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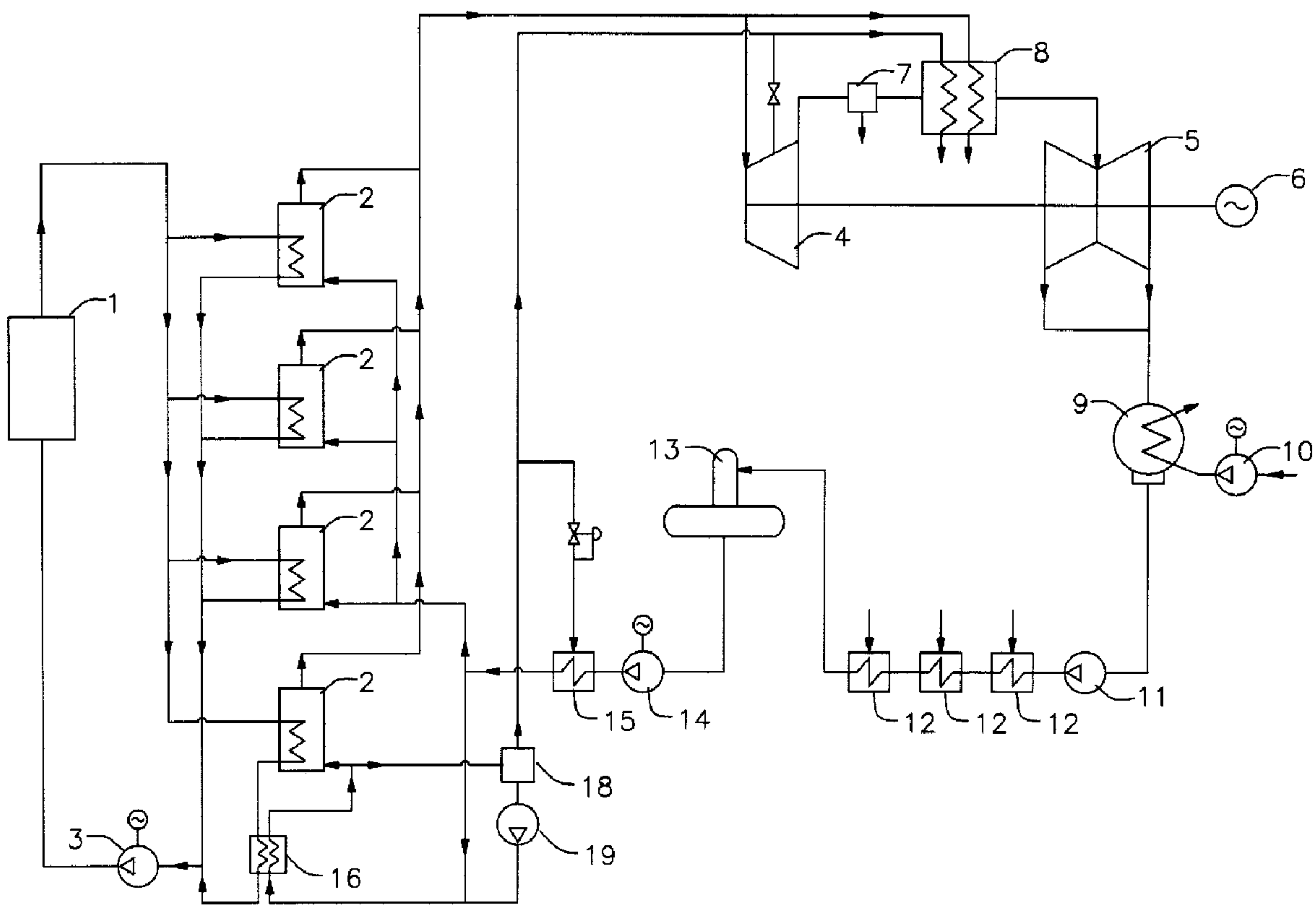

(57) Abrégé/Abstract:
The present invention provides a PWR or CANDU nuclear power plant having a primary circuit and a secondary circuit. In addition to a group of main steam boilers, the nuclear power plant has a lower pressure steam generator (LPSG) connected to primary circuit downstream of main boilers and providing additional cooling to reactor coolant. The lower pressure steam generated by

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(57) **Abrégé(suite)/Abstract(continued):**
LPSG is used by internal consumers of lower pressure steam. Those consumers include any combination of the following: feed water heaters, steam reheater of the moisture separator and reheater (MSR), the connection to the main steam turbine used to supply additional steam flow to the turbine, a steam turbine driven feed water pump, a steam turbine driven condenser cooling water pump, and a steam turbine driven reactor coolant pump. It allows to use excessive thermal capacity of the reactor without major modifications to the secondary side of the plant (main boilers, feed water heaters, steam turbine, feedwater pumps, MSR, piping, etc.). The invention can be used for power uprates of existing nuclear power plants, as an alternative for main boiler replacement (due to aging main boilers), or for new construction. Net electrical output can be increased in the range of 6 to 12% depending on selected modification.

ABSTRACT OF THE DISCLOSURE

The present invention provides a PWR or CANDU nuclear power plant having a primary circuit and a secondary circuit. In addition to a group of main steam boilers, the nuclear power plant has a lower pressure steam generator (LPSG) connected to primary circuit downstream of main boilers and providing additional cooling to reactor coolant. The lower pressure steam generated by LPSG is used by internal consumers of lower pressure steam. Those consumers include any combination of the following: feed water heaters, steam reheater of the moisture separator and reheater (MSR), the connection to the main steam turbine used to supply additional steam flow to the turbine, a steam turbine driven feed water pump, a steam turbine driven condenser cooling water pump, and a steam turbine driven reactor coolant pump. It allows to use excessive thermal capacity of the reactor without major modifications to the secondary side of the plant (main boilers, feed water heaters, steam turbine, feedwater pumps, MSR, piping, etc.). The invention can be used for power uprates of existing nuclear power plants, as an alternative for main boiler replacement (due to aging main boilers), or for new construction. Net electrical output can be increased in the range of 6 to 12% depending on selected modification.

NUCLEAR POWER PLANT

TECHNICAL FIELD OF INVENTION

The present invention relates to nuclear power plants. More specifically, the present invention relates to pressurized water reactor nuclear power plants using a steam cycle.

BACKGROUND OF THE INVENTION AND PRIOR ART

Pressurized water reactor (PWR) nuclear power plants are well known and employ a steam generation cycle. PWR nuclear power plant comprises a PWR, a group of boilers, a steam turbine, a moisture separator, a steam reheater, and a feedwater heating unit. A reactor coolant is a light water or heavy water (CANDU reactors). A primary circuit consists of reactor, primary side of boilers, and coolant pumps. The reactor coolant is pumped between fuel elements of the reactor absorbing heat and through the tube side of boilers releasing heat. A secondary circuit (with light water as a working fluid) includes a secondary side of boilers, a steam turbine-generator, a moisture separator, a steam reheater, a condenser, a group of feedwater heaters, a low-pressure feedwater pump, and a high-pressure feedwater pump. Saturated steam produced in the boilers is delivered to the steam turbine-generator. Steam is condensed in the condenser and returned to the boilers through the group of feed water heaters.

The nuclear power plant has two main consumers of feed water, the boilers and the boiler blowdown system. The boiler blowdown system is well known in power generation industry. Usually it comprises a group of throttling valves connected to the boilers and to a flash tank having a steam outlet and a drain. In some cases, the throttling valves discharge the feed water from the boilers directly to the drain.

Nuclear power plants are described in the following patents granted in Canada:
1,223,488 Schluderberg
2,190,855 Tsiklauri

The patent No. 1,223,488 discloses a nuclear power plant having a reactor, a steam generator, and a steam turbine. The steam generator consists of three stages to improve a thermal efficiency of the steam cycle.

The patent No. 2,190,855 discloses a nuclear power plant having a reactor, a steam generator, and a steam turbine. External source of steam is used to improve the steam quality entering the low-pressure (LP) turbine. This approach allows to reduce the steam moisture content in LP turbine, reduce turbine blade erosion and improve efficiency of the steam cycle.

The prior art does not address an issue of power uprate of existing PWR nuclear power plants. Many of PWR nuclear power plants are presently being uprated by increasing a reactor thermal output above previous licensing limits. Minor increase can be accommodated by existing balance-of-plant equipment. Larger increases (extended power uprates) usually involve a replacement of boilers, turbines, feedwater heaters, piping, or any combination thereof. A cost of extended power uprate can exceed 1000 $/kW. In addition, the prior art does not address an issue of aging of steam generators when a reactor thermal power is limited due to deteriorated condition of boilers thus reducing a turbine-generator output. Therefore it would be desirable to develop additional options for less expensive power uprates and/or for refurbishment of nuclear power plant with limited generation due to aging boilers.

SUMMARY OF THE INVENTION

The present invention provides a PWR nuclear power plant having a primary circuit and a secondary circuit. Primary circuit comprises a pressurized water reactor, a primary side of a group of main boilers, and a reactor coolant pump. Secondary circuit comprises a secondary side of the group of main boilers producing a main pressure steam, a steam turbine, an electrical generator, a moisture separator, a steam reheater, a condenser, and a feed water supply unit. The feed water supply unit comprises lower and higher pressure feed water heaters, deaerators, lower pressure feed water pump (condensate pump), and higher pressure feed water pump. The lower pressure feed water heaters use an extraction steam of the steam turbine (not shown on the drawing). A lower pressure steam generator is connected to primary circuit downstream of primary side of main boilers. Steam produced by lower pressure steam generator is used by steam consumers of secondary circuit. There are many potential consumers of lower pressure steam in steam cycle power plant. These consumers include feed water heaters, steam reheater of the moisture separator and reheater unit (MSR), extraction steam outlets of the steam turbine used to supply additional steam flow to the turbine, a steam turbine driven feed water pump, a steam turbine driven condenser cooling water pump, and a steam turbine driven reactor coolant pump. Using the lower pressure steam, these consumers increase the amount of main pressure steam available for main steam turbine or substitute the electrical power consumption of the pumps usually driven by electric motors. This results in the net electrical generator output increase.

The heat used by lower pressure steam generator reduces the temperature of reactor coolant at the reactor inlet and does not effect the operation of main steam boilers. The lower pressure steam generator can be represented by lower pressure steam boiler (evaporator) or by heat exchanger combined with steam separator and circulating pump. Reactor power and electrical generator output can be increased in accordance with consumption of the steam generated by lower pressure steam generator.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic representation of nuclear power plant according to one embodiment of the present invention and corresponding to the claims 1, 2, 3, 4, 11, and 13.

FIG. 2 is a schematic representation of nuclear power plant according to another embodiment of the present invention and corresponding to the claims 1, 2, 3, 4, 11, and 14.

