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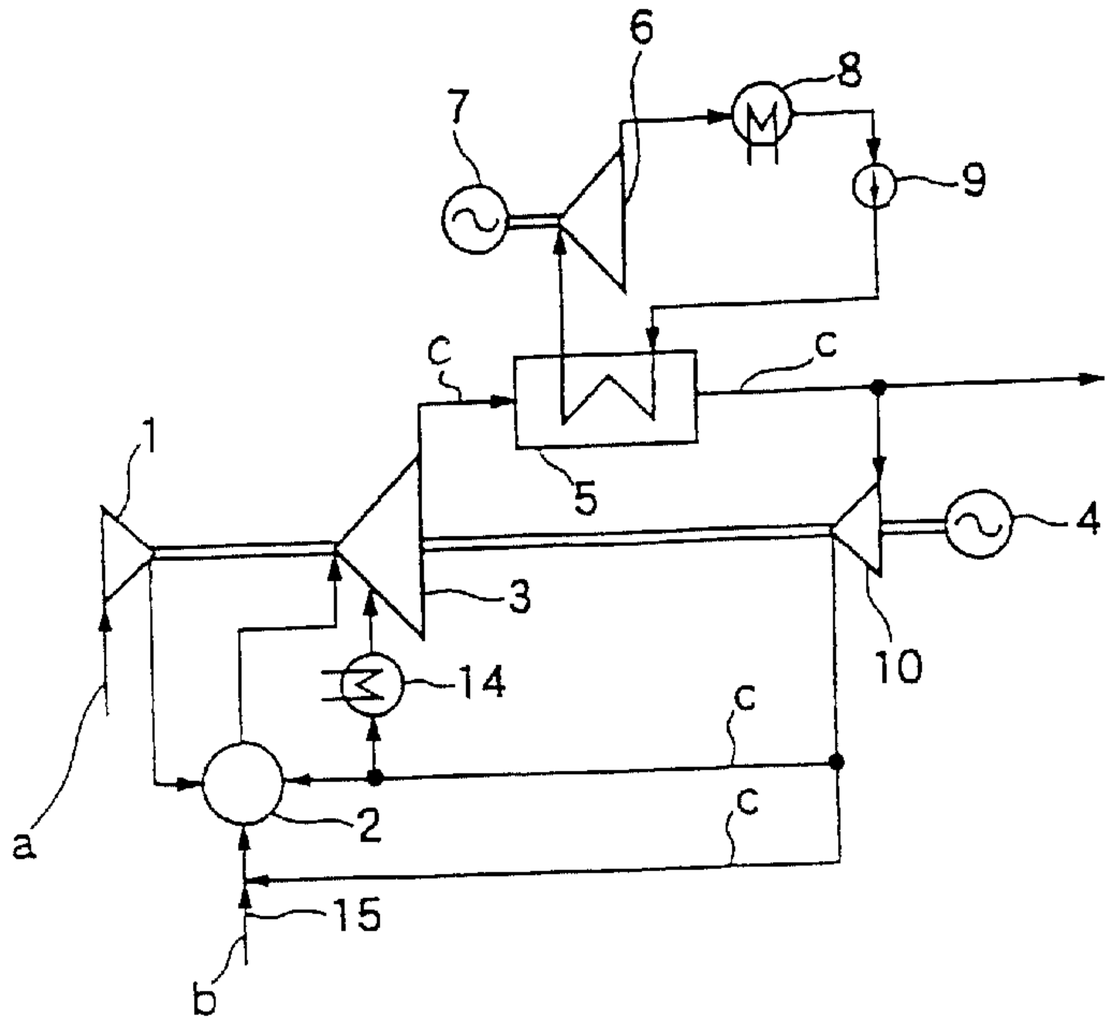
(54) **TURBINE A GAZ AVEC INSTALLATION COMBINEE**
(54) **GAS TURBINE SYSTEM AND COMBINED PLANT COMPRISING THE SAME**



(57) Gas turbine system and combined plant comprising same provide higher effect in realizing high efficiency of plant and reduction of NOx generation. The gas turbine system comprising compressor (1) for compressing combustion air, combustor (2) for burning fuel with the combustion air and gas turbine (3) driven by high temperature gas generated at the combustor (2) is constructed such that portion of exhaust gas discharged from the gas turbine (3) is circulated into the combustor (2). The combined plant comprising the gas turbine system is also provided.

