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(71) Applicant: **MITSUBISHI JUKOGYO KABUSHIKI
KAISHA
Tokyo (JP)**

(72) Inventors:
• **Arakawa, Yoshihisa,**
c/o Mitsubishi Jukogyo K.K.
Tokyo (JP)
• **Nagai, Masaaki,**
c/o Mitsubishi Jukogyo K.K.
Tokyo (JP)

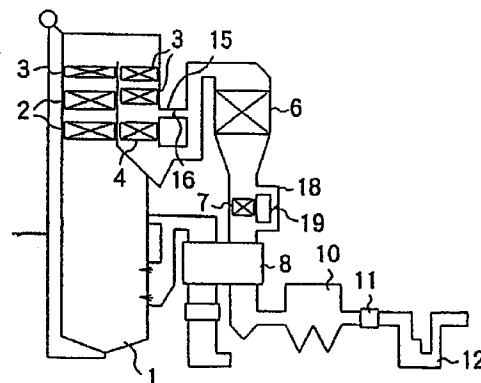
(74) Representative: **Henkel, Feiler, Hänzel & Partner
Möhlstrasse 37
81675 München (DE)**

(54) Boiler with denitrification apparatus

(57) Object: In a boiler firing heavy oil etc., to make the operational temperature of a denitrification apparatus appropriate as well as to make the gas temperature of an air preheater and an electrostatic precipitator appropriate so that a long term continuous and stable operation is made possible.

Construction: An economizer being divided into a high temperature economizer (4) and a low temperature economizer (7) disposed, respectively, on the upstream side and on the downstream side of a denitrification apparatus is provided so that the denitrification apparatus (6) can be operated at an appropriate operational temperature. Further, a by-pass duct (15,18) is provided to either or both of the high temperature economizer (4) and the low temperature economizer (7) so that the gas temperature of the denitrification apparatus (6), an air preheater and an electrostatic precipitator (10) is made appropriate.

Fig. 6



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Description

BACKGROUND OF THE INVENTION:

Field of the Invention:

The present invention relates to a boiler firing a heavy oil (including high viscosity residual oil, super heavy oil (Orinoco oil, for example) and water emulsion fuel), etc.

Description of the Prior Art:

Heavy oil contains a high amount of nitrogen content and sulfur content as compared with the usual C fuel oil. For this reason, in order to use such heavy oil for boilers under the environment regulations, there are many cases where installation of a denitrification apparatus or a desulfurization apparatus is required for reducing NOx density or SOx density in the flue gas.

Fig. 7 shows a diagrammatic view of a heavy oil firing boiler in the prior art, wherein numeral 1 designates a furnace, and on the downstream side of the furnace 1, there are provided a superheater 2, a reheater 3, an economizer 4A, a denitrification apparatus 6, an air preheater 8, an electrostatic precipitator 10, a gas-gas heater 11 and a desulfurization apparatus 12, in turn. Numeral 15A designates an economizer gas by-pass duct and numeral 16A designates a flow regulating damper interposed in the economizer gas by-pass duct 15A.

In the denitrification apparatus employed for such construction, it is a main tendency to use a dry type catalytic reduction process for a problem of NOx removal efficiency etc., but if heavy oil is fired, as a high amount of SOx is contained in the flue gas, in case the flue gas temperature becomes low for reason of a partial load etc., there is a fear of lowering of catalyst activation due to generation of ammonium hydrogen-sulfate etc., hence a method to maintain the denitrification apparatus within an appropriate temperature range by making a gas by-pass of a portion of the flue gas entering the economizer is employed.

In addition to the fact that heavy oil contains a high amount of nitrogen content and sulfur content as compared with the usual C fuel oil, due to its high residual carbon, soot and dust generated by combustion tends to become a large amount also. For this reason, progress of dirt on the heating surface is very quick and in some cases the flue gas temperature rises sharply after starting of operation, thus it is necessary to pay attention to thermal resistance of NOx removal catalysts, design temperature of each portion, etc.

Further, heavy oil contains a high amount of heavy metals, such as vanadium, nickel, etc. and in a heavy oil firing boiler having a denitrification apparatus, a vanadium compound, in addition to SO₃ generated at the combustion zone, covers the surface of NOx removal catalysts so as to act as an oxidation catalyst, thus con-

version ratio of SOx to SO₃ becomes also higher.