FIG. 3 is a schematic representation of nuclear power plant according to the embodiment of the present invention corresponding to the claims 1, 2, 3, 4, 11, and 15.

FIG. 4 is a schematic representation of nuclear power plant according to the embodiment of the present invention corresponding to the claims 1, 2, 3, 4, 11, and 16.

FIG. 5 is a schematic representation of nuclear power plant according to the embodiment of the present invention corresponding to the claims 1, 2, 3, 4, 12, and 17.

FIG. 6 is a schematic representation of nuclear power plant according to the embodiment of the present invention corresponding to the claims 1, 2, 3, 4, 12, and 17.

FIG. 7 is a schematic representation of nuclear power plant according to the embodiment of the present invention corresponding to the claims 1, 5, 6, 7, 8, 9, 10, 11, and 13.

FIG. 8 is a schematic representation of nuclear power plant according to the embodiment of the present invention corresponding to the claims 1, 5, 6, 7, 8, 9, 10, 11, and 14.

FIG. 9 is a schematic representation of nuclear power plant according to the embodiment of the present invention corresponding to the claims 1, 5, 6, 7, 8, 9, 10, 11, and 15.

FIG. 10 is a schematic representation of nuclear power plant according to the embodiment of the present invention corresponding to the claims 1, 5, 6, 7, 8, 9, 10, 11, and 16.

FIG. 11 is a schematic representation of nuclear power plant according to the embodiment of the present invention corresponding to the claims 1, 5, 6, 7, 8, 9, 10, 12, and 17.

FIG. 12 is a schematic representation of nuclear power plant according to the embodiment of the present invention corresponding to the claims 1, 5, 6, 7, 8, 9, 10, 12, and 17.

Parts that are not essential to the invention and well known in power generation industry, such as feed water heater drains, various valves, control and instrumentation equipment, etc., are not shown.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIG. 1 of the drawings, a nuclear power plant consists of primary circuit and secondary circuit. Primary circuit comprises a pressurized water reactor 1, a primary side of a group of main boilers 2, and a reactor coolant pump 3. Secondary circuit comprises a secondary side of the group of main boilers 2 producing a main pressure steam, a turbine-generator consisting of a higher-pressure (HP) steam turbine 4 and a lower pressure (LP) steam turbine 5 being shaft coupled with an electrical generator 6, a moisture separator 7, a two-stage steam reheater 8, a condenser, and a feed water supply unit. The feed water supply unit comprises lower pressure feed water heaters 12, a higher pressure feed water heater 15, a deaerator 13, lower pressure feed water pump (condensate pump) 11, and a higher pressure feed water pump 14. The lower pressure feed water heaters 12 use an extraction steam of the steam turbine (not shown on the drawing). A lower pressure steam generator unit (LPSG), represented by first heat exchanger 16, steam separator 18 and drain pump 19, is connected to primary circuit downstream of primary side of main boilers 2. Due to lower temperature of reactor coolant entering the lower pressure steam generator, the steam pressure produced by LPSG (in the range of 2.5 to 4.5 MPa) is lower than the steam pressure produced by main boilers (in the range of 4.5 to 6.5 MPa). Steam produced by lower pressure steam generator is used by lower pressure steam consumers of secondary circuit. These consumers include feed water heaters, steam reheater 8 of the moisture separator and reheater unit (MSR), and one of extraction steam outlets of the HP steam turbine 4. Using the lower pressure steam from LPSG, these consumers increase the amount of main pressure steam available for expansion in the HP and LP steam turbine. The extraction steam outlet of the steam turbine can be used as an additional steam consumer supplying additional steam to the steam turbine by bypassing higher-pressure steam expansion stages. This results in the net electrical generator output increase. The heat used by lower pressure steam generator reduces the temperature of reactor coolant at the reactor inlet and does not effect the operation of main boilers 2. The lower pressure steam generator LPSG is represented by heat exchanger 16 combined with steam separator 18 and drain pump 19.

The main boilers 2 produce the main pressure steam directed to the HP steam turbine 4 and higher temperature steam reheater of the MSR 8. After expansion in HP steam turbine 4, the moisture (in the range of 12 to 15%) from the main steam flow is removed in moisture separator 7. The steam is reheated in two-stage steam reheater 8. The lower pressure steam reheater uses the steam produced by LPSG, the higher-pressure steam reheater uses the main pressure steam generated by main boilers. The drains of moisture separator 7 and steam reheater 8 are returned to the steam cycle (not shown on drawing). After MSR, the main steam continues its expansion in LP steam turbine and condenses in the condenser 9. Condenser cooling water pump 10 supplies the condenser 9 with sufficient amount of water to remove a latent heat of condensation of the main steam flow. Lower pressure feed water pump 11 (condensate pump) returns the condensate to the steam cycle through lower pressure feed water heaters 12, deaerator 13, higher pressure feed water pump 14, and higher-pressure feed water heater 15. The feed water heaters use the turbine extraction steam to heat the feed water before it is distributed among the main boilers and LPSG.

The LPSG consists of a first heat exchanger 16, a steam separator 18, and a drain pump 19. The following parameters of the steam cycle, temperatures and pressures of feed water and reactor coolant are examples and do not represent actual design values. However, they are close to actual parameters of PWR nuclear power plant.

After the feed water heater 15, a feed water at 160°C enters the LPSG through LPSG feedwater inlet being the first heat exchanger feedwater inlet. Reactor coolant at 270°C enters the LPSG through LPSG reactor coolant inlet being the first heat exchanger reactor coolant inlet. The feedwater, being heated in the first heat exchanger 16, reaches the temperature close to the saturation temperature and, in some modes of operation, partly evaporates. The feed water leaves the first heat exchanger through first heat exchanger feed water outlet at 220°C to 240°C temperature range, from where it is in part directed to a steam separator feed water inlet. The pressure in the steam separator 18 is close or below saturation pressure of the feed water after first heat exchanger, for example, being in the range of 2.5 to 3.5 MPa; therefore, the additional amount of the feed water can evaporate if the feed water temperature exceeds the saturation temperature. The steam separated from the water, leaves the steam separator at saturation temperature through a steam separator steam outlet being a LPSG steam outlet. The feed water from steam separator 18 returns to the first heat exchanger 16 feedwater inlet after being mixed with the feed water coming from the feed water heater 15. The part of the feed water from the first heat exchanger feed water outlet being a LPSG feed water outlet, is directed to the boiler 2 feed water inlet. This part of the feed water performs the function of the blowdown and is required to reduce the concentration of impurities in this loop (first heat exchanger 16, steam separator 18, and drain pump 19). To balance the feed water flows and pressures, well known in power generation industry means can be used, for example, orifices, flow and pressure control valves, etc.

If the lower pressure steam production in the LPSG is in the range of 10% of the main pressure steam generation, and assuming the reactor coolant flow rate through the first heat exchanger represents 25% of total reactor coolant flow, the reactor coolant temperature will be in the range of 255 to 260°C at the first heat exchanger reactor coolant outlet being a LPSG reactor coolant outlet.

The lower pressure steam is used by higher pressure feed water heater 15 (through pressure control valve) and by first stage of steam reheater 8 of MSR. In typical steam cycle, total steam consumption would represent about 7% of main steam flow rate. By substitution of the turbine extraction steam by lower pressure steam from LPSG, the amount of main pressure steam available for expansion in the main steam turbine would increase. The turbine-generator output would increase by approximately 6% with reactor thermal output increase of approximately 7.5%.

The extraction steam outlet of the HP steam turbine 4 can be used as an additional lower pressure steam consumer supplying additional steam to the steam turbine by bypassing the turbine governor and higher-pressure steam expansion stages. This results in additional net electrical generator output increase.

Referring to FIG. 7 of the drawings, other lower pressure steam consumers are shown. The reactor coolant pump 3, the higher-pressure feed water pump 14, and the condenser cooling water pump 10 are shown being driven by a steam turbine drive using lower pressure steam from LPSG. These steam turbine drives are preferably of backpressure type, thus reducing the required size of steam piping and the turbines. Steam turbine drive steam outlets can be connected to one of the lower pressure feed water heater 12 steam inlets or to the deaerator 13 steam inlet (not shown on the drawing). These pumps usually have an electric drive. Therefore, electrical consumption by these pump drives is substituted by mechanical energy generated by steam turbine drives increasing net electrical output of nuclear power plant. Typically, the reactor coolant pump 3 (or group of pumps) consumes about 4% of turbine-generator output, the higher-pressure feed water pump 14 (or group of pumps) consumes about 1% of turbine-generator output, and the condenser cooling water pump (or group of pumps) consumes about 0.6% of turbine-generator output. As a result, the net nuclear power plant electrical output can be increased by 5.6% by increasing the reactor thermal output by approximately 6.5% without any changes to existing secondary circuit equipment (turbine-generator, feed water heaters, main boilers, etc.).

Nuclear power plant can utilize any combination of lower pressure steam consumers shown on FIG.1 and FIG.7 with appropriate electrical generation increase.

Referring to FIG. 2 of the drawings, the nuclear power plant differs from the one shown on FIG. 1 by having a second heat exchanger 17 being connected in parallel with the first heat exchanger 16 by reactor coolant and by feed water flow. The first heat exchanger 16 is used to preheat the feed water before it enters the main boiler 2. The second heat exchanger 17 is used to heat the feed water before it enters the steam separator 18 of LPSG. The nuclear power plant of FIG.8 differs from the one shown on FIG 2 by shown lower pressure steam consumers. The reactor coolant pump 3, the higher-pressure feed water pump 14, and the condenser cooling water pump 10 are shown being driven by a steam turbine drive using the lower pressure steam from LPSG.

Referring to FIG. 3 of the drawings, the nuclear power plant differs from the one shown on FIG. 1 by the steam separator of LPSG being replaced by lower pressure steam boiler 20. The part of feed water flow after the first heat exchanger 16 of LPSG moves through the tubes of the lower pressure steam boiler 20, generates a lower pressure steam on secondary side of lower pressure steam boiler 20, and returns by the drain pump 19 to the first heat exchanger 16 feed water inlet. The remaining part of the feed water after first heat exchanger 16 of LPSG is directed to main boiler 2 thus increasing the efficiency of main cycle by supplying the main boiler with the feed water of higher temperature and increasing the main steam pressure and steam generation flow rate. The nuclear power plant of FIG.9 differs from the one shown on FIG 3 by shown lower pressure steam consumers. The reactor coolant pump 3, the higher-pressure feed water pump 14, and the condenser cooling water pump 10 are shown being driven by a steam turbine drive using the lower pressure steam from LPSG.