ABSTRACT

Gas turbine system and combined plant comprising same provide higher effect in realizing high efficiency of plant and reduction of NOx generation. The gas turbine system comprising compressor (1) for compressing combustion air, combustor (2) for burning fuel with the combustion air and gas turbine (3) driven by high temperature gas generated at the combustor (2) is constructed such that portion of exhaust gas discharged from the gas turbine (3) is circulated into the combustor (2). The combined plant comprising the gas turbine system is also provided.

GAS TURBINE SYSTEM AND COMBINED PLANT COMPRISING THE SAME

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a high efficiency gas turbine system and a combined plant comprising this gas turbine system.

2. Description of the Prior Art

One example of a gas turbine system and a combined plant comprising this gas turbine system in the prior art will be described with reference to Fig. 3. Fig. 3 shows a main construction of a prior art example of a combined plant comprising a gas turbine system and a steam turbine.

In Fig. 3, combustion air a is compressed at a compressor 01 and is then mixed with fuel b at a combustor 02 to effect a combustion for generating a high temperature combustion gas. This high temperature combustion gas drives a gas turbine 03 to expand and is then supplied into an exhaust gas boiler 05 as exhaust gas c for generating steam there.

A high temperature high pressure steam generated at the exhaust gas boiler 05 drives a steam turbine 06 to expand and is then condensed at a condenser 08. Pressure of the condensed water is elevated by a feed water pump 09 so that the condensed water is circulated into the exhaust gas boiler 05.

A generator 04 is fitted to the gas turbine 03 and another generator 07 is fitted to the steam turbine 06 and so the

construction is made such that work each of the turbines 03, 06 may be taken out.

In the combines plant as so constructed, there is currently a high demand for realizing a higher efficiency thereof. Especially, for a gas turbine system which constitutes a first stage portion of the combined plant to effect a high temperature combustion of the fuel, further enhancement of the efficiency and reduction of NOx generation are both demanded. Also, in case the gas turbine system comprises a gas turbine unit only, enhancement of the efficiency and reduction of NOx generation are likewise demanded.

SUMMARY OF THE INVENTION

In view of the mentioned high demand for realizing a higher efficiency and a further reduction of NOx generation in the gas turbine system and the combined plant comprising the same in the prior art, it is an object of the present invention to provide a more effective gas turbine system and combined plant comprising the same.

In order to achieve the mentioned object, the present invention provides means of the following (1) to (5);

(1) A gas turbine system comprising a compressor for compressing combustion air, a combustor for burning fuel with the combustion air and a gas turbine driven by a high temperature gas generated at the combustor, characterized in that the gas turbine system is constructed such that a portion of exhaust gas discharged from the gas turbine is circulated into the combustor.

According to the means of (1) above, while, in the conventional

gas turbine system, the combustion gas has a high excess air ratio due to limitation in the turbine inlet temperature and the exhaust gas has a high oxygen concentration, in the present invention, a portion of the exhaust gas is circulated into the combustor and thereby the oxygen concentration in the exhaust gas can be reduced, exhaust loss of the gas turbine system is reduced largely and generation of NOx is also reduced. Further, as the exhaust gas to be circulated into the combustor has a high steam concentration, work output of the gas turbine is increased because of physical property of the high steam concentration.

(2) A gas turbine system as mentioned in (1) above, characterized in that the gas turbine system further comprises an exhaust gas compressor and is constructed such that the portion of exhaust gas is pressurized by the exhaust gas compressor to be partly circulated into the combustor and to be partly mixed into the fuel before the fuel is supplied into the combustor.

According to the means of (2) above, while, in the conventional gas turbine system, the combustion gas has a high excess air ratio due to limitation in the turbine inlet temperature and the exhaust gas has a high oxygen concentration, in the present invention, the exhaust gas is circulated into the combustor and thereby the excess air ratio of the combustion gas can be made lower. Hence, oxygen concentration in the exhaust gas can be reduced and exhaust loss of the gas turbine system can be reduced largely.

Also, the exhaust gas of the low oxygen concentration and the fuel are mixed together before the fuel is supplied into the combustor so that a low BTU gas may be formed and this low BTU gas

is mixed with air to burn. Hence, flame temperature can be maintained lower and NOx generation quantity can be reduced.

Moreover, the exhaust gas circulated into the combustor or the fuel has a high steam concentration, work output of the gas turbine is increased because of physical property of the high steam concentration.