This reaction tends to be more accelerated as the gas temperature becomes higher and yet if SO₃ density becomes higher, low temperature corrosions or blockades of the air preheater, or increase of soot and dust at the inlet of the electrostatic precipitator, etc. occur, hence in order to avoid troubles of machinery and equipment on the downstream side also, it is necessary to suppress the operational temperature of the denitrification apparatus approximately to 40°C.

But in case of the steam temperature being high, additives like a magnesium group etc. are often injected as a countermeasure to prevent high temperature corrosions of the superheater or the reheater, and due to dirt of the furnace surface, the heat absorption becomes lowered so that the gas temperature at the furnace outlet becomes high, thus the gas temperature of each portion is liable to be elevated.

On the other hand, if the gas temperature at the inlet of the denitrification apparatus becomes too low, ammonium hydrogen-sulfate is generated, as mentioned above, so that a problem of lowering of catalyst activation etc. occurs, hence it is necessary to maintain the gas temperature higher than approximately 360°C.

Accordingly, in a heavy oil firing boiler, as the range of the appropriate flue gas temperature is as narrow as approximately 360°C to 400°C, how to control this gas temperature, taking into account of the time passing or aging changes also, is important for a continuous stable operation.

Such problems as mentioned above exist likewise in respect to the gas temperature at the inlet of the electrostatic precipitator also. In a heavy oil firing boiler, as SO₃ density in the flue gas is high, an air heater of regenerative type is usually employed and elements of high corrosion resistant materials and of such shapes as having good effects for soot blowing are employed as a countermeasure for low temperature corrosions or blockades, but it is still necessary to operate the metal temperature on the low temperature side at a temperature considerably higher than in the C fuel oil firing, or to install a steam type air preheater additionally. Accompanying therewith, the flue gas temperature also becomes high, and if it exceeds approximately 180°C, the ammonium injected at the inlet of the electrostatic precipitator for SO₃ removal is resolved to generate an ammonium hydrogen sulfate of low melting temperature, thereby ash clogging or corrosion, or in some cases a charging obstruction, might be caused, hence the elevation of the flue gas temperature as time passes must be suppressed as much as possible.

In the construction of the above-mentioned heavy oil firing boiler in the prior art, as the allotment of the heat recovery at the economizer 4A and the air preheater 8 is decided by the operational temperature of the denitrification apparatus 6, in case of the flue gas temperature being lowered due to a partial load etc., it is possible to maintain the denitrification apparatus 6 at a most suitable operational temperature by letting a par-

tial gas by-pass the economizer, but in case of elevation of the operational temperature, there is no means other than strengthening of soot blowing on the heating surface, etc.

Further, as the installation temperature of the denitrification apparatus 6 is comparatively high and the heat recovery proportion of the air preheater 8 thus becomes larger, the temperature effectiveness also becomes high and the heating area of the air preheater tends to be increased. In respect of elevation of the gas temperature at the inlet of the electrostatic precipitator 10 also, countermeasures are being taken by lowering the metal temperature on the low temperature side of the air preheater 8 in fear of low temperature corrosions or blockades.

Thus, in the construction of the heavy oil firing boiler in the prior art, as shown by the dashed line in Fig. 3, in case of elevation of the flue gas due to dirt of the furnace or the heating surface, no control being able, the boiler is operated with a lowered load or there is occasionally such case that the boiler is unavoidably shut down within a short period of time.

SUMMARY OF THE INVENTION:

It is therefore an object of the present invention to provide a boiler which is able to dissolve the above-mentioned problems.

The present invention has following features:

(1) An economizer is divided into a high temperature economizer and a low temperature economizer disposed, respectively, on the upstream side and on the downstream side of a denitrification apparatus.

(2) In the boiler mentioned in (1) above, a duct by-passing said high temperature economizer is provided and a flow regulating damper is interposed in said duct.

(3) In the boiler mentioned in (1) or (2) above, a duct by-passing said low temperature economizer is provided and a flow regulating damper is interposed in said duct.

In the invention of (1) above, by the economizer being divided into the high temperature economizer and the low temperature economizer disposed, respectively, on the upstream side and on the downstream side of the denitrification apparatus, the denitrification apparatus can be operated at an optimized operational temperature and further the heat recovery proportion of the economizers and the air preheater can be selected without being influenced by the operational temperature of the denitrification apparatus, hence the temperature effectiveness of the air preheater can be maximized and economical operation becomes possible.