Referring to FIG. 4 of the drawings, the nuclear power plant differs from the one shown on FIG. 3 by having a second heat exchanger 17 being connected in parallel with the first heat exchanger 16 by reactor coolant and by feed water flow. The first heat exchanger 16 is used to preheat the feed water before it enters the main boiler 2 consequently increasing the efficiency of main steam cycle by supplying the main boiler with the feed water of higher temperature and increasing the main steam pressure and steam generation flow rate. The second heat exchanger 17 is used to heat the feed water before it enters the lower pressure steam boiler 20 of LPSG. The nuclear power plant of FIG.10 differs from the one shown on FIG 4 by shown lower pressure steam consumers. The reactor coolant pump 3, the higher-pressure feed water pump 14, and the condenser cooling water pump 10 are shown being driven by a steam turbine drive using the lower pressure steam from LPSG.

Referring to FIG. 5 of the drawings, the nuclear power plant differs from the one shown on FIG. 3 by the lower pressure steam boiler 20 being connected downstream of main boiler 2 primary outlet and heated directly by reactor coolant. In this case, the steam separator and the drain pump are not required. The nuclear power plant of FIG.11 differs from the one shown on FIG 5 by shown lower pressure steam consumers. The reactor coolant pump 3, the higher-pressure feed water pump 14, and the condenser cooling water pump 10 are shown being driven by a steam turbine drive using the lower pressure steam from LPSG.

Referring to FIG. 6 of the drawings, the nuclear power plant differs from the one shown on FIG. 5 by the lower pressure steam boiler 20 being connected to reactor coolant header downstream of main boiler primary outlets and heated directly by reactor coolant. The lower pressure steam boiler uses a part of total reactor coolant flow; the other part of the flow goes through the bypass (orifice 21). The nuclear power plant of FIG.12 differs from the one shown on FIG 6 by shown lower pressure steam consumers. The reactor coolant pump 3, the higher-pressure feed water pump 14, and the condenser cooling water pump 10 are shown being driven by a steam turbine drive using the lower pressure steam from LPSG.

The nuclear power plant has two main consumers of feed water, the boilers and the boiler blowdown system. The boiler blowdown system is well known in power generation industry. Usually it comprises a group of throttling valves connected to the boilers and to a flash tank having a steam outlet and a drain. In some cases, the throttling valves discharge the feed water from the boilers directly to the drain. It is required to remove impurities from the feed water in boilers.

Main boilers 2 have blowdown outlets connected to boiler blowdown system (not shown on drawings). The lower pressure steam boiler 20 of LPSG has a blowdown outlet connected to boiler blowdown system (not shown on drawings). This is required to reduce the concentration of impurities in the lower pressure steam boiler 20.

The same numbers on the drawings were assigned to similar pieces of equipment, for example, to the main boilers 2 and to the lower pressure feed water heaters 12. The steam reheater 8 of moisture separator and reheater unit MSR is shown having two reheat stages (no numbers assigned on the drawings). However, the nuclear power plant implementing the present invention can have only one reheat stage. It will result in slightly lower thermal efficiency of the steam cycle.

Terminology used in this application has the following meanings. The drive of a pump is a source of mechanical energy (electrical motor, diesel, steam engine, gas turbine, steam turbine) used by the pump. The drive can be directly shaft coupled with the pump, or through a transmission, gearbox, etc.

Flow communication means that the same fluid moves from first piece of equipment (component, element) to second piece of equipment, or the same fluid moves to the first piece of equipment (component, element) and to the second piece of equipment. It does not imply a direct connection by pipes without additional equipment being installed between those two pieces of equipment. Other pieces of equipment (elements, components) can be installed between the first and the second piece of equipment (for example, isolating valves, pressure control valves, pumps, etc.).

Boiler is a heat exchanger having a primary and a secondary side. A heating fluid (reactor coolant) moves through the primary side of the boiler (usually through the tube side) and transfers the heat to the secondary side (usually the shell side). The secondary side liquid (feed water) boils producing a steam. Part of feed water is being removed from the boiler as a blowdown to reduce a concentration of impurities in the boiler. Reactor coolant is a light or heavy water used to remove the heat from the reactor fuel and transfer it to the boiler.

After LP steam turbine, the steam condenses in the condenser transforming into the water, which is often called a condensate or, downstream of lower pressure feed water pump (condensate pump), a lower pressure feed water. The same condensate is traditionally called a feed water (higher pressure feed water) downstream of higher pressure feed water pump.

Several preferred embodiments of the present invention have been shown and described. However, it is apparent to those skilled in the art that many changes and modifications may be made without departing from the invention as it is defined in the appended claims.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A nuclear power plant comprising
    - a pressurized water reactor comprising a reactor coolant inlet and a reactor coolant outlet;
    - a reactor coolant pump comprising reactor coolant pump inlet, a reactor coolant pump outlet, and a reactor coolant pump drive, said reactor coolant pump outlet being in flow communication with said reactor coolant inlet;
    - a plurality of main boilers producing a main pressure steam, each of said boilers comprising a main boiler primary inlet, a main boiler primary outlet, a main boiler feedwater inlet, a main boiler steam outlet, said main boiler primary inlet of each main boiler being in flow communication with said reactor coolant outlet, said main boiler primary outlet of each main boiler being in flow communication with said reactor coolant pump inlet;
    - a steam turbine comprising a plurality of steam expansion stages, each of them having inlet and outlet, a steam turbine inlet, a steam turbine outlet, said steam turbine inlet being in flow communication with main boiler steam outlet;
    - an electrical generator being shaft coupled with said steam turbine;
    - a condenser comprising a condenser steam inlet, a condenser condensate outlet, a condenser cooling water inlet, and a condenser cooling water outlet, said condenser steam inlet being in flow communication with said steam turbine outlet;
    - a condenser cooling water pump having a drive and being in flow communication with said condenser cooling water inlet;
    - a feed water supply unit comprising a plurality of feed water heaters, a higher pressure feed water pump having a drive and a lower pressure feed water pump, arranged to heat and to move a

feed water from said condenser condensate outlet to said main boiler feed water inlet;

- a moisture separator and reheater unit comprising a moisture separator having a moisture separator inlet and a moisture separator outlet, a steam reheater having a steam reheater inlet, a steam reheater outlet, and a first heating steam inlet, said moisture separator inlet being in flow communication with predetermined steam expansion stage outlet of said steam turbine, said moisture separator outlet being in flow communication with said steam reheater inlet, said steam reheater outlet being in flow communication with subsequent steam expansion stage inlet of said steam turbine;
- a consumer of lower pressure steam;
- a lower pressure steam generator unit comprising a lower pressure steam generator unit reactor coolant inlet, a lower pressure steam generator unit reactor coolant outlet, a lower pressure steam generator unit feed water inlet, a lower pressure steam generator unit feed water outlet, and a lower pressure steam generator unit steam outlet, wherein said lower pressure steam generator unit reactor coolant inlet being in flow communication with at least one of said main boiler primary outlets, said lower pressure steam generator unit reactor coolant outlet being in flow communication with said reactor coolant inlet, said lower pressure steam generator unit feed water inlet being in flow communication with said feed water supply unit feed water outlet, said lower pressure steam generator unit steam outlet being in flow communication with said consumer of lower pressure steam;
- a consumer of feed water being in flow communication with said lower pressure steam generator feed water outlet.

2. The nuclear power plant of claim 1, wherein said consumer of lower pressure steam comprises at least one of said feed water heaters.
3. The nuclear power plant of claim 1, wherein said consumer of lower pressure steam comprises said steam turbine.
4. The nuclear power plant of claim 1, wherein said consumer of lower pressure steam comprises said steam reheater of said moisture separator and reheater unit.
5. The nuclear power plant of claim 1, wherein said consumer of lower pressure steam comprises said drive of said higher pressure feed water pump of said feed water supply unit.
6. The nuclear power plant of claim 5, wherein said drive of said higher pressure feed water pump of said feed water supply unit comprises a steam turbine.
7. The nuclear power plant of claim 1, wherein said consumer of lower pressure steam comprises said drive of said condenser cooling water pump.
8. The nuclear power plant of claim 7, wherein said drive of said condenser cooling water pump comprises a steam turbine.
9. The nuclear power plant of claim 1, wherein said consumer of lower pressure steam comprises said drive of said reactor coolant pump.
10. The nuclear power plant of claim 9, wherein said drive of said reactor coolant pump comprises a steam turbine.
11. The nuclear power plant of claim 1, wherein said consumer of feed water comprises said main boiler feed water inlet of said main boiler.
12. The nuclear power plant of claim 1, comprising a boiler blowdown system, wherein said consumer of feed water being said boiler blowdown system.
13. The nuclear power plant of claim 1, wherein said lower pressure steam generator unit comprises a first heat exchanger having a first heat exchanger reactor coolant inlet, a first heat exchanger reactor coolant outlet, a first heat exchanger feed water inlet, and a first heat exchanger feed water outlet, a steam separator having a steam separator feed water

inlet, a steam separator steam outlet, and a steam separator drain outlet, a drain pump having a drain pump inlet and a drain pump outlet, wherein said first heat exchanger feed water outlet being said lower pressure steam generator unit feed water outlet, said first heat exchanger reactor coolant outlet being said lower pressure steam generator unit reactor coolant outlet, said first heat exchanger feed water inlet being said lower pressure steam generator unit feed water inlet, said first heat exchanger reactor coolant inlet being said lower pressure steam generator unit reactor coolant inlet; said steam separator steam outlet being said lower pressure steam generator unit steam outlet, said drain pump outlet being in flow communication with said first heat exchanger feed water inlet, said first heat exchanger feed water outlet being in flow communication with said steam separator feed water inlet, said steam separator drain outlet being in flow communication with said drain pump inlet.

14. The nuclear power plant of claim 1, wherein said lower pressure steam generator unit comprises a first heat exchanger having a first heat exchanger reactor coolant inlet, a first heat exchanger reactor coolant outlet, a first heat exchanger feed water inlet, and a first heat exchanger feed water outlet, a second heat exchanger having a second heat exchanger reactor coolant inlet, a second heat exchanger reactor coolant outlet, a second heat exchanger feed water inlet, and a second heat exchanger feed water outlet, a steam separator having a steam separator feed water inlet, a steam separator steam outlet, and a steam separator drain outlet, a drain pump having a drain pump inlet and a drain pump outlet, wherein said first heat exchanger feed water outlet being said lower pressure steam generator unit feed water outlet, said first heat exchanger reactor coolant outlet being said lower pressure steam generator unit reactor coolant outlet, said first heat exchanger feed water inlet being said lower pressure steam generator unit feed water inlet, said first heat exchanger reactor coolant inlet being said lower pressure steam generator unit reactor coolant inlet; said steam separator steam outlet being said

lower pressure steam generator unit steam outlet, said drain pump outlet being in flow communication with said first heat exchanger feed water inlet and with said second heat exchanger feed water inlet, said second heat exchanger feed water outlet being in flow communication with said steam separator feed water inlet, said steam separator drain outlet being in flow communication with said drain pump inlet, said second heat exchanger reactor coolant outlet being in flow communication with said lower pressure steam generator unit reactor coolant outlet, said second heat exchanger reactor coolant inlet being in flow communication with said lower pressure steam generator unit reactor coolant inlet.

