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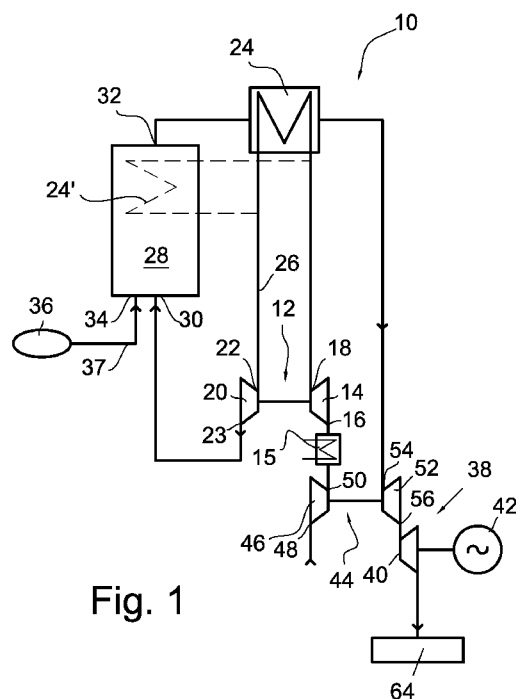
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(54) Title: A POWER PLANT AND METHOD OF OPERATING A POWER PLANT



(57) Abstract: A power plant (10) comprising a first turbine-compressor unit (12) provided with a first compressor part (14) and a first turbine part (20); a gas heater unit (24) arranged in fluid connection with the first compressor part (14) and the turbine part (20), so as to increase heat of gas compressed by the first compressor part (14) prior to entering into the first turbine part (20). The power plant (10) comprises a reactor (28) for at least partially combusting fuel material therein. The first turbine part (20) is in fluid connection with the reactor (28) for supplying combustion gas to the reactor (28); and the reactor (28) is in fluid connection with the gas heater unit (24) arranged to transfer heat to the combustion gas. The reactor (28) is in fluid connection with a thermal power device (38). Invention relates also to method of operating a power plant.

A power plant and method of operating a power plant

Technical field

- 5 [001] The present invention relates to a power plant according to the preamble of claim 1. Invention relates also to method of operating a power plant.

Background art

- [002] It is a general aim to increase the variety of fuels usable in energy
10 production. It is also known that different processes set different demand for the quality of the fuel. For example, direct use of solid fuels is not possible in internal combustion engines and when a gas turbine is concerned the combustion should result in gas substantially free from solid particles. US2011239643 discloses a power assembly, especially for an
15 automotive vehicle, comprising a main internal combustion engine including an air intake line and an exhaust gas line. The power assembly comprises a Brayton cycle system capable of providing additional power to the main internal combustion engine. The Brayton cycle system include a gas compressor, a fuel burning heater and a turbine linked to the
20 compressor so that air is drawn into the compressor where it is pressurized, the pressurized air is further heated by flowing through at least one heat exchanger where it exchanges heat with exhaust gases from the main internal combustion engine, the heated and pressurized air is further heated by the fuel burning heater and is thereafter expanded
25 through the turbine where a first fraction of the work extracted by the turbine is used to drive the compressor and a second fraction of the work extracted by the turbine is used to bring additional energy.

[003] In this solution the gas to be expanded in the turbine is heated in a combustion chamber so it is the exhaust gas that is flowing through the

turbine. Therefore the gas must be very clean and free of any particulate matter.

[004] An object of the invention is to provide a power plant and a method of operating a power plant in which the reliability is considerably improved compared to the prior art solutions.

Disclosure of the Invention

[005] Object of the invention is substantially met by a power plant as recited in the independent claim 1 and its advantageous embodiment recited in the claims depending on the claim 1.

[006] Object of the invention is also met by method of operating a power plant as recited in the independent method claim, and its advantageous embodiment recited in the claims depending on the independent method claim.

[007] According to an embodiment of the invention the power plant comprises
a first turbine-compressor unit provided with a first compressor part having a gas inlet and a gas outlet and a first turbine part having a gas inlet and a gas outlet; the compressor part and the turbine part being in force transmission connection with each other;
a gas heater unit arranged in fluid connection with the gas outlet of the first compressor part and the gas inlet of the turbine part, so as to increase heat of gas compressed by the first compressor part prior to entering into the first turbine part, and
a reactor for at least partially combusting fuel material therein comprising a gas inlet and a product gas outlet, and that the gas outlet of the first turbine part is in fluid connection with a gas inlet of the reactor for supplying combustion gas to the reactor, and that the product gas outlet of the

reactor is in fluid connection with the gas heater unit arranged to transfer heat produced by the reactor to the compressed gas; and that the product gas outlet of the reactor is in fluid connection with a thermal power device provided downstream the gas heater unit, which thermal power

5 device is a first turbine-electric generator arranged in flow connection with the product gas outlet of the reactor, the first turbine-electric generator being positioned after the gas heater unit in the flow direction of gas when the power plant is in operation, and

a second compressor-turbine unit provided with a second compressor

10 part having a gas inlet and a gas outlet and a second turbine part having a gas inlet and a gas outlet; the compressor part and the turbine part being in force transmission connection with each other, and in which the second turbine part is connected between the first turbine-generator and the product gas outlet of the reactor and the second compressor part is

15 arranged in connection with first compressor part to pressurize the gas to be fed to the gas inlet of the first compressor part.

[008] The first turbine-compressor unit is arranged to receive power via transferring heat from the product gas and/or combustion in the reactor

20 by a recuperative heat exchanger which ensures that the gas which is providing work in the first turbine part is very clean keeping the turbine is good operating conditions for long period of time.

[009] Furthermore, the remaining energy in the gas may be efficiently

25 utilized in energy production according to the invention. Advantageously the second compressor part is connected with first compressor part to via an intercooler providing cooling of the pressurized air.

[0010] According to an embodiment of the invention the thermal power

30 device comprises at least one internal combustion engine - generator set arranged in flow connection with the product gas outlet of the reactor such that the at least one internal combustion piston engine - generator

set is arranged to receive the product gas of the reactor to be used as its fuel. In this embodiment the reactor is provided with fuel feeding system adapted to feed solid fuel into the reactor and the reactor is a fuel gasifier.

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[0011] According to an embodiment of the invention the at least one internal combustion engine - generator set comprises a piston engine.