Further, in the invention of (2) above, by the duct by-passing the high temperature economizer being provided and the flow regulating damper being interposed

in said duct in addition to the invention of (1) above, the heating area of the high temperature economizer can be set in surplus based on the heat transfer coefficient taking account of dirt, and by the gas amount by-passing the high temperature economizer being regulated correspondingly to the degree of dirt of the high temperature economizer, the operational temperature of the denitrification apparatus, the gas temperature at the outlet of the air preheater and the gas temperature of the electrostatic precipitator can be maintained within an appropriate range, hence a long term continuous and stable operation becomes possible.

Furthermore, in the invention of (3) above, by the duct by-passing the low temperature economizer being provided and the flow regulating damper being interposed in said duct in addition to the invention of (1) or (2) above, the heating area of the low temperature economizer can be set in surplus based on the heat transfer coefficient taking account of dirt, and by the gas amount by-passing the low temperature economizer being regulated correspondingly to the degree of dirt of the low temperature economizer, the gas temperature at the outlet of the air preheater and the gas temperature at the outlet of the electrostatic precipitator can be maintained within an appropriate range, hence a long term continuous and stable operation becomes possible.

BRIEF DESCRIPTION OF THE DRAWINGS:

In the accompanying drawings:

Fig. 1 is a diagrammatic view of a boiler of a first preferred embodiment according to the present invention.

Fig. 2 is a diagrammatic view of a boiler of a second preferred embodiment according to the present invention.

Fig. 3 is a graph showing time passing changes of gas temperature at an inlet of a denitrification apparatus of heavy oil firing boilers.

Fig. 4 is a diagrammatic view of a boiler of a third preferred embodiment according to the present invention.

Fig. 5 is a graph showing time passing changes of gas temperature at an outlet of an air preheater of heavy oil firing boilers.

Fig. 6 is a diagrammatic view of a boiler of a fourth preferred embodiment according to the present invention.

Fig. 7 is a diagrammatic view of a heavy oil firing boiler in the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS:

A first preferred embodiment according to the present invention is described with reference to Fig. 1. This preferred embodiment relates to a modification, as

herebelow, of the boiler shown in Fig. 7, and same parts of Fig. 1 as those of Fig. 7 are designated by same numerals and description thereof is omitted.

In this preferred embodiment, the economizer is divided into that on the upstream side and that on the downstream side of the denitrification apparatus 6, that is, the economizer is divided into a high temperature economizer 4 and a low temperature economizer 7 and the high temperature economizer 4 is disposed on the upstream side of the denitrification apparatus 6 and the low temperature economizer 7 on the downstream side of same, respectively. Incidentally, the economizer by-pass duct 15A in the boiler shown in Fig. 7 is not provided.

In this preferred embodiment having the above-mentioned construction, as the heat recovery proportion of the low temperature economizer 7 and the air preheater 8 can be selected without being influenced by the operational temperature of the denitrification apparatus, the denitrification apparatus 6 can be maintained at an appropriate operational temperature and the temperature effectiveness of the air preheater can be maximized so that economical operation can be made.

A second preferred embodiment according to the present invention is described with reference to Fig. 2. In this preferred embodiment, in addition to the above-mentioned first preferred embodiment according to the present invention, the heating area of the high temperature economizer 4 is set in surplus, a high temperature economizer gas by-pass duct 15 by-passing said high temperature economizer 4 is provided and a flow regulating damper 16 is interposed in said high temperature economizer gas by-pass duct 15.

In this preferred embodiment, by the heating area of the high temperature economizer 4 on the upstream side of the denitrification apparatus 6 being selected in surplus taking account of the time passing dirt so that the temperature becomes lower than the operational temperature of the denitrification apparatus and by the by-passed high temperature gas being regulated of the flow rate and mixed into the inlet portion of the denitrification apparatus 6, the denitrification apparatus can be controlled at a temperature at which the right performance can be effected. Further, as shown by the line in Fig. 3, with respect to the time passing elevation also of the gas temperature due to the dirt of the heating surface, the elevation of the flue gas temperature can be suppressed by the effect of said surplus heating area of the high temperature economizer 4 and a long term continuous and stable operation can be made possible.