15. The nuclear power plant of claim 1, wherein said lower pressure steam generator unit comprises a first heat exchanger having a first heat exchanger reactor coolant inlet, a first heat exchanger reactor coolant outlet, a first heat exchanger feed water inlet, and a first heat exchanger feed water outlet, a lower pressure steam boiler having a lower pressure steam boiler feed water inlet, a lower pressure steam boiler steam outlet, a lower pressure steam boiler drain outlet, and a lower pressure steam boiler secondary feed water inlet, a drain pump having a drain pump inlet and a drain pump outlet, wherein said first heat exchanger feed water outlet being said lower pressure steam generator unit feed water outlet, said first heat exchanger reactor coolant outlet being said lower pressure steam generator unit reactor coolant outlet, said first heat exchanger feed water inlet being said lower pressure steam generator unit feed water inlet, said first heat exchanger reactor coolant inlet being said lower pressure steam generator unit reactor coolant inlet; said lower pressure steam boiler steam outlet being said lower pressure steam generator unit steam outlet, said drain pump outlet being in flow communication with said first heat exchanger feed water inlet, said first heat exchanger feed water outlet being in flow communication with said lower pressure steam boiler feed water inlet, said lower pressure steam boiler drain outlet being in flow communication with said drain pump inlet, said lower pressure steam

boiler secondary feed water inlet being in flow communication with said lower pressure steam generator unit feed water inlet.

16. The nuclear power plant of claim 1, wherein said lower pressure steam generator unit comprises a first heat exchanger having a first heat exchanger reactor coolant inlet, a first heat exchanger reactor coolant outlet, a first heat exchanger feed water inlet, and a first heat exchanger feed water outlet, a second heat exchanger having a second heat exchanger reactor coolant inlet, a second heat exchanger reactor coolant outlet, a second heat exchanger feed water inlet, and a second heat exchanger feed water outlet, a lower pressure steam boiler having a lower pressure steam boiler feed water inlet, a lower pressure steam boiler steam outlet, a lower pressure steam boiler drain outlet, and a lower pressure steam boiler secondary feed water inlet, a drain pump having a drain pump inlet and a drain pump outlet, wherein said first heat exchanger feed water outlet being said lower pressure steam generator unit feed water outlet, said first heat exchanger reactor coolant outlet being said lower pressure steam generator unit reactor coolant outlet, said first heat exchanger feed water inlet being said lower pressure steam generator unit feed water inlet, said first heat exchanger reactor coolant inlet being said lower pressure steam generator unit reactor coolant inlet; said lower pressure steam boiler steam outlet being said lower pressure steam generator unit steam outlet, said drain pump outlet being in flow communication with said first heat exchanger feed water inlet and with said second heat exchanger feed water inlet , said second heat exchanger feed water outlet being in flow communication with said lower pressure steam boiler feed water inlet, said lower pressure steam boiler drain outlet being in flow communication with said drain pump inlet, said lower pressure steam boiler secondary feed water inlet being in flow communication with said lower pressure steam generator unit feed water inlet, said second heat exchanger reactor coolant outlet being in flow communication with said lower pressure steam generator unit reactor

coolant outlet, said second heat exchanger reactor coolant inlet being in flow communication with said lower pressure steam generator unit reactor coolant inlet.

17. The nuclear power plant of claim 1, wherein said lower pressure steam generator unit comprises a lower pressure steam boiler having a lower pressure steam boiler primary inlet, a lower pressure steam boiler steam outlet, a lower pressure steam boiler primary outlet, a lower pressure steam boiler blowdown outlet, and a lower pressure steam boiler secondary feed water inlet, wherein said lower pressure steam boiler blowdown outlet being said lower pressure steam generator unit feed water outlet, said lower pressure steam boiler primary outlet being said lower pressure steam generator unit reactor coolant outlet, said lower pressure steam boiler secondary feed water inlet being said lower pressure steam generator unit feed water inlet, said lower pressure steam boiler primary inlet being said lower pressure steam generator unit reactor coolant inlet; said lower pressure steam boiler steam outlet being said lower pressure steam generator unit steam outlet.