[0012] The piston engine is provided with a turbo charger a compressor part of which is arranged to increase the pressure of the air to be delivered to the reactor for partially combusting the fuel material therein. The turbo charger is provided with a compressor part having a gas inlet and a gas outlet and turbine part having a gas inlet and a gas outlet; the compressor part and the turbine part being in force transmission connection with each other.

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[0013] According to an embodiment of the invention the gas heater unit is integrated to the reactor arranged to transfer heat from the reactor by convection and/or radiation recuperative heat transfer.

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[0014] According to an embodiment of the invention the reactor is adapted to combust the fuel substantially completely.

[0015] The method of operating a power plant according to an embodiment of the invention comprising steps of:

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compressing air successively in a second compressor part of a second turbine-compressor unit and in a first compressor part of a first turbine-compressor unit;

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leading the compressed air into a gas heater unit in which the air is heated;

leading the compressed and heated air into a first turbine part of the first turbine-compressor unit to operate the first compressor part by the first turbine part;

leading the air from the first turbine part to a reactor where fuel material is at least partially combusted with the air producing product gas; the product gas is led to the gas heater unit and the compressed air is heated by transferring heat from the product gas to the compressed air in

5 the gas heater unit, and

leading the product gas into a second turbine part of the second turbine-compressor unit to operate the second compressor part by the second turbine part; and leading the product gas to a thermal power device to be utilized therein.

10

[0016] According to an embodiment of the invention the thermal power device is a turbine-electric generator and product gas is led from the gas heater unit to a first turbine-electric generator wherein the gas expands operating the electric generator.

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[0017] According to an embodiment of the invention product gas is led to an internal combustion engine - generator set from the gas heater unit in which the product gas is used as its fuel and combusted therein.

20

[0018] According to an embodiment of the invention the fuel material is solid fuel and the solid fuel is gasified producing combustible product gas.

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[0019] The compressor part / parts and the turbine parts and the electric generators connected to turbine part are advantageously high speed devices arranged to rotate at a speed of more than 10000rpm. The reactor is a pressurized reactor which provides a pressurized system for combustion or gasification of biomass enabled by high speed power devices for efficient power take out.

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[0020] In connection of this application the term "combustion" should be understood meaning both partial or complete combustion as well as gasi-

fication based on the requirement of a specific embodiment. The fuel may be basically any fuel but the power plant is particularly intended to be used with biofuels. Biofuels are combustible materials derived from forest, swamp and agricultural biomass, and from organic solid, liquid
5 and gaseous biowaste recoverable from municipal, agricultural and industrial processes.

Brief Description of Drawings

[0021] In the following, the invention will be described with reference to
10 the accompanying exemplary, schematic drawings, in which
Figure 1 illustrates a power plant according to an embodiment of the invention,
Figure 2 illustrates power plant according to another embodiment of the invention,
15 Figure 3 illustrates power plant according to still another embodiment of the invention,
Figure 4 illustrates power plant according to still another embodiment of the invention, and
Figure 5 illustrates power plant according to still another embodiment of
20 the invention.

Detailed Description of Drawings

[0022] Figure 1 depicts schematically a power plant 10 into which the invention has been applied. The power plant is a combination of a combustion system and a power production system by gas expansion in a
25 thermal power device. The power plant 10 comprises a first turbine-compressor unit 12. The first turbine-compressor unit 12 is provided with a first compressor part 14 having a gas inlet 16 and a gas outlet 18. Here the first compressor part 14 is in connection with ambient air at its inlet
30 side and therefore it is the air which is supplied to the first compressor part 14. The first turbine-compressor unit 12 is also provided with a first

turbine part 20 having a gas inlet 22 and a gas outlet 23. In the turbine-compressor unit the turbine part is coupled in force transmission connection with the compressor part to drive the compressor part. The first turbine-compressor unit 12 is advantageously a high speed turbine-compressor unit arranged to rotate at a speed of more than 10000 rpm. There is also provided a second compressor- turbine unit 44 in the plant 10. It is respectively provided with a second compressor part 46 having a gas inlet 48 and a gas outlet 50 and a second turbine part 52 having a gas inlet 54 and a gas outlet 56. The compressor part 46 and the turbine part 52 are in force transmission connection with each other so that the compressor part is operated by the turbine part. The second compressor part 46 is arranged in connection with first compressor part 14 to pre-pressurize the gas to be fed to the first compressor part 14. There is an intercooler 15 provided between the second compressor part 46 and the first compressor part 14 to cool down the pre-pressurized air.

[0023] The power plant 10 has also a reactor 28 which is provided with a combustion gas inlet 30 and a product gas outlet 32 and a reaction chamber in the reactor 28. The reactor is a fuel combustor or a fuel gasifier depending on the specific application. The reactor 28 is arranged to the power plant 10 such that the combustion gas inlet 30 is in fluid connection with the outlet 22 of the turbine part 20, that is, the reactor is arranged downstream the turbine part 20 in the flow direction of the gas to receive combustion gas i.e. pressurized air from the turbine part 20. In this embodiment the combustion gas inlet 30 is directly in flow communication with the outlet 23. As can be seen in the figure 1 the reactor is also downstream the first turbine part 14, which is arranged to pressurize the combustion gas i.e. the air which is used for combustion and/or gasification process in the reactor 28. The reactor 28 is a pressurized reactor for combustion or gasification of the fuel, preferably biomass.

[0024] The product gas outlet 32 of the reactor is connected to a gas heater unit 24 such that the product gas produced in the reactor may transfer heat to the compressed gas arranged to flow through the gas heater unit 24. The gas heater unit 24 is thus connected into a conduit 26
5 arranged between the gas outlet 18 of the first compressor part 14 and the gas inlet 22 of the first turbine part 20, so as to increase heat of the gas compressed by the compressor part prior to entering into the turbine part. As is depicted in figure 1 the gas heater unit 24' may alternatively or additionally be integrated into the reactor 28. The gas heater unit is advantageously a recuperative heat exchanger arranged to receive heat
10 from the product gas and/or reactions in the reactor 28 and to transfer the heat to the air flowing in the conduit 26.