Further, as to the elevation of the gas temperature at the inlet of the electrostatic precipitator 10 also, it can be suppressed with same effect as mentioned above.

On the other hand, also in case of the flue gas temperature being lowered due to a partial load, by making a gas by-pass through said high temperature economizer by-pass duct 15, lowering of the flue gas temperature can be prevented and the denitrification apparatus 6 can be maintained at an appropriate operational tem-

perature.

A third preferred embodiment according to the present invention is described with reference to Fig. 4. In this preferred embodiment, in addition to said first preferred embodiment according to the present invention, the heating area of the low temperature economizer 7 is set in surplus, a low temperature economizer by-pass duct 18 by-passing said low temperature economizer 7 is provided and a flow regulating damper 19 is interposed in said low temperature economizer by-pass duct 18.

In this preferred embodiment, by the heating area of the low temperature economizer 7 on the downstream side of the denitrification apparatus 6 being set in surplus and by the gas flow by-passing the low temperature economizer 7 and flowing through the low temperature economizer by-pass duct 18 being regulated and mixed into the outlet portion of the low temperature economizer 7, as shown by the line in Fig. 5, the time passing elevation of the gas temperature at the outlet of the air preheater 8, or the gas temperature at the inlet of the electrostatic precipitator 18, due to the dirt of the heating surface of said low temperature economizer 7 can be suppressed by the effect of the surplus heating area of this low temperature economizer 7.

A fourth preferred embodiment according to the present invention is described with reference to Fig. 6. This preferred embodiment comprises a combination of a high temperature economizer 4 and a high temperature economizer by-pass duct 15 having a flow regulation damper 16, as in said second preferred embodiment according to the present invention, and a low temperature economizer 7 and a low temperature economizer by-pass duct 18 having a flow regulating damper 19, as in said third preferred embodiment according to the present invention.

Accordingly, in this preferred embodiment, there are functions and effects of said second preferred embodiment and said third preferred embodiment being combined, and the denitrification apparatus 6 can be controlled at a temperature at which the right performance can be effected and yet with respect to the time passing elevation of the gas temperature due to the dirt of the heating surface also, the elevation of the flue gas temperature can be suppressed by the effect of the surplus heating area of this high temperature economizer 4 and a long term continuous and stable operation can be made.

As described above, according to the present invention as having constructions mentioned in Claims 1 to 3, the denitrification apparatus can be operated in the range of the maximized operational temperature, the temperature of the air preheater and the electrostatic precipitator on the downstream side can be made appropriate and a long term continuous and stable operation can be made possible.

It is understood that the invention is not confined to the particular construction and arrangement of parts herein illustrated and described but embraces such

modified forms thereof as come within the scope of the following claims.

Claims

1. A boiler characterized in that an economizer is divided into a high temperature economizer 4 and a low temperature economizer 7 disposed, respectively, on the upstream side and on the downstream side of a denitrification apparatus 6.

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2. A boiler as claimed in Claim 1, characterized in that a duct 15 by-passing said high temperature economizer 4 is provided and a flow regulating damper 16 is interposed in said duct 15.

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3. A boiler as claimed in Claim 1 or Claim 2, characterized in that a duct 18 by-passing said low temperature economizer 7 is provided and a flow regulating damper 19 is interposed in said duct 18.