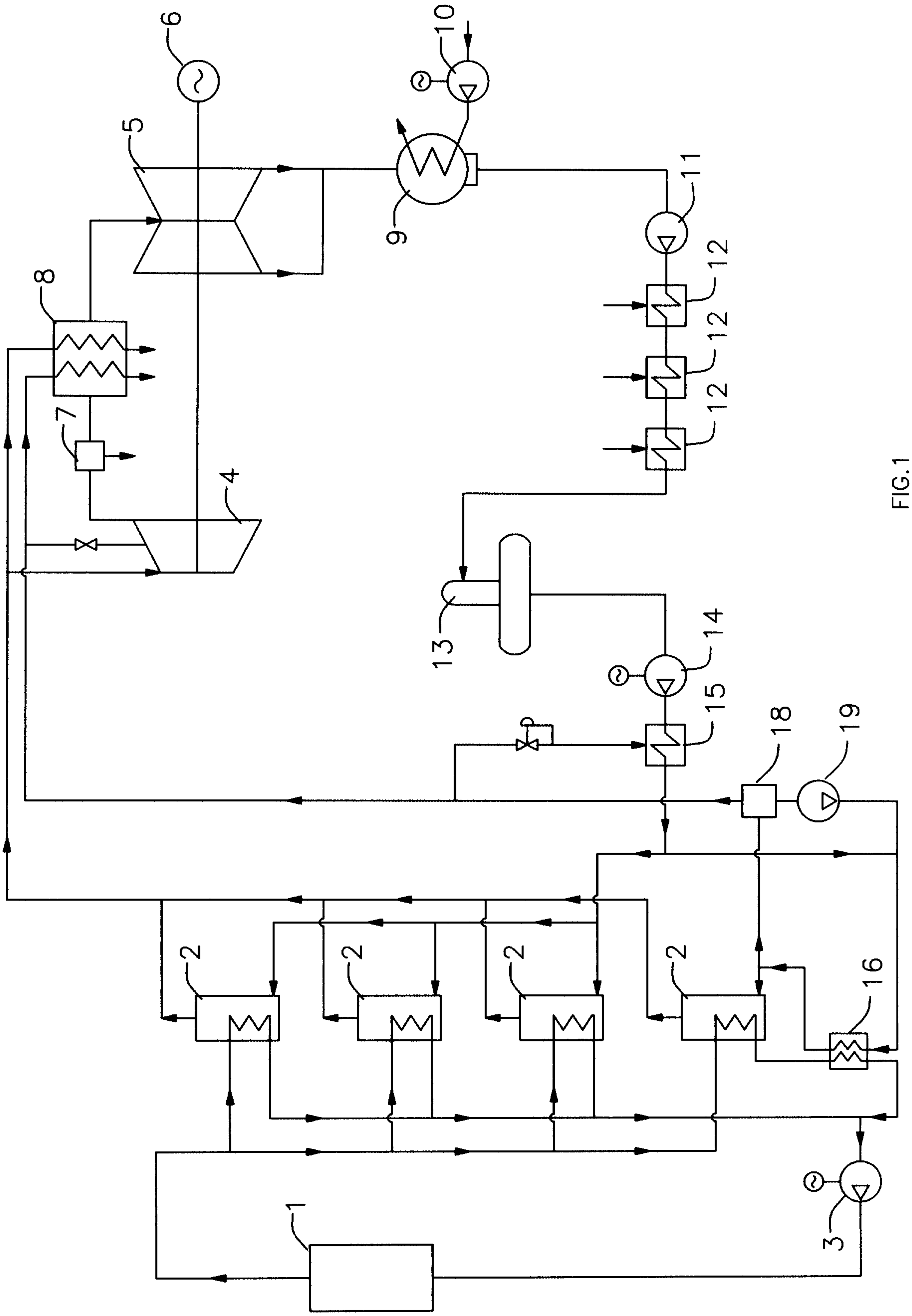


FIG.1

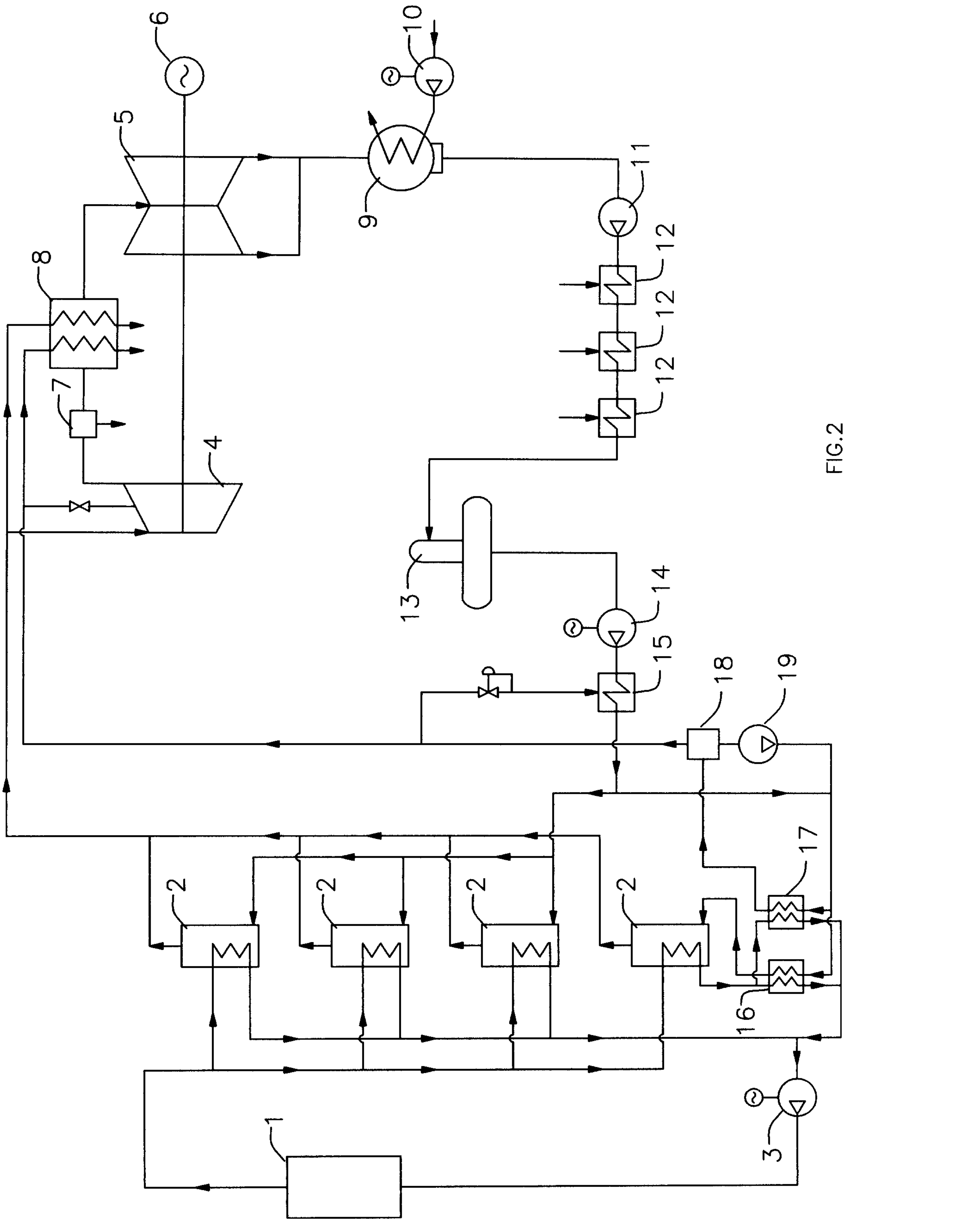


FIG.2

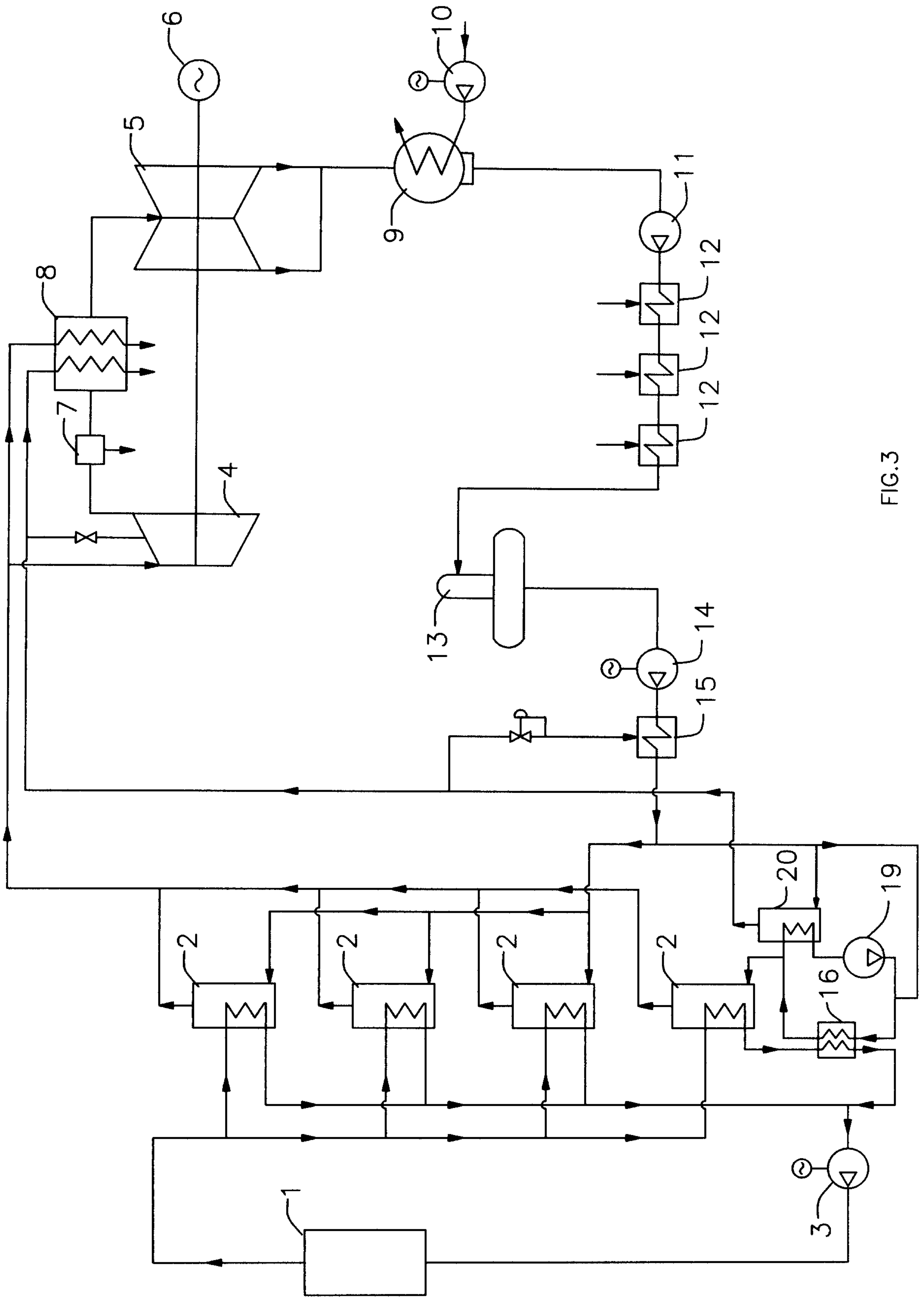


FIG.3

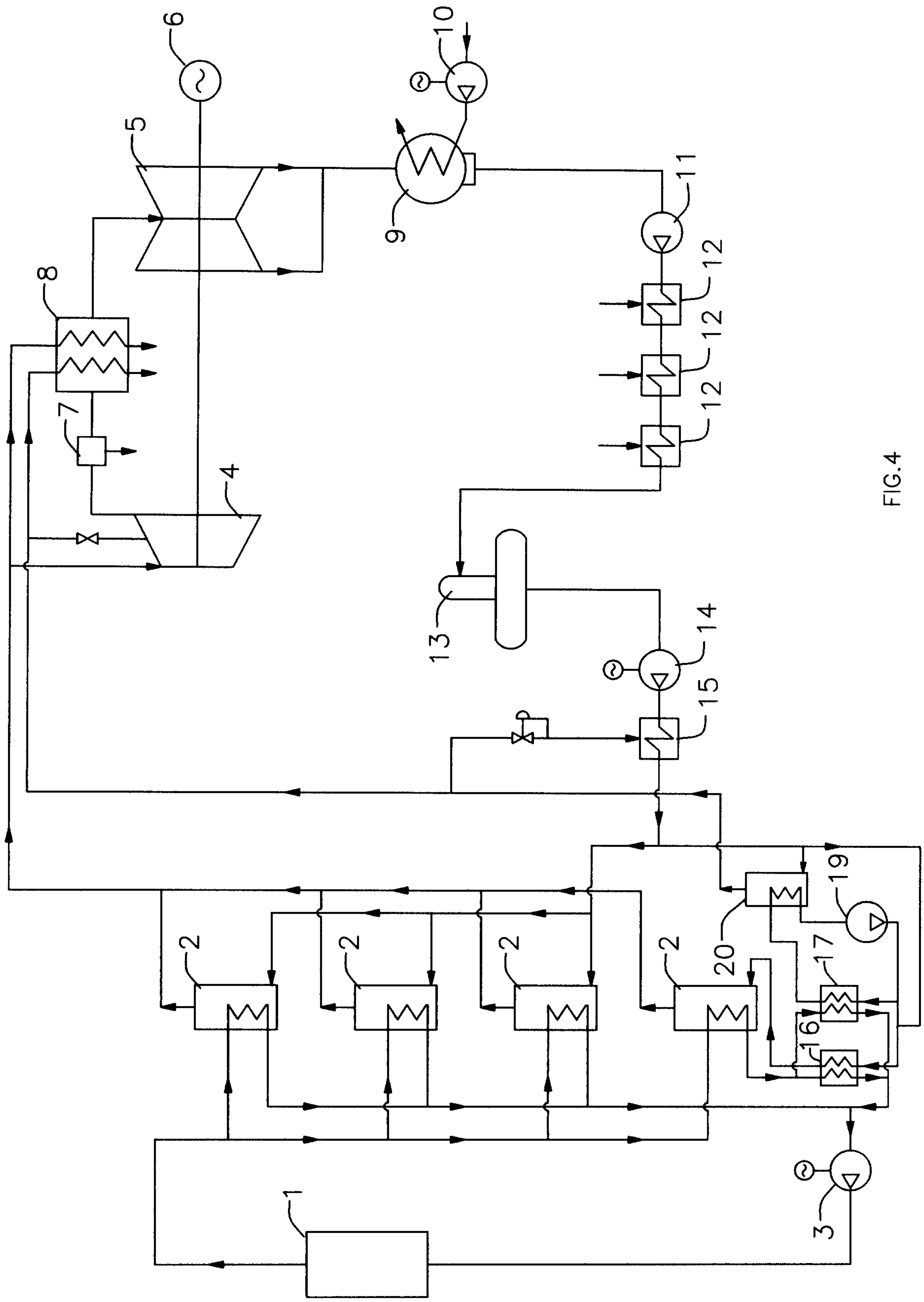