[0025] The reactor 28 is also provided with a fuel inlet 34 which is in connection with a source of fuel 36. The source of fuel is in connection with
15 the fuel inlet by a fuel feeding system 37 adapted for feeding solid fuel, when the power plant is used for gasifying biomass. According to the embodiment shown in the figure 1 the fuel is partially combusted in the reactor 28 so that the product gas is substantially clean product gas resulted from the gasification process. The product gas may be led from
20 the power plant 10 to be used in an external gas processing system, such as an internal combustion engine (not shown in figure 1), or a boiler system. The fuel may be basically any fuel, but the power plant is particularly intended to be used with biofuels. Biofuels are combustible materials derived from forest, swamp and agricultural biomass, and from
25 organic solid, liquid and gaseous biowaste recoverable from municipal, agricultural and industrial processes.

[0026] The power plant 10 is provided with a thermal power device 38
30 arranged in flow connection with the gas outlet 32 of the reactor 28 downstream the gas heater unit 24 and the second turbine unit 52 such as to receive the product gas from the reactor 28. The thermal power de-

vice 38 is in embodiment of the figure 1 a turbine-electric generator. The turbine-electric generator comprises a turbine part 40 coupled with an electric generator 42. The turbine-electric generator 38 is advantageously a high speed turbine-electric generator arranged to rotate at a speed of more than 10000 rpm. The second turbine part 52 of the second compressor- turbine unit 44 is, in turn, connected between the turbine part 40 of the first turbine-generator 38 and the product gas outlet 32 of the reactor.

[0027] In other words, the turbine-electric generator 38 is arranged in flow connection with the product gas outlet 32 of the reactor 28 via the second turbine part 52 and it is positioned after the gas heater unit 24 and the second turbine part 52 in the flow direction of the gas when the power plant being in operation. By means of the turbine – electric generator remaining part of the energy in the product gas after the recuperative gas heater unit 24 and the expansion of gas in the second turbine part 52 is utilized for production of electric power. It is also conceivable to replace the combination of the second turbine-compressor unit 44 and the first turbine –electric generator 38 with a gas turbine aggregate. Each of the turbine-compressor units may be a high speed turbine-compressor unit arranged to rotate at a speed of more than 10000 rpm.

[0028] The power plant shown in figure 1 is operated so that the air is first compressed in the second compressor unit 48 of the second turbine-compressor unit 44 after which the air is further compressed in the first compressor part 14 of a first turbine-compressor unit 12. There is an intercooler 15 arranged between the compressor parts 46 and 14 for cooling the air pressurized in the second compressor unit 48. The compressed air is led from the first compressor part 14 into the gas heater unit 24 in which the compressed air is heated and its enthalpy is increased. Next, the heated and compressed air is passed to the first turbine part 20 of the first turbine-compressor unit 20 where part of the en-

ergy contained in the air is used. This way the first compressor part 14 is operated by the first turbine part 20. The compressed air, the temperature and pressure of which has been decreased by the expansion in the first turbine part 20 is led to the reactor 28. Also fuel material is fed to the
5 reactor 28. Subsequently fuel is at least partially gasified in the reactor 28 with the air producing product gas.

[0029] The product gas in the embodiment of figure 1 is advantageously combustible gas. The product gas is led from the reactor 28 to the gas
10 heater unit 24 where the compressed air is heated by the heat of the product gas. After that, the product gas is led to the second turbine part 52 of the second turbine-generator unit 44 by means of which turbine part 52 the second compressor part 46 is operated. The exhaust gas is led from the second turbine part 52 to the turbine part 40 of the first tur-
15 bine-electric generator 38 wherein the gas expands further, operating the electric generator 42 thereof. Finally, the product gas may be used fuel gas e.g. in an internal combustion engine 64 which is shown as being connected downstream the turbine part 52 of the second turbine-generator unit 44.

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[0030] The power plant 10 shown in figure 1 can also be operated so that instead of gasification the fuel the reactor 28 may also be operated so that the product gas does not substantially contain any combustible material, i.e. the fuel is substantially completely combusted.

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[0031] In the figure 2 there is shown another embodiment of the invention. Similarly to the embodiment shown in the figure 1, the power plant 10 comprises a first turbine-compressor unit 12 and a second compressor - turbine unit 44 in connection with the reactor 28 and the gas heater
30 unit 24. The embodiment is otherwise similar to that in the figure 1 except that it comprises a boiler 80 arranged downstream from the first turbine-electric generator 38. The boiler 80 is connected to an outlet of the

turbine part 40 of the first turbine-electric generator 38. Since the product gas is combustible gas in the embodiment of figure 2 a burner of the boiler 80 is arranged to receive the product gas and to combust the gas therein.

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[0032] The product gas in the embodiment of figure 2 is also combustible gas. The product gas is led to the second turbine part 52 of the second of the second turbine-generator unit 44 by means of which turbine part 52 the second compressor part 46 is operated. The product gas is led
10 from the second turbine part 52 to the turbine part 40 of the first turbine-electric generator 38 wherein the gas expands operating the electric generator 42 thereof. There is a boiler 80 arranged downstream from the first turbine-electric generator 38. The gas is led from the second turbine part 52 to the boiler 80 and is combusted therein.

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[0033] In the figure 3 there is shown another embodiment of the invention. Similarly to the embodiment shown in the figure 1, the power plant 10 comprises a first turbine-compressor unit 12 and a second compressor - turbine unit 44 in connection with the reactor 28 and the gas heater
20 unit 24. The embodiment is otherwise similar to that in the figure 1 except that it the power plant 10 is provided with a second turbine-electric generator 58 arranged between the first turbine part 20 and the reactor 28. The second turbine-electric generator 58 comprises a turbine part 60 and an electric generator 62. In the second turbine- electric generator 58
25 part of the energy in the gas after its expansion in the first turbine part 20 may be partly transformed into electric power by a second electric generator 62. It is also conceivable to replace the combination of the first turbine-compressor unit 12 and the second turbine -electric generator 58 with a gas turbine aggregate. This may be also considered as the electric
30 generator being coupled directly to the first turbine part 20 designed to operate both the compressor part and the generator. As can be seen in the figure 3 the reactor is also downstream the compressor parts, which

are arranged to pressurize the combustion gas i.e. the air, which is used for combustion and/or gasification process in the reactor 28. Therefore the reactor is a pressurized reactor for combustion or gasification of the fuel, preferably biomass.