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Fig. 1

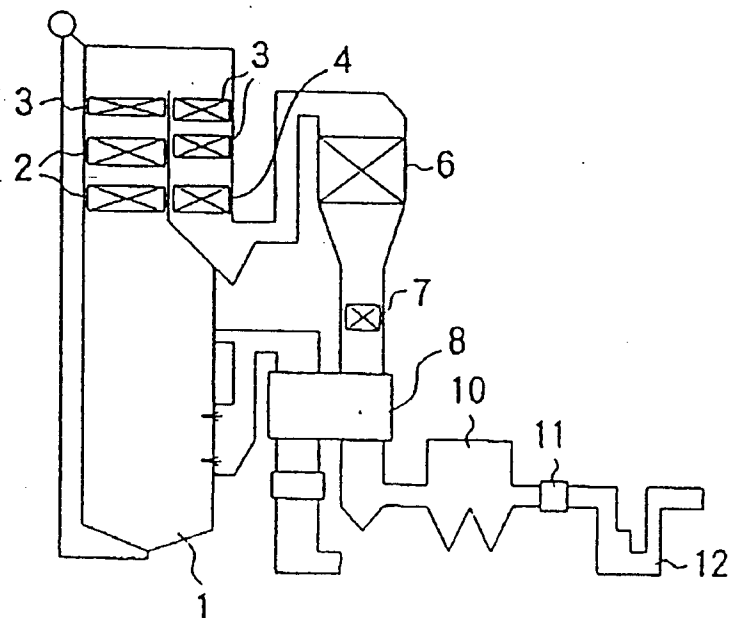


Fig. 2

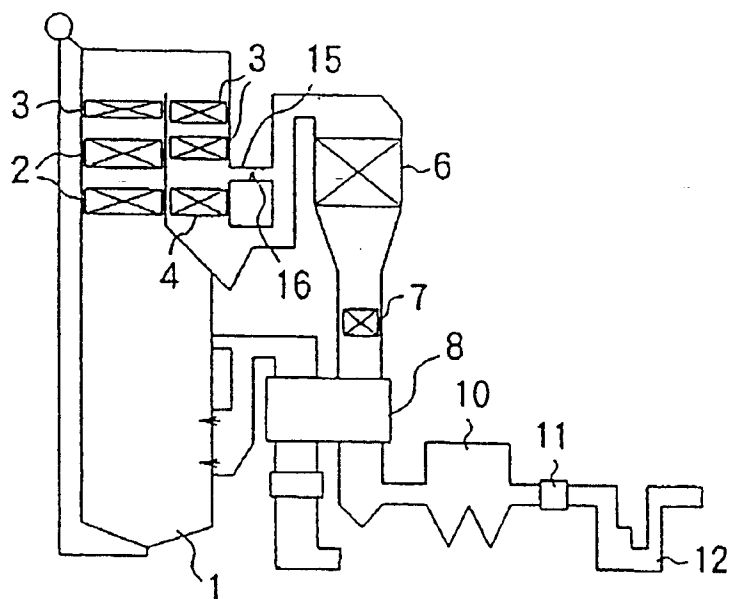


Fig. 3

