fuel supply to the combustion chamber 56 is increased by a value matched to the required extra generator output simultaneously with or directly after the increasing of the

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water W injection rate.

The steam power plant 1 ensures fast closed-loop output control with particularly simple means. An extra generator output is possible in this case by means of increasing the water W injection rate into the high-pressure superheater 34 and/or into the reheater 40.

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CLAIMS:

1. Method for closed-loop output control of a steam power plant (1) with a turbo-generator set having a steam turbine (2) and a generator (6), in the case of the
5 operation of which plant water (W) is injected into or upstream of a superheater heating surface, characterized in that, an extra generator output of approximately 3 to 5% referred to full load is set within a reaction time of up to approximately 30 seconds by increasing the water (W)
10 injection rate.
2. Method according to Claim 1, in which for the purpose of setting the extra generator output the water (W) injection rate is increased in or upstream of a high-pressure superheater (34).
- 15 3. Method according to Claim 1 or 2, in which for the purpose of setting the extra generator output the water injection rate is increased in or upstream of a reheater (40).
4. Method according to any one of Claims 1 to 3, in
20 which at the latest after a waiting time of approximately one minute, calculated from the increase in the water (W) injection rate, the desired value for the temperature of the steam (D) flowing out from the superheater heating surface is lowered by a prescribable amount.
- 25 5. Method according to any one of Claims 1 to 4, in which simultaneously with or directly after the increasing of the water (W) injection rate, the fuel supply to a combustion chamber (56) heated by fossil fuel and assigned to the steam generator of the steam power plant (1) is
30 increased by a value matched to the required extra generator output.

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6. Steam power plant (1) with a turbo-generator set having a steam turbine (2) and a generator (6), and with a steam generator whose heating surfaces are connected into a water-steam circuit (46) of the steam turbine (2), a
5 superheater heating surface of the steam generator being provided with a water injector (70, 74) which is connected to a controller module (82) for the purpose of setting a water (W) injection rate into the superheater heating surface, characterized in that as a function of an extra
10 generator output of approximately 3 to 5% referred to full load, the controller module (82) prescribes an actuating signal for the water injector (70, 72) for the purpose of increasing the injection rate.

7. Steam power plant (1) according to Claim 6, in
15 which the controller module (82) is connected on the output side via a signal line (84) to a control valve (86) provided for setting the feedwater supply into the steam generator.

8. Steam power plant (1) according to Claim 6 or 7, in which the controller module (82) is connected on the
20 output side via a signal line (92) to a control valve (58) provided for setting the fuel supply into a combustion chamber (56) assigned to the steam generator.

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PATENT AGENTS

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