(3) A gas turbine system as mentioned in (2) above, characterized in that the exhaust gas so pressurized by the exhaust gas compressor is used as cooling gas of the gas turbine.

According to the means of (3) above, in addition to the feature of the means of (2) above, the exhaust gas pressurized by the exhaust gas compressor is made use of as cooling medium of the gas turbine and as the exhaust gas has a high steam and CO_2 gas concentration, a high cooling effect can be obtained because of physical property of the high steam and CO_2 gas concentration.

(4) A gas turbine system as mentioned in (1) above, characterized in that the gas turbine system further comprises a condenser through which the exhaust gas passes so that water content in the exhaust gas may be condensed and the portion of exhaust gas is the water content in the exhaust gas so condensed at the condenser.

According to the means of (4) above, in case the combustion gas in the combustor has an excessively high temperature even if the excess air ratio is set to a lower level, water injection or steam injection is effected using the water content in the exhaust gas to be circulated into the combustor so that a predetermined turbine inlet temperature may be obtained and the excess air ratio of the

combustion gas may be reduced, and thereby oxygen concentration in the exhaust gas can be reduced and exhaust loss can be reduced largely, as compared with the conventional gas turbine system.

Also, flame temperature and oxygen concentration in the combustor can be maintained lower and thereby NOx generation quantity can be reduced.

Moreover, water content concentration in the combustion gas becomes higher and thereby work output of the gas turbine is increased because of physical property of the higher water content concentration.

It is to be noted that if the oxygen concentration in the exhaust gas is maintained lower, then necessarily steam concentration in the exhaust gas becomes higher and hence the water content in the exhaust gas can be recovered easily at the condenser and thereby the water injection or steam injection becomes possible without a make-up water.

(5) A combined plant comprising the gas turbine system as mentioned in any one of (1) to (4) above.

According to the means of (5) above, a combined plant having the feature of the gas turbine system mentioned in any one of the means of (1) to (4) above can be obtained and a combined plant having a high efficiency and a low NOx generation as a whole can be realized.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an explanatory view of a gas turbine system and a combined plant comprising the same as a first embodiment according

to the present invention.

Fig. 2 is an explanatory view of a gas turbine system and a combined plant comprising the same as a second embodiment according to the present invention.

Fig. 3 is an explanatory view of a gas turbine system and a combined plant comprising the same in the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A gas turbine system and a combined plant comprising the same as a first embodiment according to the present invention will be described with reference to Fig. 1.

Fig. 1 shows a main construction of the combined plant comprising the gas turbine system as the first embodiment. In Fig. 1, numeral 1 designates a compressor for compressing combustion air a. A gas turbine 3, an exhaust gas compressor 10 and a generator 4 are fitted coaxially to the compressor 1. The combustion air a compressed at the compressor 1 is mixed with fuel b at a combustor 2 to effect a combustion for generating a high temperature combustion gas. This high temperature combustion gas drives the gas turbine 3 to expand and is then discharged as exhaust gas c.

Numeral 5 designates an exhaust gas boiler for recovering waste heat of the exhaust gas c. A high temperature high pressure steam generated at the exhaust gas boiler 5 drives a steam turbine 6 to expand and is then condensed at a condenser 8. Pressure of the condensed water is elevated by a feed water pump 9 so that the condensed water is circulated into the exhaust gas boiler 5.

About a half quantity of the exhaust gas c coming out of the

exhaust gas boiler 5 diverges into the exhaust gas compressor 10 to be compressed. A portion of so compressed exhaust gas c is led into the combustor 2 as dilution gas, a portion of the same is led into a cooler 14 to be cooled (or is led as it is) to be further led into the gas turbine 3 as cooling medium of the gas turbine 3 and the remaining portion of the same flows through a supply pipe 15 of the fuel b to join in the fuel b of gas or liquid before the fuel b is supplied into the combustor 2, so that a low BTU gas may be formed.

The generator 4 is fitted to the gas turbine 3 and a generator 7 is fitted to the steam turbine 6 and so the construction is made such that work each of the turbines 3, 6 may be taken out.

In the conventional gas turbine system, the combustion gas has an excess air ratio of 2.6 or more due to limitation in the turbine inlet temperature and hence oxygen concentration in the exhaust gas is as high as 13% or more, but in the present embodiment as mentioned above, the exhaust gas c circulates into the combustor 2 and thereby the combustion gas can be made to have the excess air ratio of about 1.1 and the oxygen concentration in the exhaust gas can be made to about 2%. It is to be noted that the oxygen concentration in the exhaust gas is preferably 10% or less, or more preferably 5% or less. Further, if the oxygen concentration in the exhaust gas is reduced, then it will also suppress a generation of NOx.