FIG.4

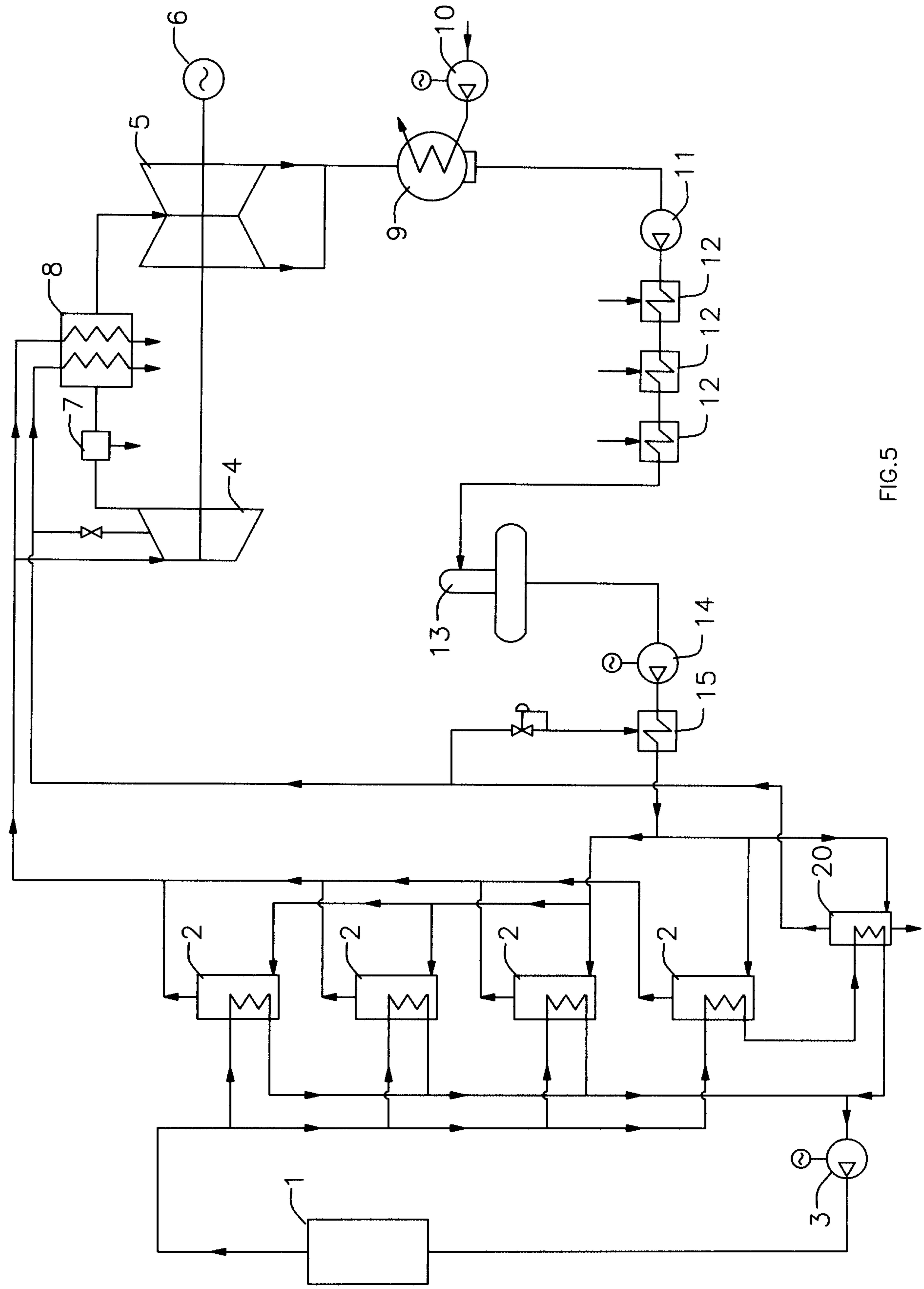


FIG.5

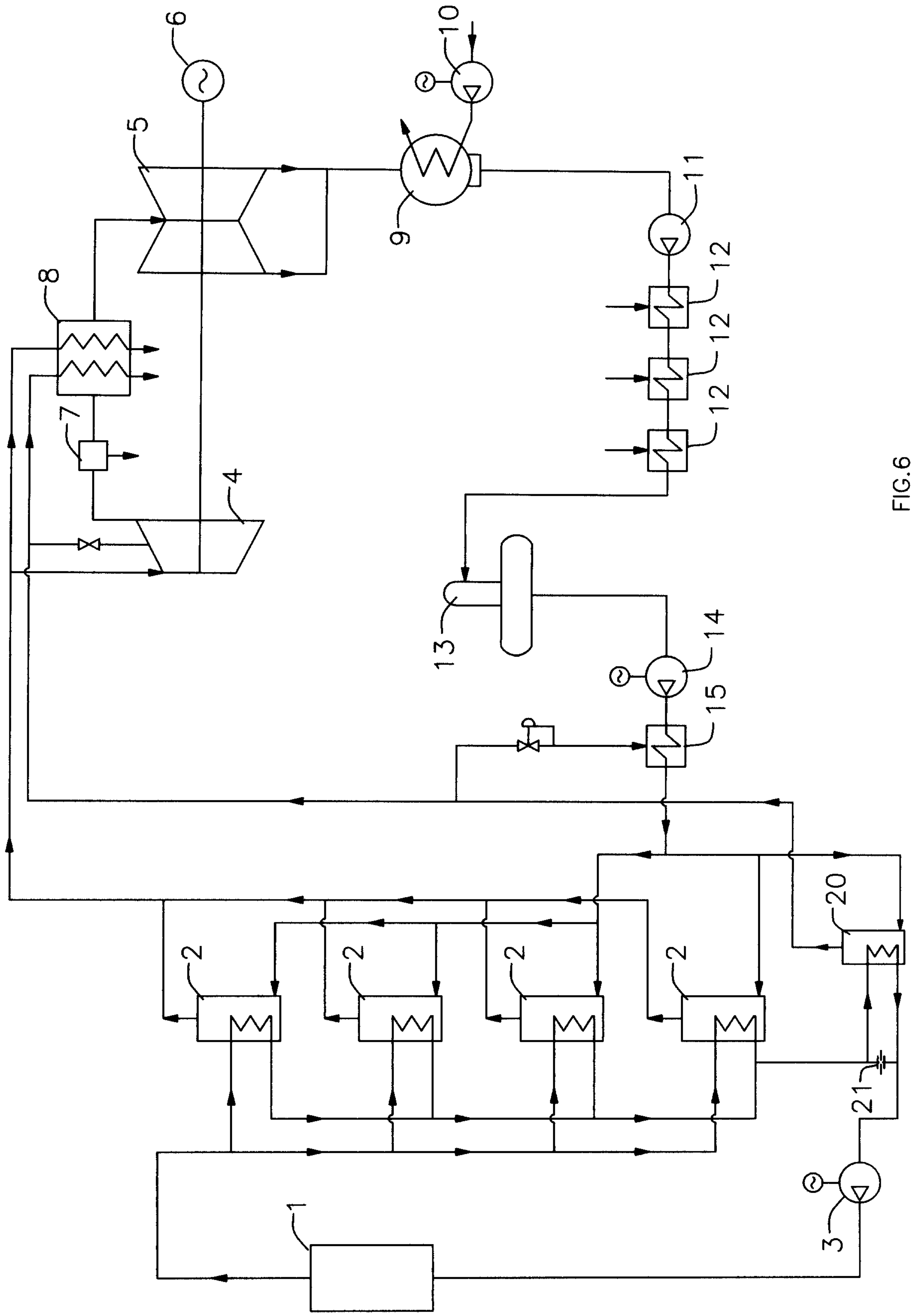


FIG.6

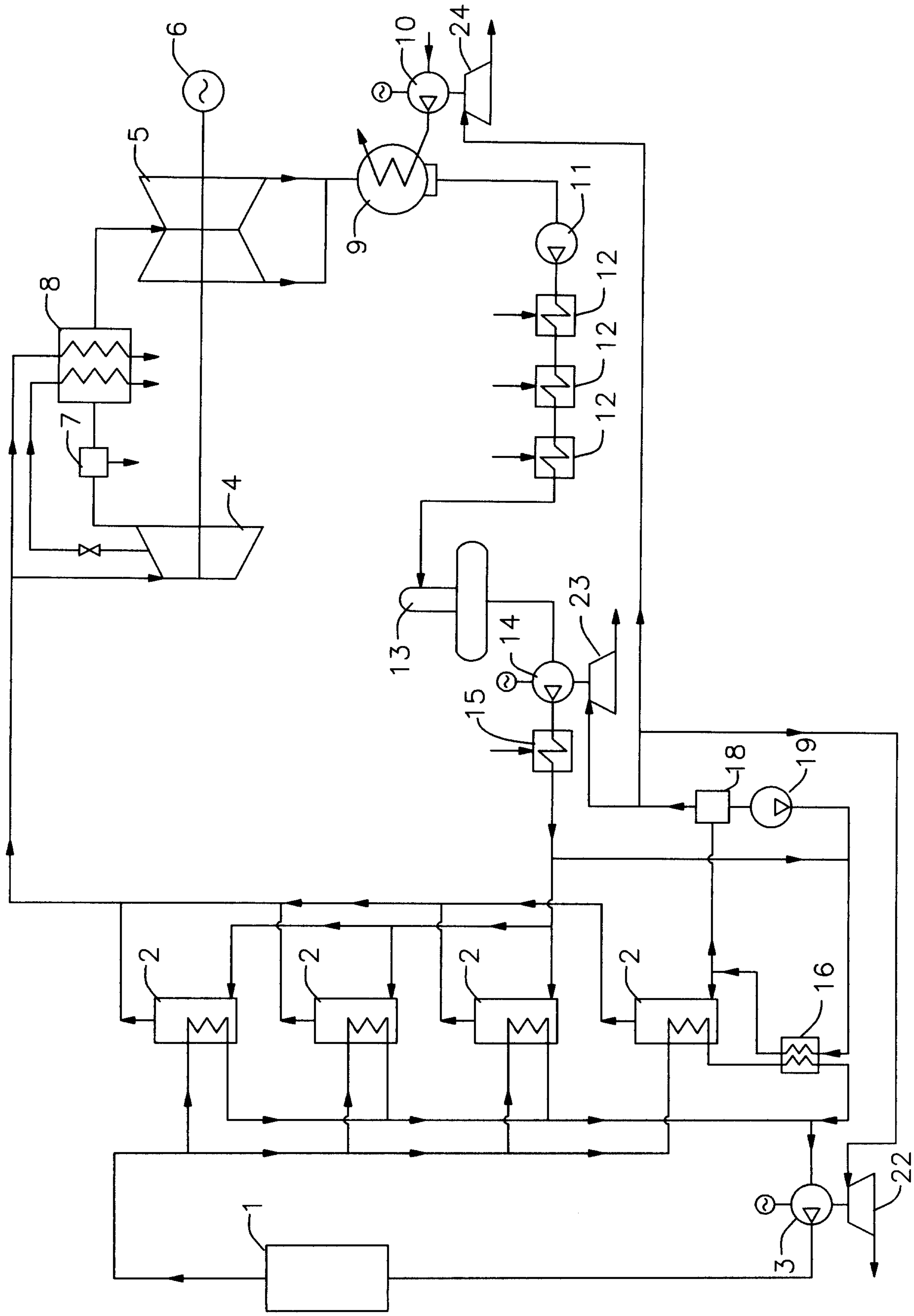


FIG.7