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[0034] The reactor 28 in the Figures 2 and 3 comprises a recuperative gas heater unit 24' integrated therein such that the product gas produced in the reactor may transfer heat to the compressed gas providing an option of making use of radiation heat transfer. The gas heater unit 24' is on the other hand arranged between the gas outlet 18 of the compressor part and the gas inlet 22 of the turbine part, so as to increase heat of the gas compressed by the compressor part prior to entering into the turbine part. As is depicted in figure 1 the gas heater unit 24' may alternatively or additionally be external to the reactor 28.

15

[0035] The reactor 28 is also provided with a fuel inlet 34 which is in connection with a source of fuel 36. The source of fuel is in connection with the fuel inlet by a fuel feeding system 37 suitable for feeding solid fuel in the reactor 28. According to the embodiment shown in the figure 2 the fuel is partially combusted and gasified in the reactor 28 so that the product gas is combustible gas resulted from the gasification process.

20

[0036] Also in this embodiment the turbine-electric generator 38 is advantageously a high speed turbine-electric generator arranged to rotate at a speed of more than 10000 rpm.

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[0037] In the figure 3 the compressed air, the temperature and pressure of which has been decreased by the expansion in the first turbine part 20 is led to turbine part 60 of the second turbine-electric generator 58 in which part of the energy in the air is utilized. Subsequently the air is led to the reactor 28. Also fuel material is fed to the reactor 28 and it is gasified at elevated pressure in the reactor 28 producing product gas and heating air in the gas heater unit 24' in the reactor 28.

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[0038] The product gas in the embodiment of figure 3 is combustible gas. The product gas is led to the second turbine part 52 of the second of the second turbine-generator unit 44 by means of which turbine part 52 the second compressor part 46 is operated. The exhaust gas is led from the second turbine part 52 to the turbine part 40 of the first turbine-electric generator 38 wherein the gas expands operating the electric generator 42 thereof.

10 [0039] In the figure 4 there is shown an embodiment of the invention being otherwise similar to that shown in the figure 1 except that the second turbine-generator unit 44 has been replaced by a turbo charged internal combustion piston engine – generator set 65. Here the reactor 28 is a gasifier providing gaseous combustible gas as its product gas to be used
15 a fuel in the piston engine. The internal combustion engine 64 belonging to the internal combustion engine - generator set, and arranged to run a generator of the set, is in this embodiment a piston engine arranged in flow connection with the product gas outlet 32 of the reactor 28. The piston engine 64 comprises a turbocharger unit 66 which comprises a compressor part 68 and a turbine part 70. The turbine part 70 operates the compressor part as is known in turbochargers as such. The compressor part 68 in fluid connection with the inlet of the first compressor part 14 of the first compressor – turbine unit 12 and also with the inlet gas system 72 of the engine 64. There is an intercooler 15 provided between the
20 compressor part 68 of the engine and the first compressor part 14 of the first compressor – turbine unit 12 to cool down the pre-pressurized air. There is a first branch location 74 in inlet gas system downstream the compressor part 68 at which location the inlet gas system joins with the inlet 16 of the first compressor part 14. Respectively there is a second
25 branch location 76 in the inlet gas system 72 downstream the first branch location i.e. closer to the engine 64 in the gas flow direction than the first branch location. The gas outlet 32 of the reactor 28 is in fluid connection

with the inlet gas system 72 of the engine at the second branch location 76. Between the first 74 and the second branch locations 76 there is a pressure reduction device 78. The pressure reduction device comprises advantageously an inlet gas cooling unit. A flow control valve or valves
5 may also be used in this position to control the operation.

[0040] The reactor is also provided with a fuel inlet 34 which is in connection with a source of fuel 36. The source of fuel is in connection with the fuel inlet by a solid fuel feeding system 37. The fuel is solid fuel which is
10 gasified producing combustible fuel gas for the engine. As can be seen in the figure 4 the reactor is also downstream the first turbine part, which is arranged to pressurize the combustion gas i.e. the air which is used for combustion and/or gasification process in the reactor 28. Therefore the reactor is a pressurized reactor for combustion or gasification of the fuel,
15 preferably biomass.

[0041] The power plant shown in figure 4 is operated so that the air is first compressed in the compressor 68 of the turbocharger unit 66 after which a partial stream of the air is further compressed in the first compressor part 14 of a first turbine-compressor unit 12. There may be an intermediate cooler arranged between the compressors, even if not
20 shown in the figure 4. The compressed air is led into the gas heater unit 24 in which the compressed air is heated. The air is heated in the gas heater unit 24' in the reactor 28 or in the external gas heater unit 24. Next, the heated and compressed air is passed to the first turbine part
25 20 of the first turbine-compressor unit 20. This way the first compressor part 14 is operated by the first turbine part 20 making use of the energy in the air heated by the process heat obtained from the reactor 28. The compressed air, the temperature and pressure of which has been decreased by the expansion in the first turbine part 20 is led to the reactor
30 28. Also fuel material is fed to the reactor 28 and it is at only partially

combusted or gasified with the air in the reactor 28 producing combustible product gas.

[0042] In this embodiment the internal combustion piston engine - generator set 65 is arranged to receive the product gas of the reactor to be used as its fuel. The product gas is led to an internal combustion engine - generator set 65 from the gas heater unit 24 in which the product gas is used as its fuel and combusted therein. The gas is premixed with compressed air in the inlet gas system and the premixed charge is admitted to the cylinders of the engine to be combusted.

[0043] The plant 10 is according to the embodiment of figure 5 also provided with an optional a turbine-electric generator 38, which is arranged in flow connection with the gas outlet 32 of the reactor 28 via the gas heater unit 24, and with the inlet gas system 72 of the engine. The optional turbine-generator may be used particularly in cases where the pressure in the reactor 28 is considerably higher than the pressure in the inlet system of the engine 64. The turbine-electric generator 38 comprises a turbine part 40 coupled with an electric generator 42. By means of the turbine - electric generator 38 energy in the product gas is utilized for production of electric power. The turbine-electric generator 38 is advantageously a high speed turbine-electric generator arranged to rotate at a speed of more than 10000 rpm. The turbine part 40 may be provided with an inlet for cleaning agent upstream thereof.

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[0044] While the invention has been described herein by way of examples in connection with what are, at present, considered to be the most preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments, but is intended to cover various combinations or modifications of its features, and several other applications included within the scope of the invention, as defined in the appended claims. The details mentioned in connection with any embodi-

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ment above may be used in connection with another embodiment when such combination is technically feasible.