By the matter mentioned above, while exhaust loss in the conventional gas turbine system has been about 13%, the exhaust loss in the gas turbine system of the present embodiment can be reduced to about a half thereof and this results in enhancement by about

7% of a thermal efficiency of the combined plant as a whole.

Further, the exhaust gas c of the low oxygen concentration and the fuel b of gas or liquid are mixed together before the fuel b is supplied into the combustor 2 so that a low BTU gas of about 1000 Kcal/Nm^3 may be formed and this low BTU gas is mixed with air to burn and thereby flame temperature can be maintained lower even in a diffusion type combustor and NOx generation quantity can be reduced to 10 ppm or less.

Moreover, the exhaust gas c circulating into the combustor 2 through the supply pipe 15 of the fuel b has a high steam concentration and work output of the turbine can be increased because of physical property of the high steam concentration.

Also, a portion of the exhaust gas c, as cooled (or as it is), is made use of as cooling medium of the gas turbine and the exhaust gas c has a high steam and CO_2 concentration. Hence, because of physical property thereof, a high cooling effect can be obtained.

A gas turbine system and a combined plant comprising the same as a second embodiment according to the present invention will be described with reference to Fig. 2.

Fig. 2 shows a main construction of the combined plant comprising the gas turbine system as the second embodiment. In Fig. 2, numeral 101 designates a compressor for compressing combustion air a. A gas turbine 103 and a generator 104 are fitted coaxially to the compressor 101. The combustion air a compressed at the compressor 101 is mixed with fuel b at a combustor 102 to effect a combustion for generating a high temperature combustion gas. This high temperature combustion gas drives the gas turbine 103 to

expand and is then discharged as exhaust gas c.

Numeral 105 designates an exhaust gas boiler for recovering waste heat of the exhaust gas c. A high temperature high pressure steam generated at the exhaust gas boiler 105 drives a steam turbine 106 to expand and is then condensed at a condenser 108. Pressure of the condensed water is elevated by a feed water pump 109 so that the condensed water is circulated into the exhaust gas boiler 105.

The exhaust gas c coming out of the exhaust gas boiler 105 heats injection water d, to be described below, at a feed water heater 111 and then passes through a condenser 112 so that water content in the exhaust gas c is condensed and separated. Pressure of the condensed water is elevated by a pump 113 and then the condensed water is heated at the feed water heater 111. The condensed water so pressure-elevated and heated is sent to the combustor 102 of th gas turbine 103 to be used as injection water d, which is injected into the combustor 102.

As the combustion gas generated at the combustor 102 has an excessively high temperature even if excess air ratio thereof is set to about 1.1, water injection or steam injection is effected into the combustor 102 using the injection water d and thereby the temperature of the combustion gas is set to a predetermined gas turbine inlet temperature and, at the same time, the excess air ratio of the combustion gas can be reduced.

It is to be noted that the generator 104 is fitted to the gas turbine 103 and a generator 107 is fitted to the steam turbine 106 and so the construction is made such that work each of the turbines 103, 106 may be taken out.

In the present embodiment as mentioned above, the water content in the exhaust gas c is circulated to the combustor 102 to be water-injected or steam-injected thereinto and thereby the combustion gas can be made to have excess air ratio of about 1.1 and oxygen concentration in the exhaust gas can be made as low as about 2%. Hence, as compared with the conventional gas turbine system, exhaust loss becomes smaller and thermal efficiency of the entire combined plant can be enhanced. It is to be noted that the oxygen concentration in the exhaust gas is preferably 10% or less, or more preferably 5% or less. Further, if the oxygen concentration in the exhaust gas is reduced, then it will also suppress a generation of NOx.

If the oxygen concentration in the exhaust gas c is maintained lower, then necessarily steam concentration in the exhaust gas c becomes higher and hence the water content in the exhaust gas c can be recovered easily at the condenser 112 and thereby the water injection or steam injection becomes possible without a make-up water.

Also, flame temperature and oxygen concentration in the combustor 102 can be maintained lower by the water injection or steam injection using the injection water d and hence NOx generation quantity can be reduced.

Furthermore, because of physical property of the high water content concentration in the exhaust gas, work output of the gas turbine 103 can be increased and the exhaust gas temperature also can be maintained higher.