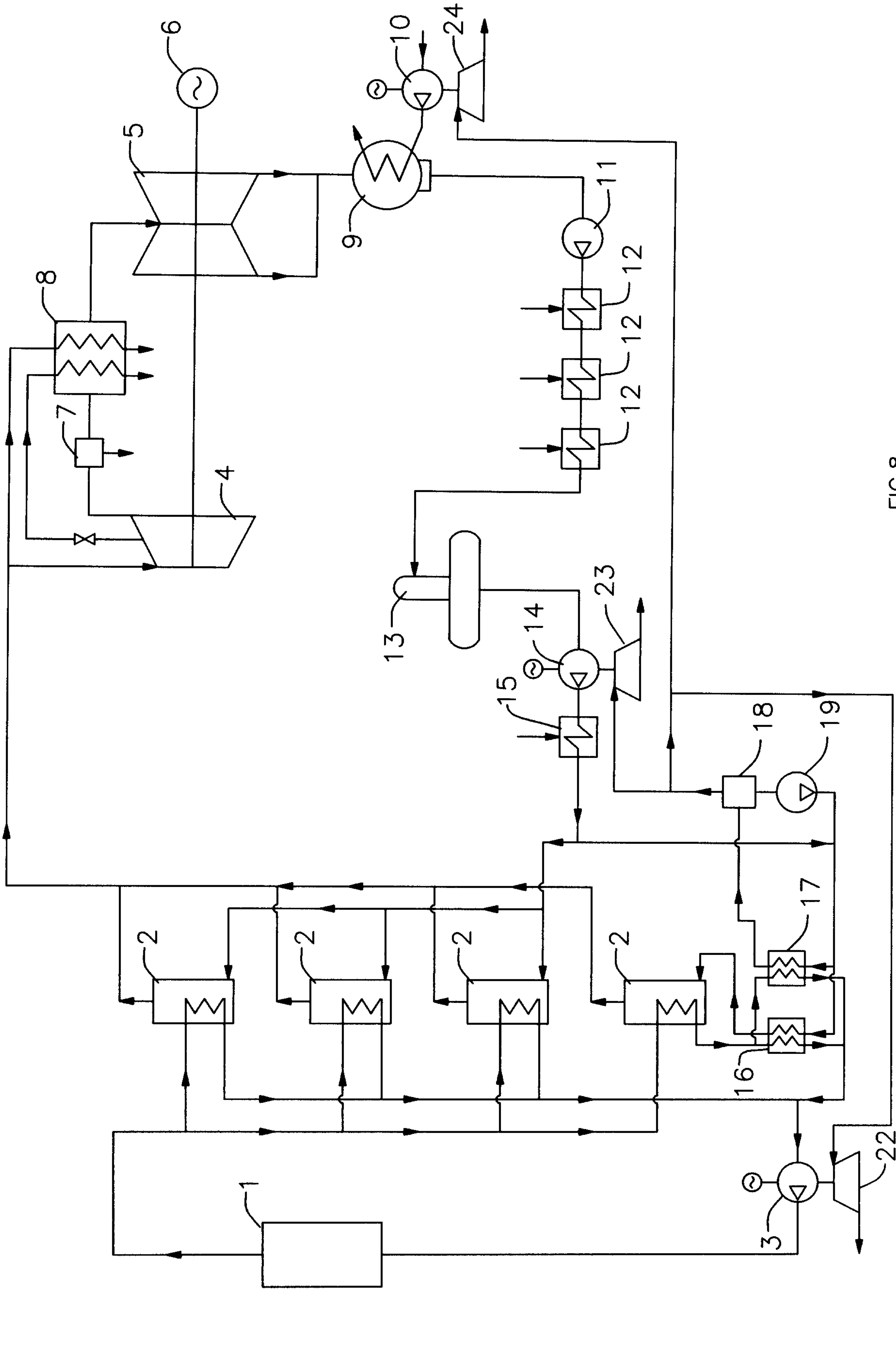


FIG.8

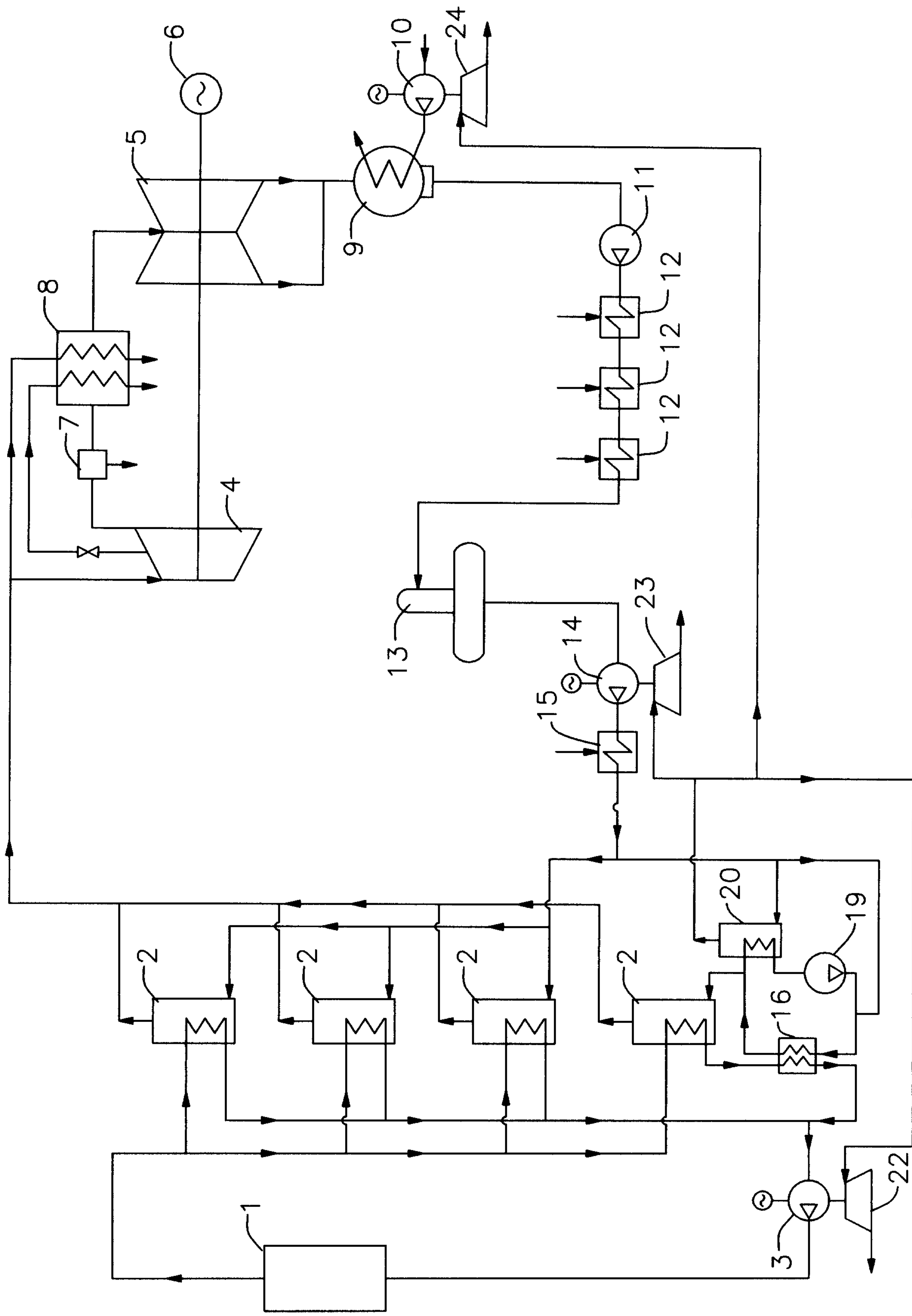


FIG.9

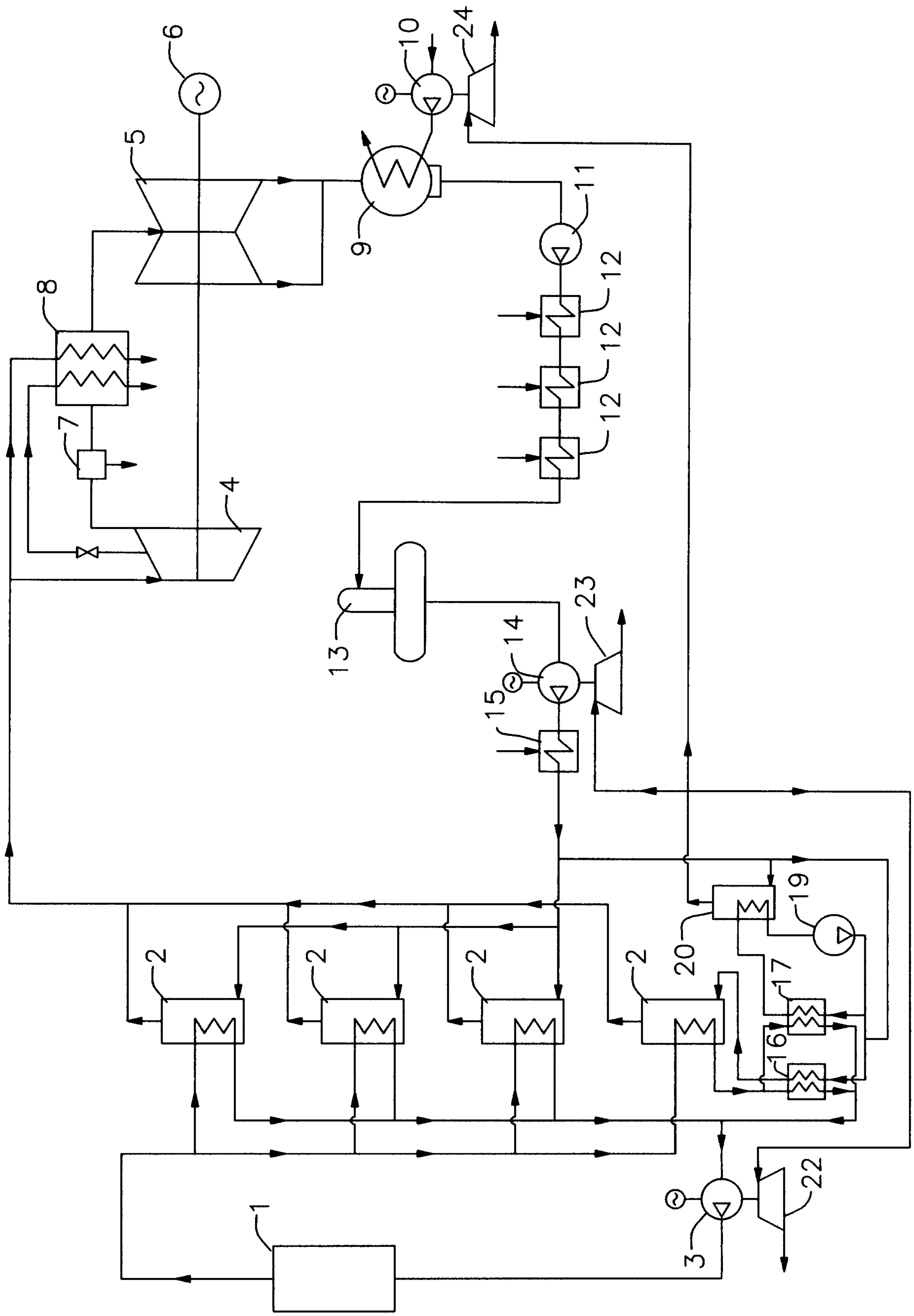


FIG.10

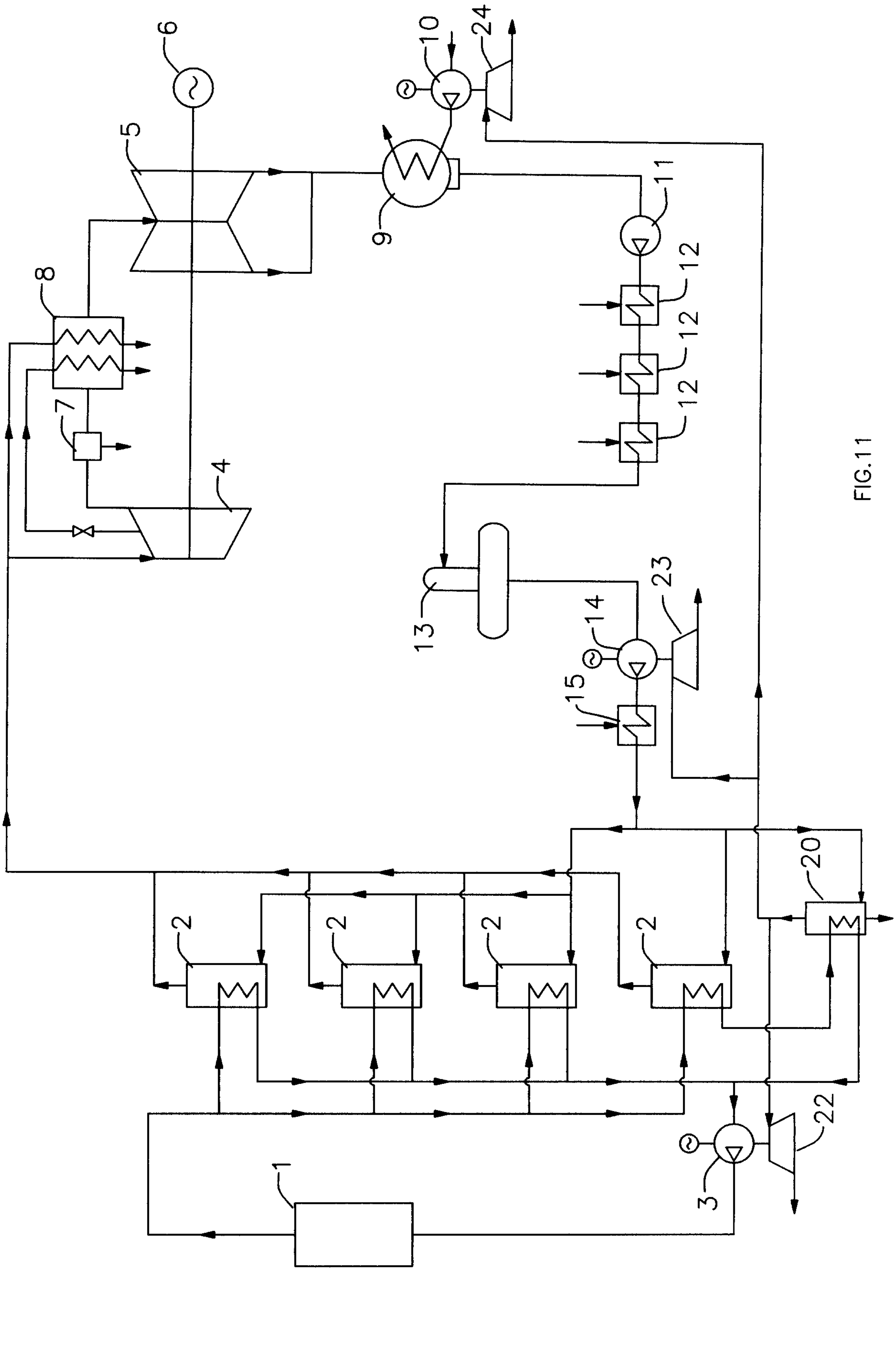