Claims

- 5 1. A power plant (10) comprising:
- a first turbine-compressor unit (12) provided with a first compressor part (14) having a gas inlet (16) and a gas outlet (18) and a first turbine part (20) having a gas inlet (22) and a gas outlet (23); the compressor part (14) and the turbine part (20) being in force transmission connection
10 with each other;
 - a gas heater unit (24) arranged in fluid connection with the gas outlet (18) of the first compressor part (14) and the gas inlet (22) of the turbine part (20), so as to increase heat of gas compressed by the first compressor part (14) prior to entering into the first turbine part (20), **character-**
15 **ized** in that
 - the power plant (10) comprises a reactor (28) for at least partially combusting fuel material therein comprising a gas inlet (30) and a product gas outlet (32); and that
 - the gas outlet (23) of the first turbine part (20) is in fluid connection
20 with the gas inlet (30) of the reactor (28) for supplying combustion gas to the reactor (28); and that
 - the product gas outlet (32) of the reactor (28) is in fluid connection with the gas heater unit (24) arranged to transfer heat produced by the reactor (28) to the combustion gas; and that
 - 25 - the product gas outlet (32) of the reactor (28) is in fluid connection with a first turbine-electric generator (38) arranged in flow connection with the product gas outlet (32) of the reactor (28), the first turbine-electric generator (38) being positioned after the gas heater unit (24) in the flow direction of gas when the power plant is in operation; and that
 - 30 - the plant comprises a second compressor-turbine unit (44) provided with a second compressor part (46) having a gas inlet (48) and a gas outlet (50) and a second turbine part (52) having a gas inlet (54) and a

gas outlet (56), and in which the second turbine part (52) is connected between the first turbine-generator (38) and the product gas outlet (32) of the reactor (28); and that

- the second compressor part (46) is arranged in connection with first compressor part (14) to pressurize the gas to be fed to the gas inlet (16) of the first compressor part (14).

2. A power plant (10) according to claim 1, **characterized** in that the power plant (10) is provided boiler (80) arranged downstream the first turbine-electric generator (38) in the flow direction of gas when the power plant is in operation.

3. A power plant (10) according to claim 1, **characterized** in that the thermal power device (38) comprises at least one internal combustion engine – generator set (65) arranged in flow connection with the product gas outlet (32) of the reactor (28) such that the at least one internal combustion piston engine – generator set (65) is arranged to receive the product gas of the reactor to be used as its fuel.

4. A power plant (10) according to claim 3, **characterized** in that the at least one internal combustion engine – generator set (65) comprises a piston engine (64).

5. A power plant according to claim 3, **characterized** in that the reactor (28) is provided with fuel feeding system (37) adapted to feed solid fuel into the reactor and the reactor is a fuel gasifier.

6. A power plant according to claim 1, **characterized** in that the gas heater unit (24') is integrated to the reactor (28).

7. A power plant according to claim 2, **characterized** in that the reactor (28) is adapted to combust the fuel substantially completely.

8. A power plant according to claim 5, **characterized** in that the reactor is adapted to provide combustible product gas from solid fuel.

9. Method of operating a power plant (10) comprising steps of:

- compressing air successively in a second compressor part (46) of a second turbine-compressor unit (44) and in a first compressor part (14) of a first turbine-compressor unit (12);
- leading the compressed air into a gas heater unit (24,24') in which the air is heated;
- leading the compressed and heated air into a first turbine part (20) of the first turbine-compressor unit (12) to operate the first compressor part (14) by the first turbine part (20);
- leading the air from the first turbine part (20) to a reactor (28) where fuel material is at least partially combusted with the air producing product gas;
- the product gas is led to the gas heater unit (24',24) and the compressed air is heated by transferring heat from the product gas to the compressed air in the gas heater unit;
- leading the product gas into a second turbine part (52) of the second turbine-compressor unit (12) to operate the second compressor part (46) by the second turbine part (52); and
- leading the product gas to a thermal power device (38) to be utilized therein.

10. Method of operating a power plant according to claim 9, **characterized** in that the thermal power device (38) is a turbine-electric generator (38) and product gas is led from the gas heater unit to a first turbine-electric generator (38) wherein the gas expands operating the electric generator (42).

11. Method of operating a power plant according to claim 10, **characterized** in that product gas is led to an internal combustion engine - gen-

erator set (65) from the gas heater unit (24',24) in which the product gas is used as its fuel and combusted therein.

12. Method of operating a power plant according to claim 12, **characterized** in that the fuel material is solid fuel and the solid fuel is gasified producing combustible product gas.
- 5