That is, the gas turbine 103 of the present embodiment is such

a gas turbine as uses not only the conventional combustion gas but also a high temperature steam as working medium and thus it has advantages both of the conventional gas turbine and steam turbine.

In the above, while the invention has been described based on the embodiments as illustrated, the invention is not limited thereto but, needless to mention, may be added with various modifications in the concrete construction thereof within the scope of the claims as appended herebelow.

For example, while the gas turbine system employed in the combined plant has been described in either of the embodiments, the gas turbine system of the present invention may be employed with the same function and effect in a plant having a gas turbine only without an exhaust gas boiler or a steam turbine.

WHAT IS CLAIMED IS:

1. A gas turbine system comprising a compressor (1, 101) for compressing combustion air (a), a combustor (2, 102) for burning fuel (b) with said combustion air (a) and a gas turbine (3, 103) driven by a high temperature gas generated at said combustor (2, 102), characterized in that said gas turbine system is constructed such that a portion of exhaust gas discharged from said gas turbine (3, 103) is circulated into said combustor (2, 102).

2. A gas turbine system as claimed in Claim 1, characterized in that said gas turbine system further comprises an exhaust gas compressor (10) and is constructed such that said portion of exhaust gas is pressurized by said exhaust gas compressor (10) to be partly circulated into said combustor (2) and to be partly mixed into said fuel (b) before said fuel (b) is supplied into said combustor (2).

3. A gas turbine system as claimed in Claim 2, characterized in that the exhaust gas so pressurized by said exhaust gas compressor (10) is used as cooling gas of said gas turbine (3).

4. A gas turbine system as claimed in Claim 1, characterized in that said gas turbine system further comprises a condenser (112) through which said exhaust gas passes so that water content in said exhaust gas may be condensed and said portion of exhaust gas is said water content in the exhaust gas so condensed at said condenser (112).