FIG.11

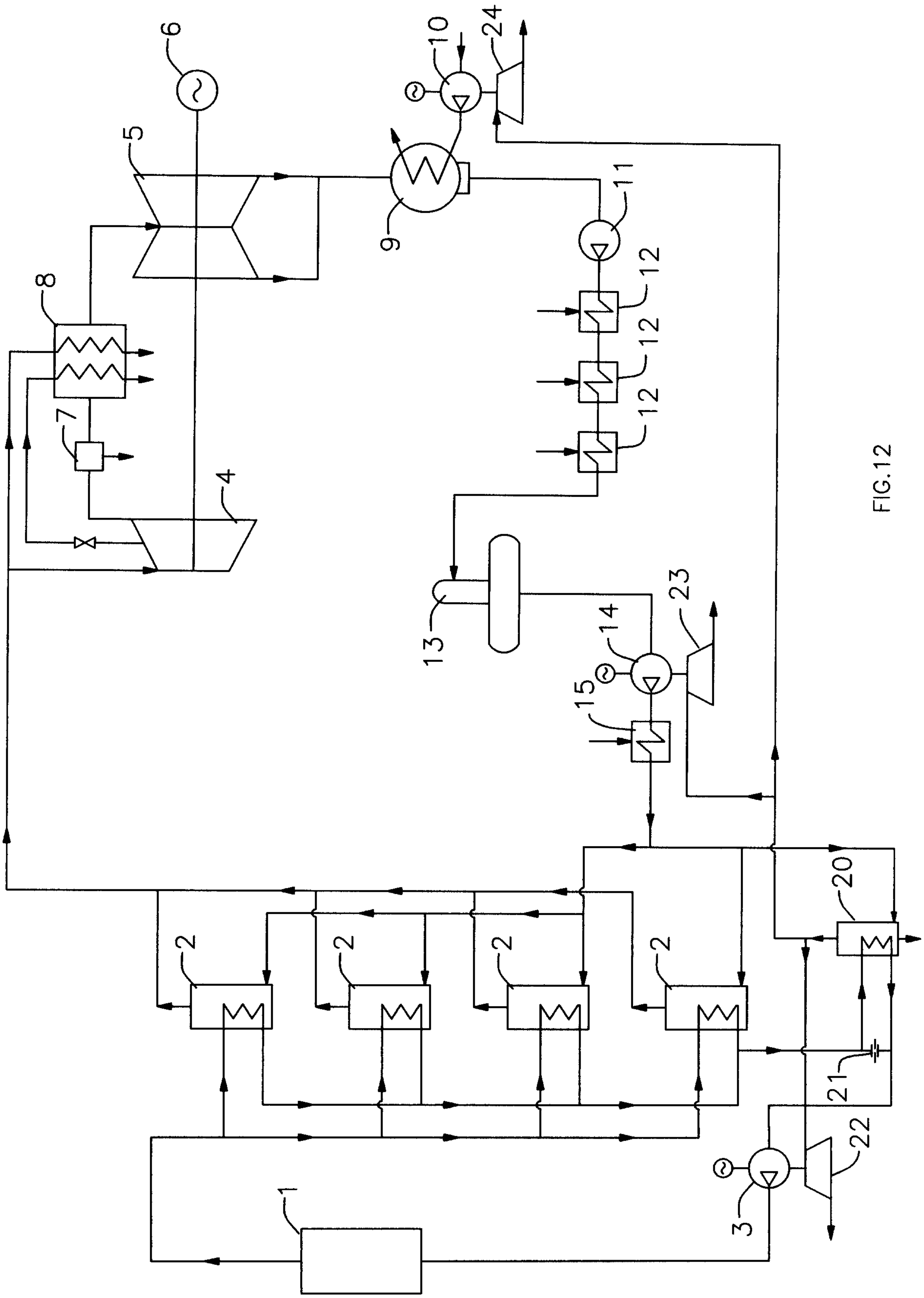
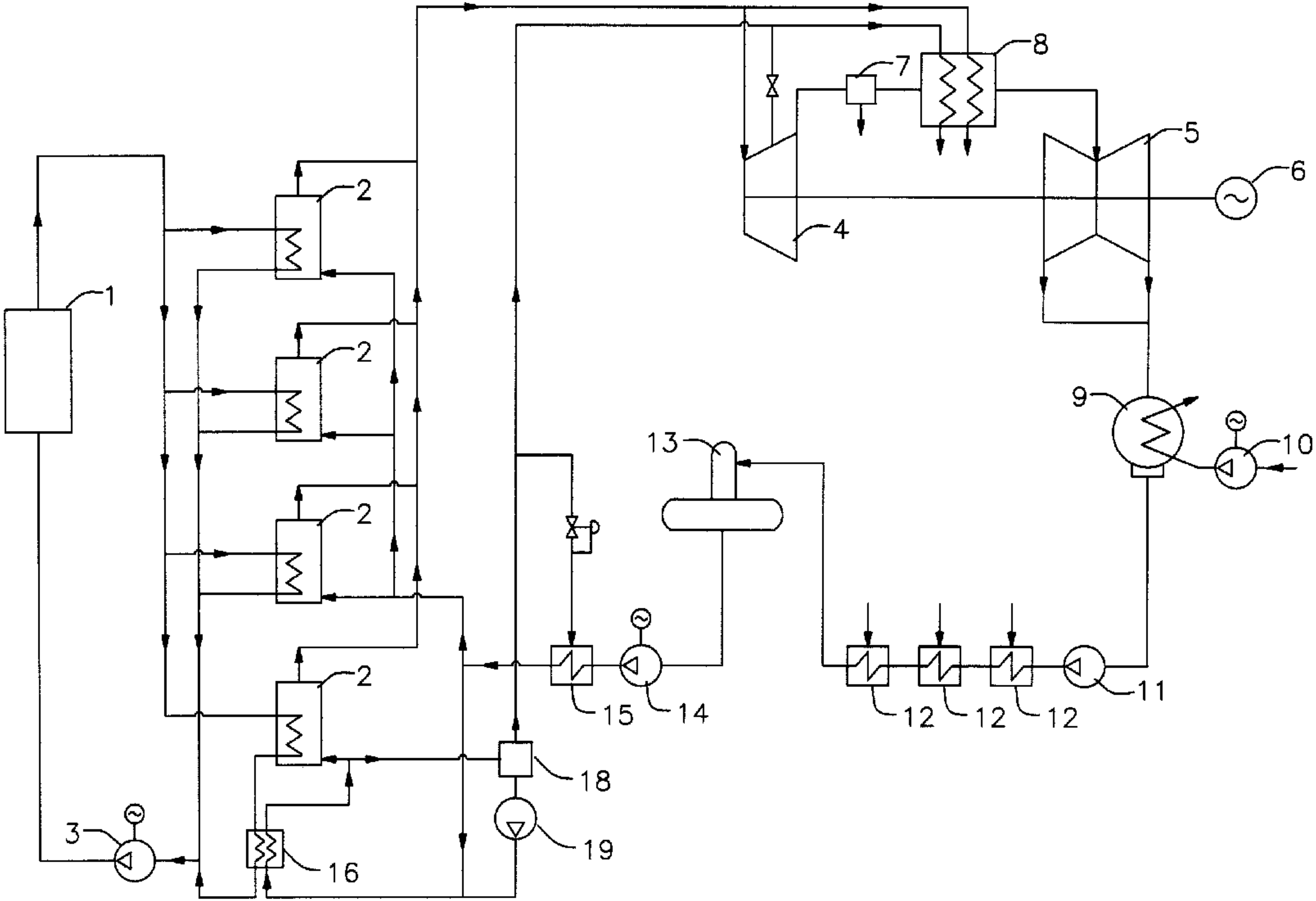


FIG.12



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