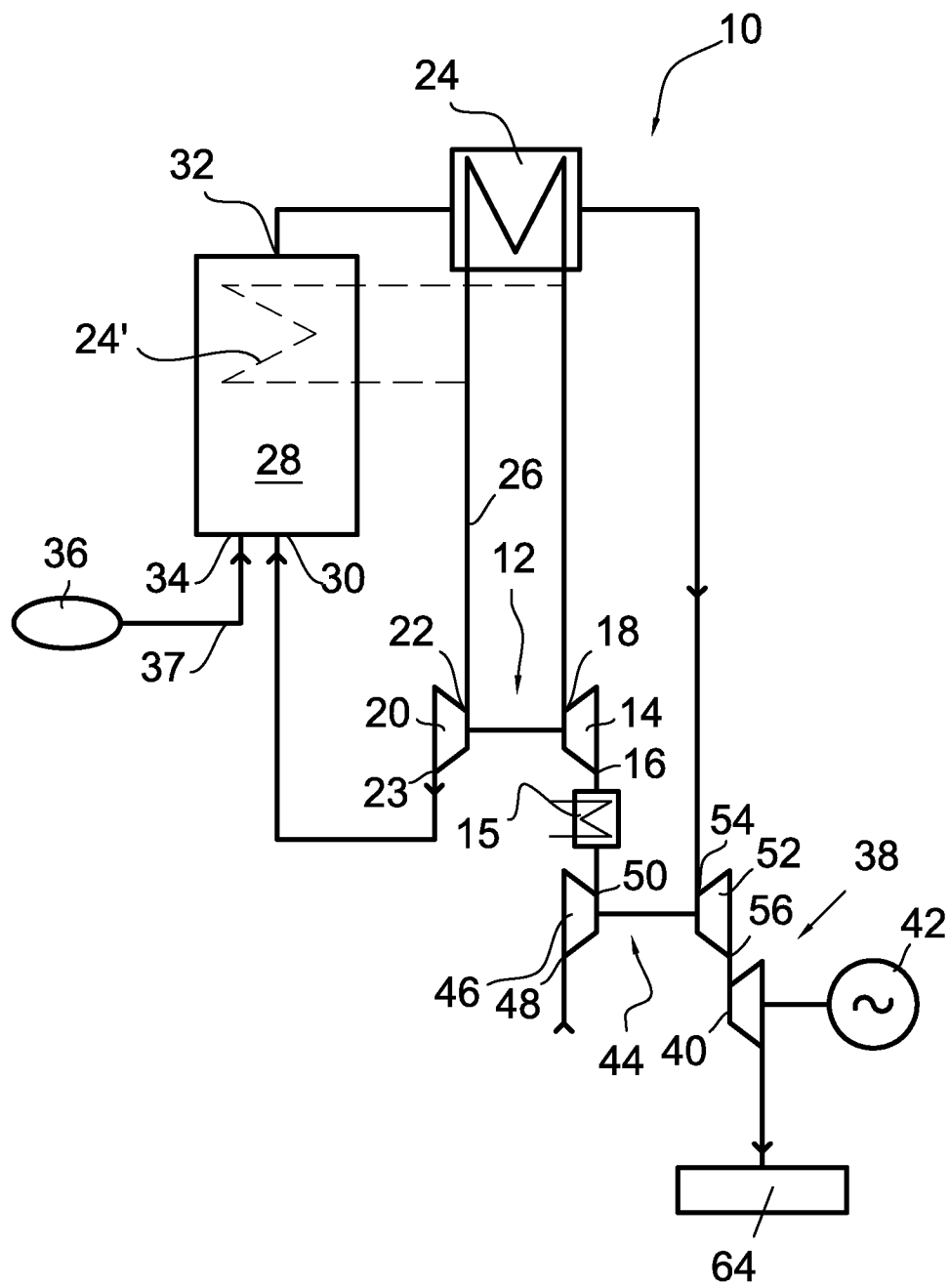


Fig. 1

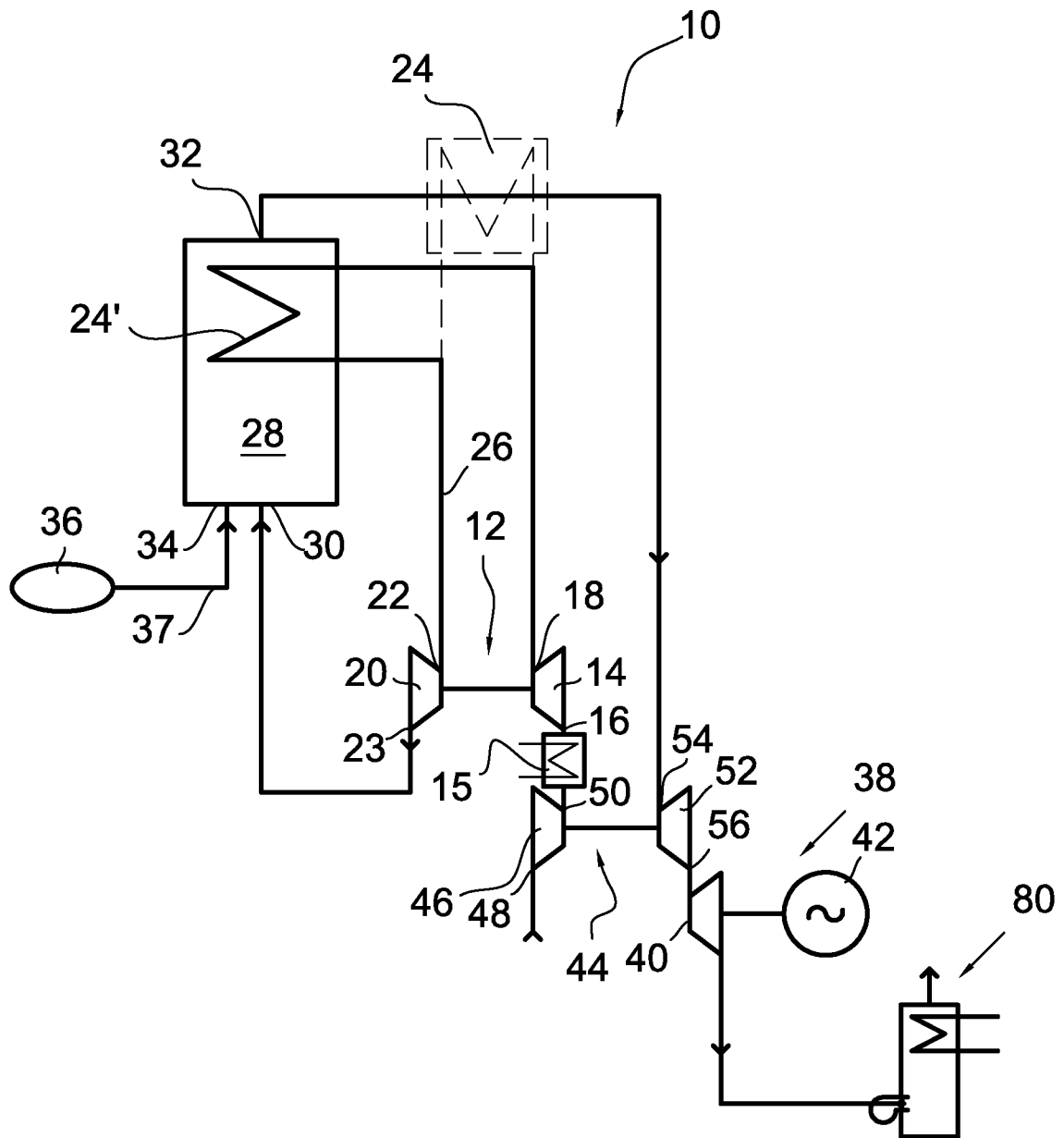


Fig. 2

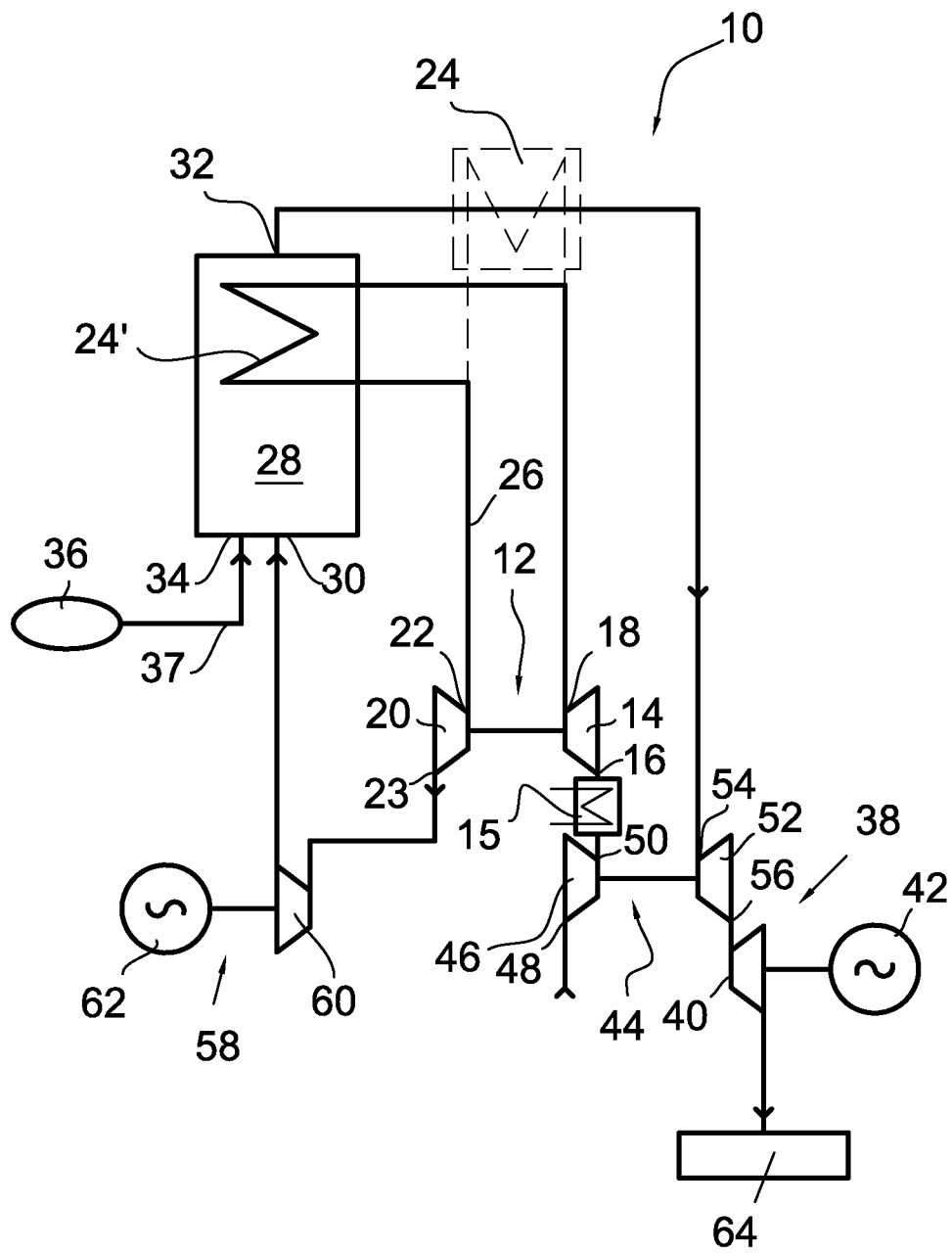


Fig. 3

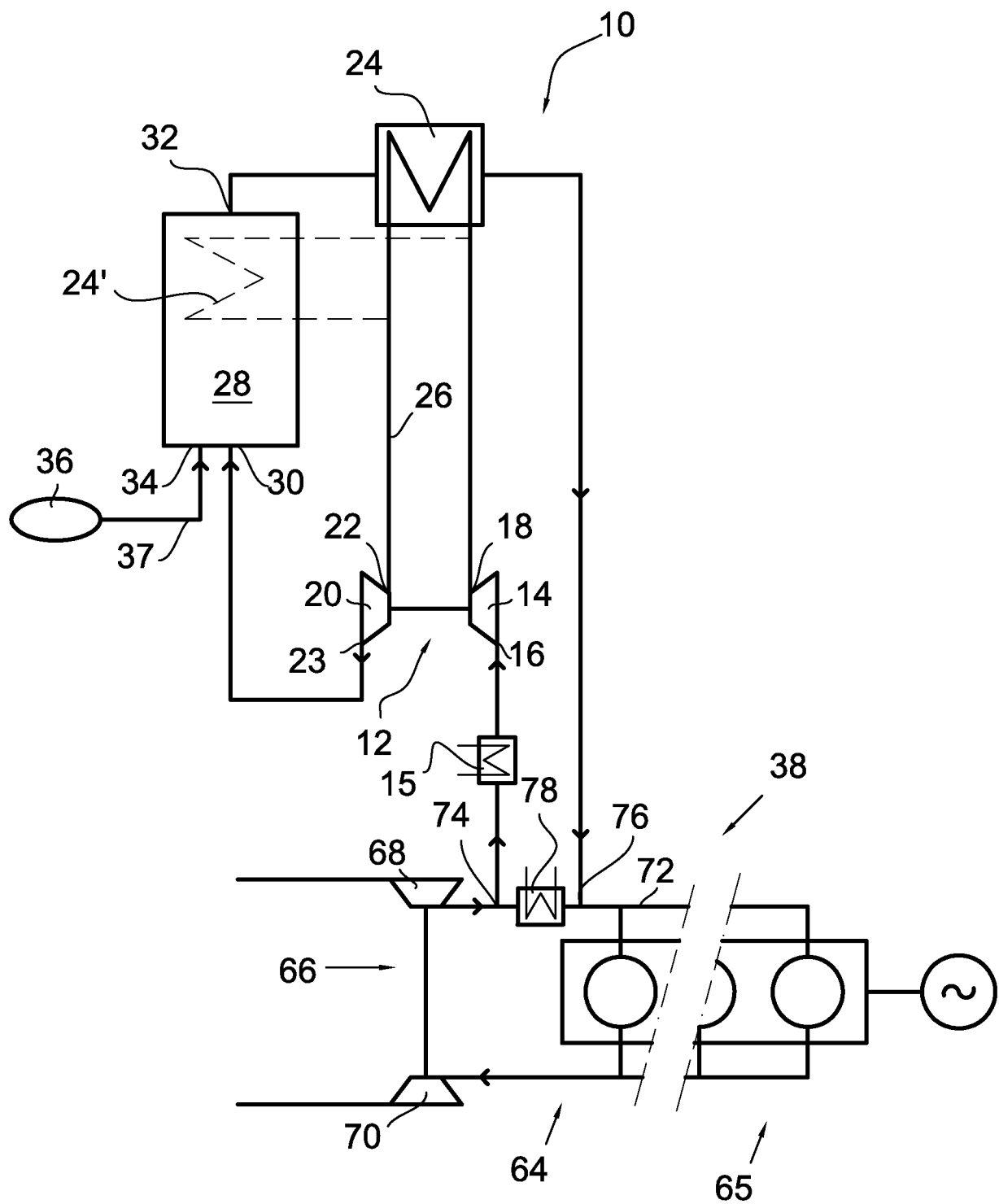


Fig. 4

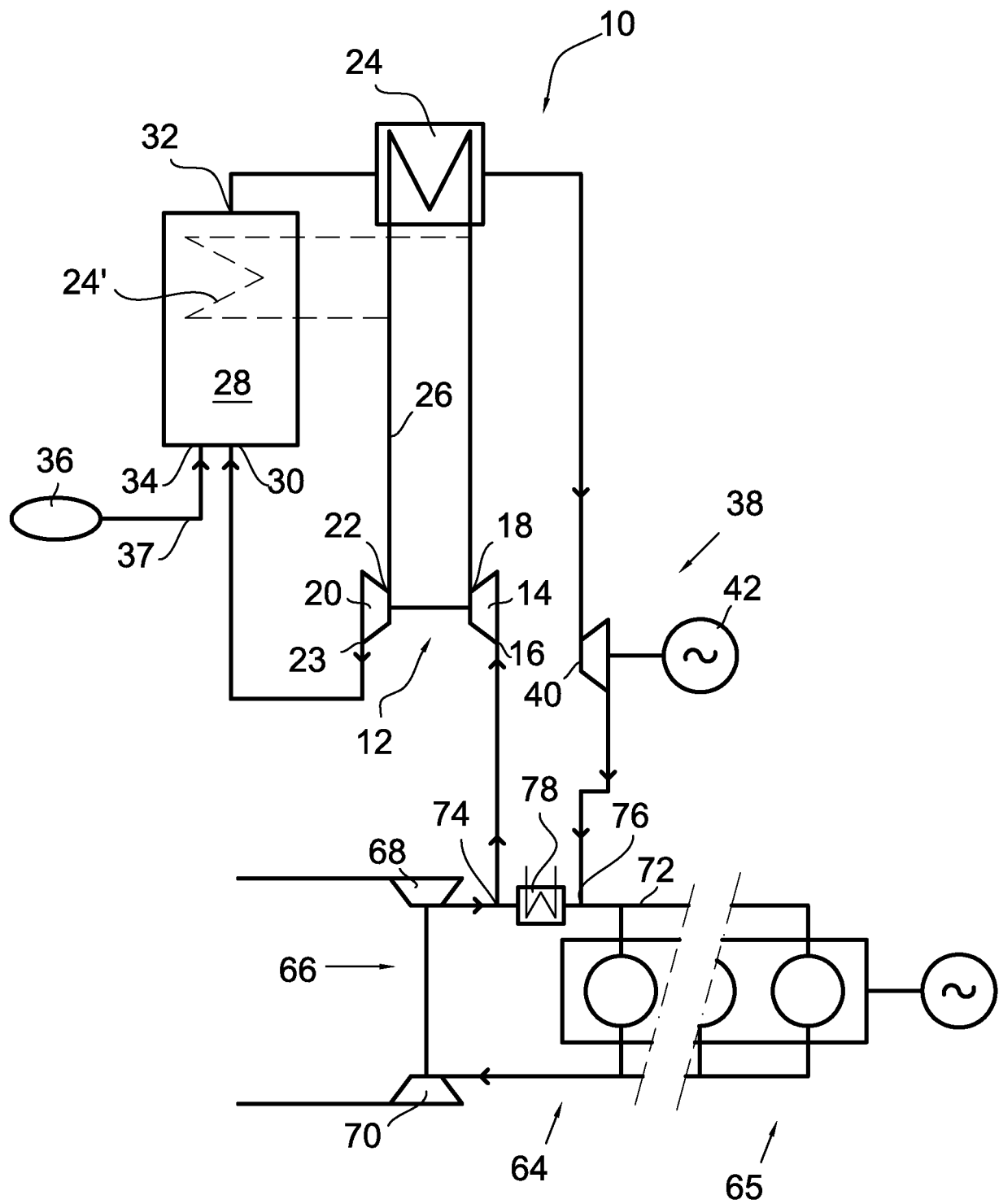


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2015/050369

A. CLASSIFICATION OF SUBJECT MATTER

INV. F01D13/02 F01D15/10 F02C1/04 F02C3/28 F02C6/12
F02C7/08

ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F01D F02C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 167 706 B1 (BRONICKI LUCIEN Y [IL] ET AL) 2 January 2001 (2001-01-02) figure 7 column 1, line 8 - line 11 column 8, line 66 - column 9, line 15 -----	1-12
A	EP 1 426 586 A1 (BECH JEAN ANDRE [FR]) 9 June 2004 (2004-06-09) figure 1 -----	1-12
A	US 2009/211260 A1 (KESSELI JAMES B [US] ET AL) 27 August 2009 (2009-08-27) figures 1-3 -----	1-12
A	US 2 472 846 A (FREDERICK NETTEL ET AL) 14 June 1949 (1949-06-14) figure 3 ----- -/--	1-12



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

11 February 2016

Date of mailing of the international search report

19/02/2016

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INTERNATIONAL SEARCH REPORT

International application No
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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2013/153257 A1 (WAERTSILAE FINLAND OY [FI]) 17 October 2013 (2013-10-17) figures 1-4 -----	1-12

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/FI2015/050369

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