5. A combined plant comprising the gas turbine system as claimed in any one of Claims 1 to 4.

Fig. 1

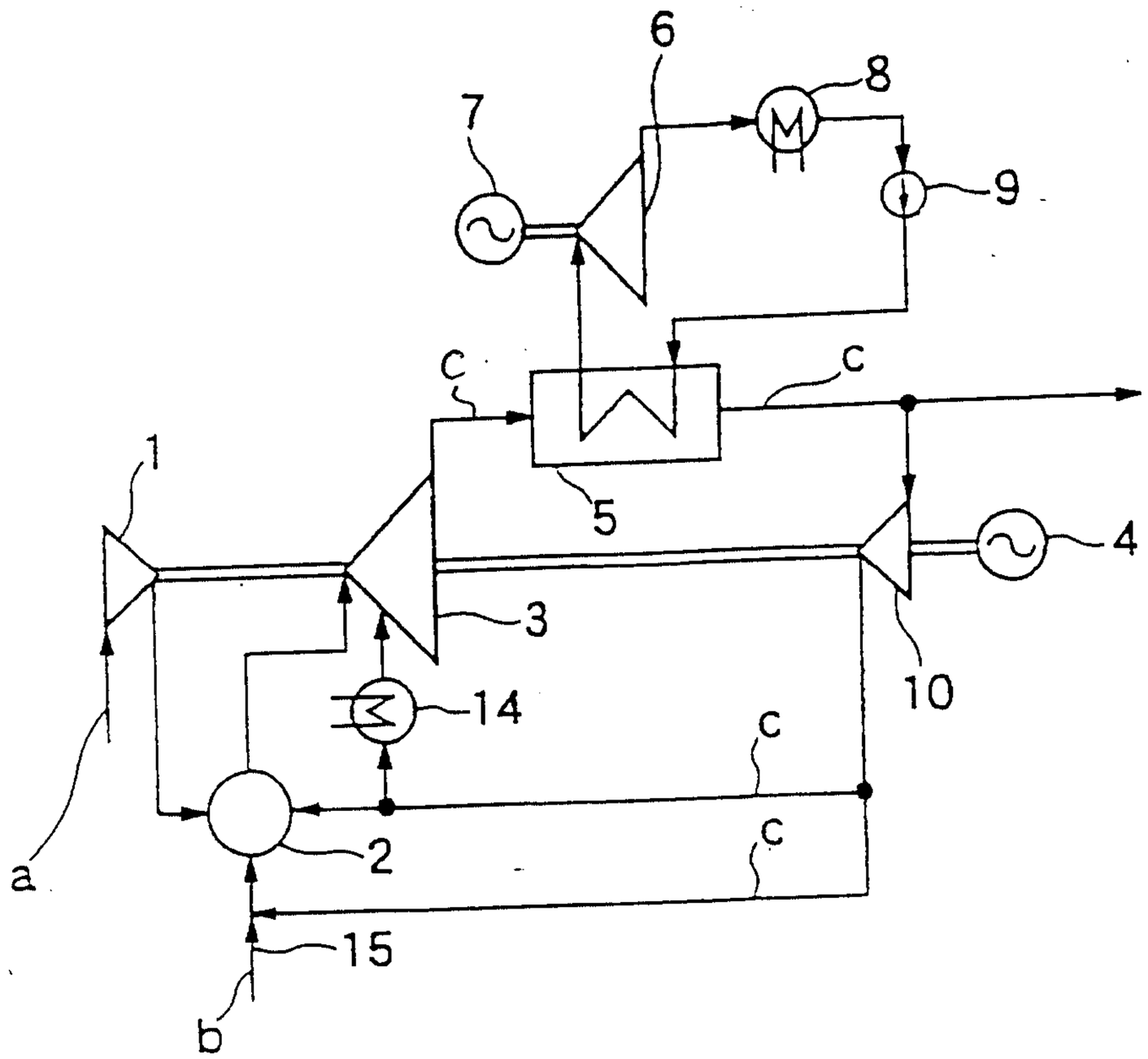

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Fig. 2

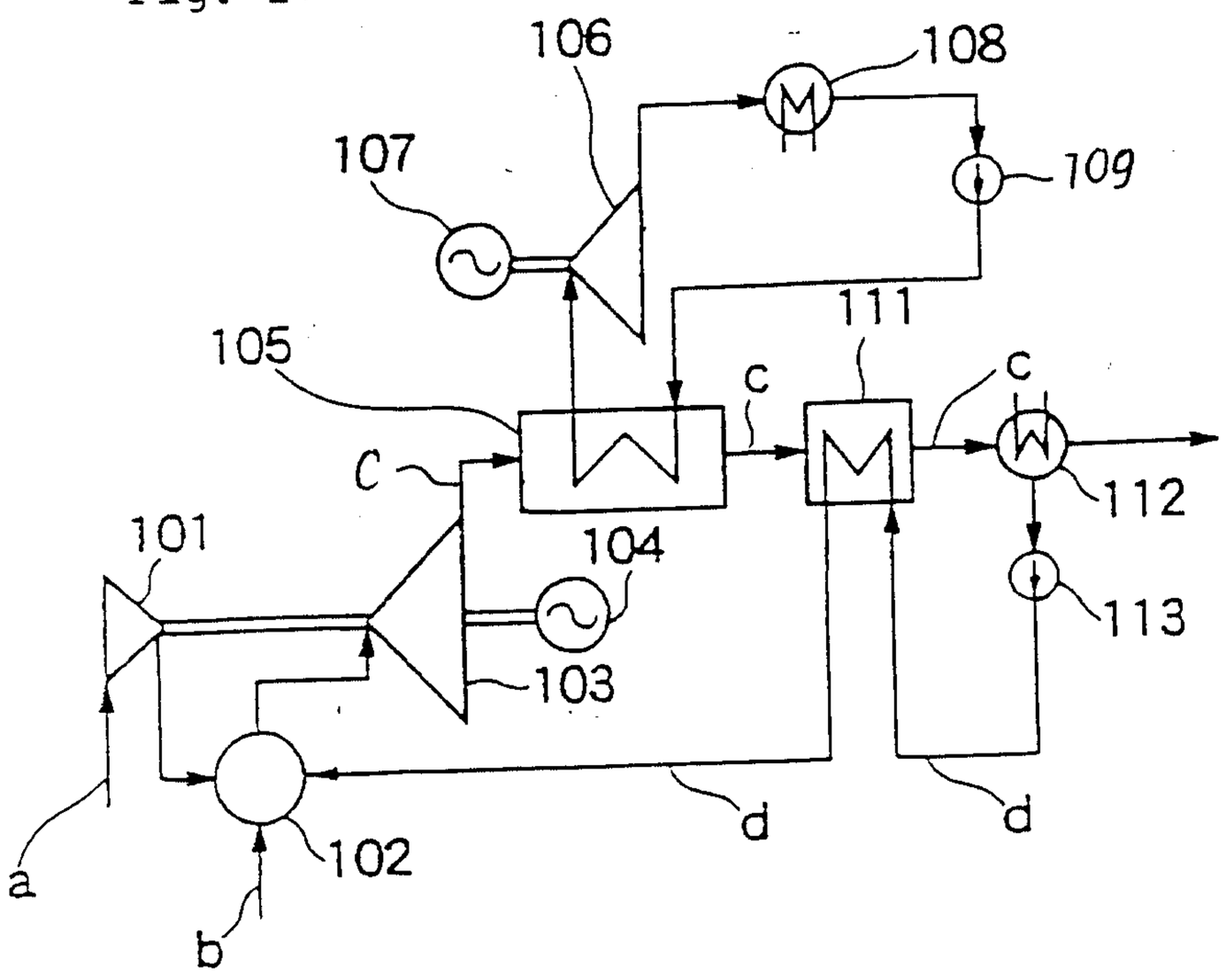
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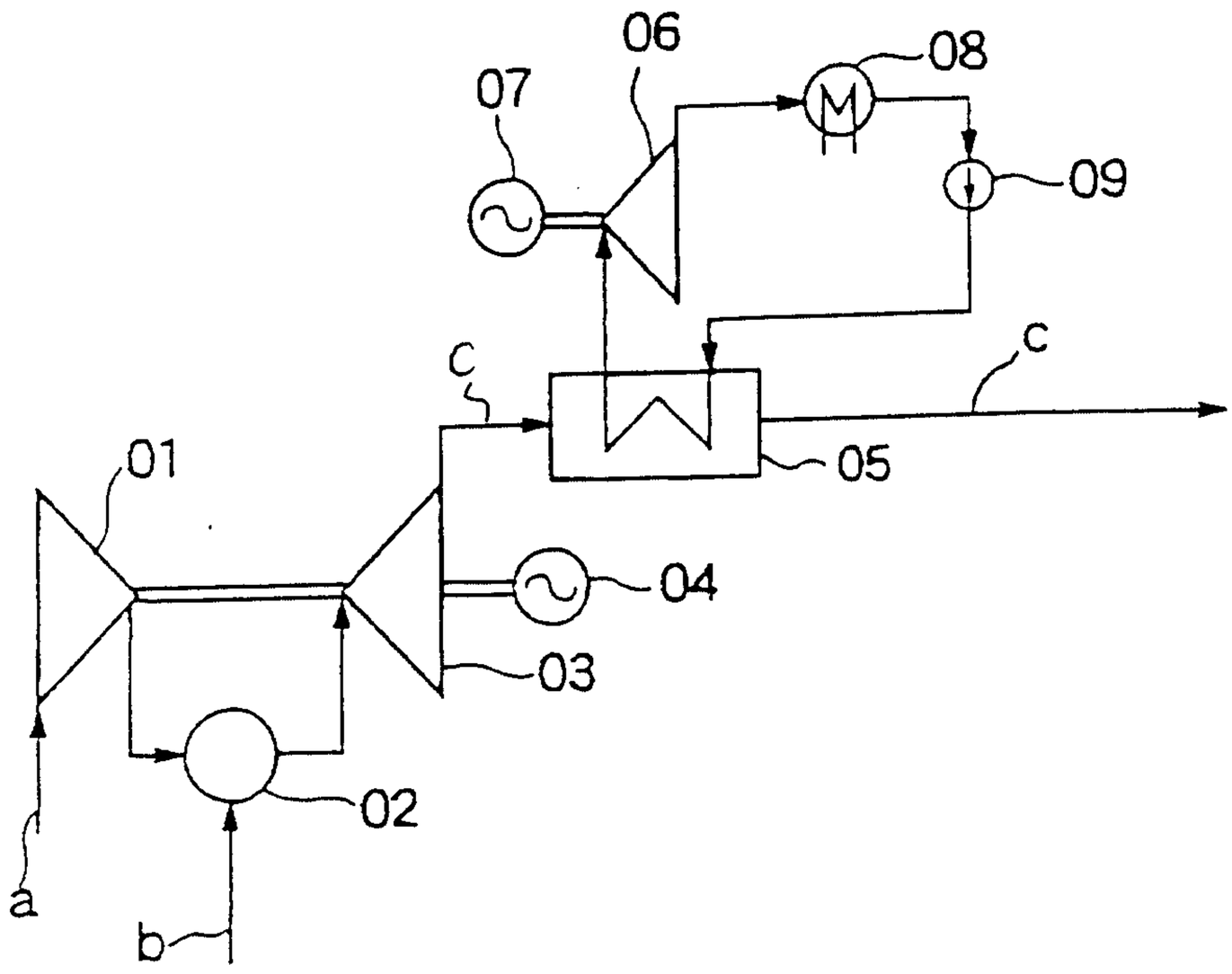
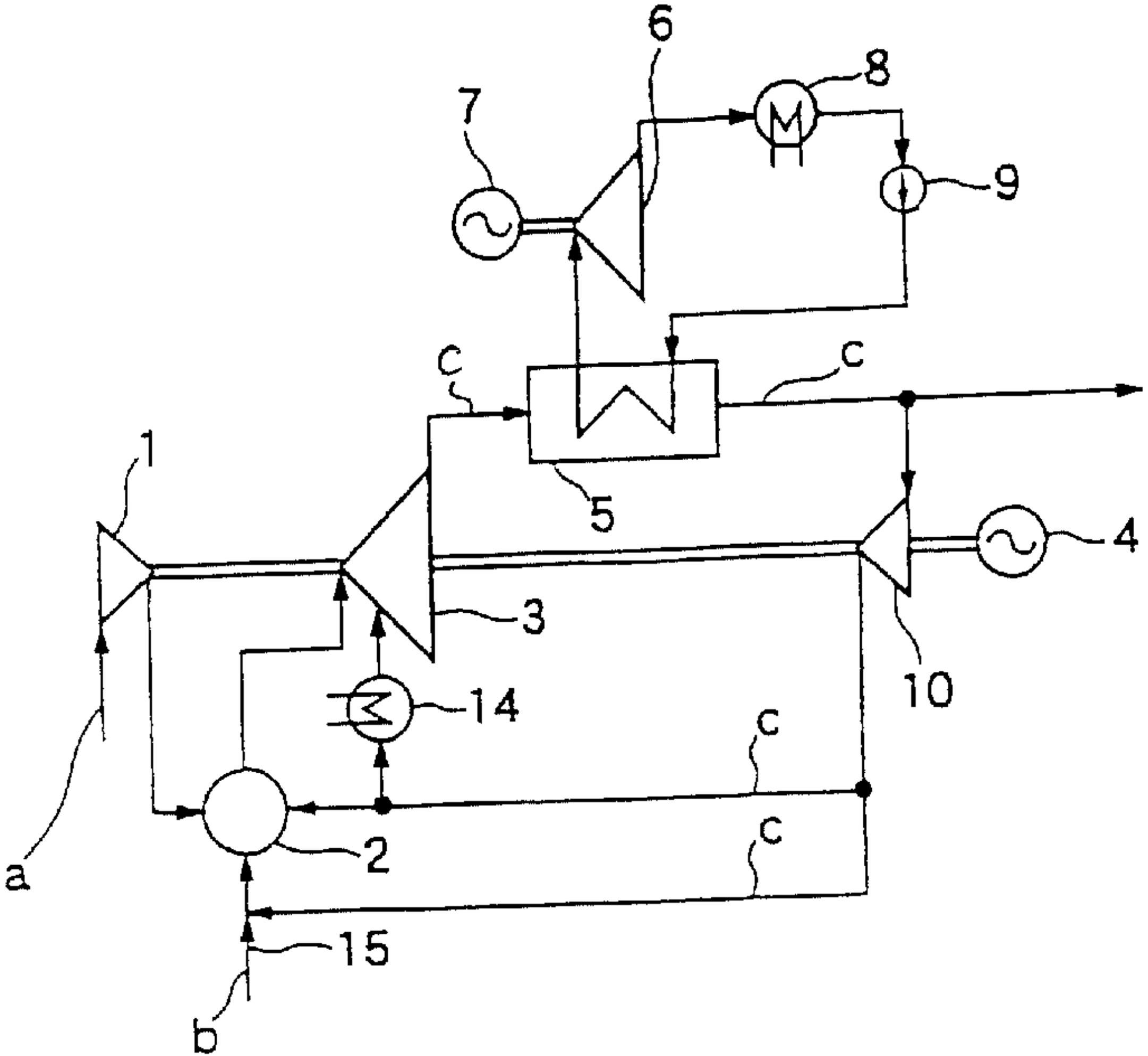
Fig. 3

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