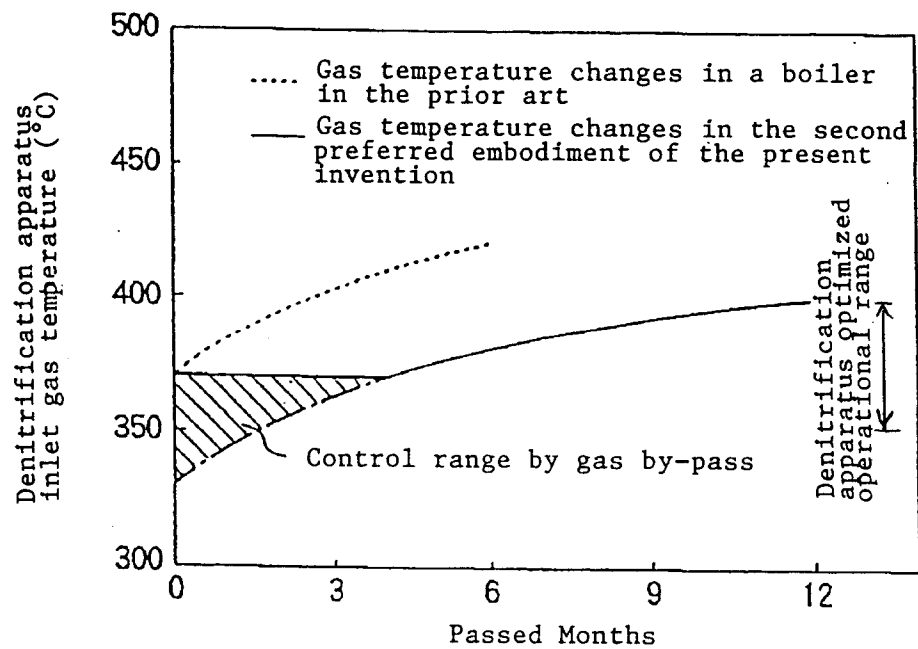


Fig. 4

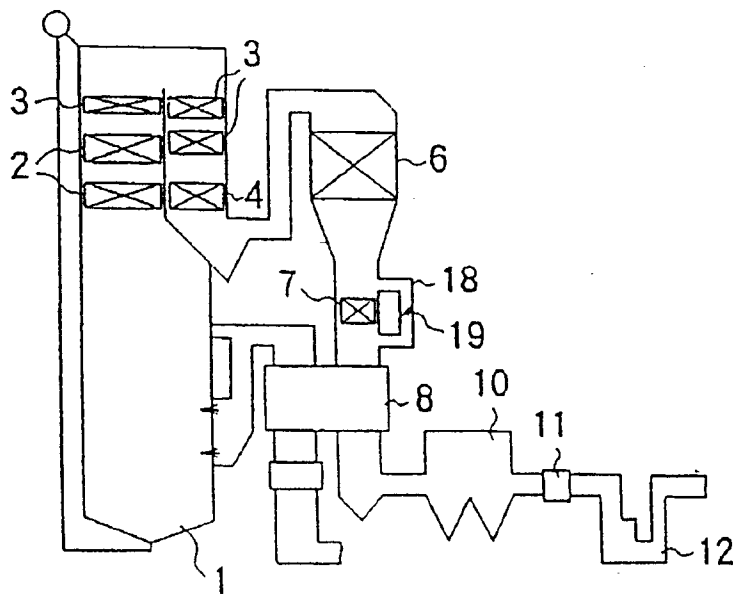


Fig. 5

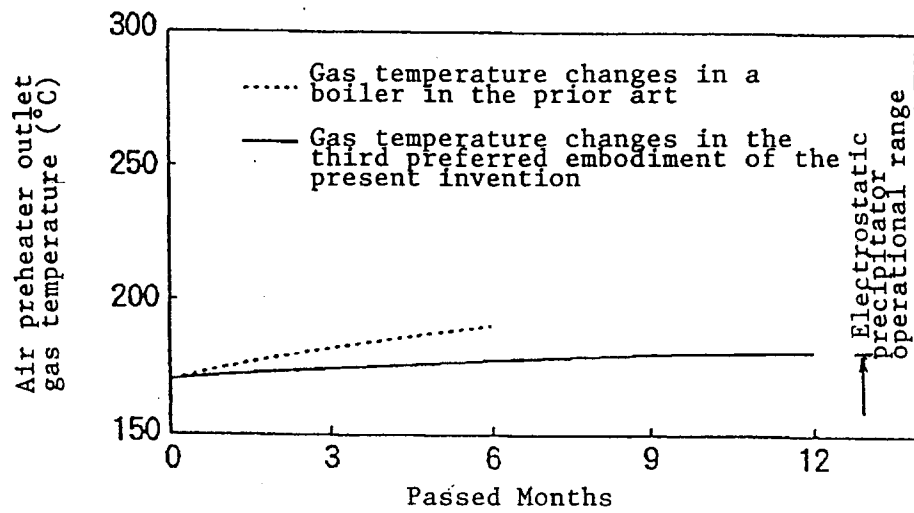


Fig. 6

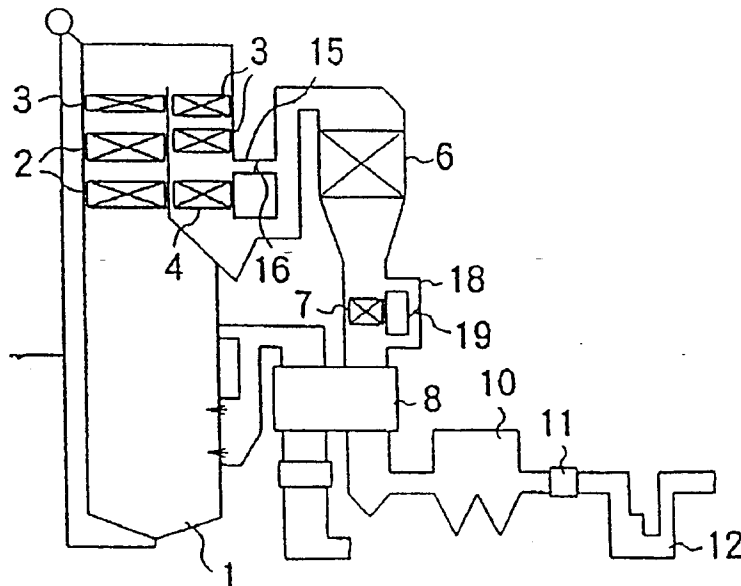
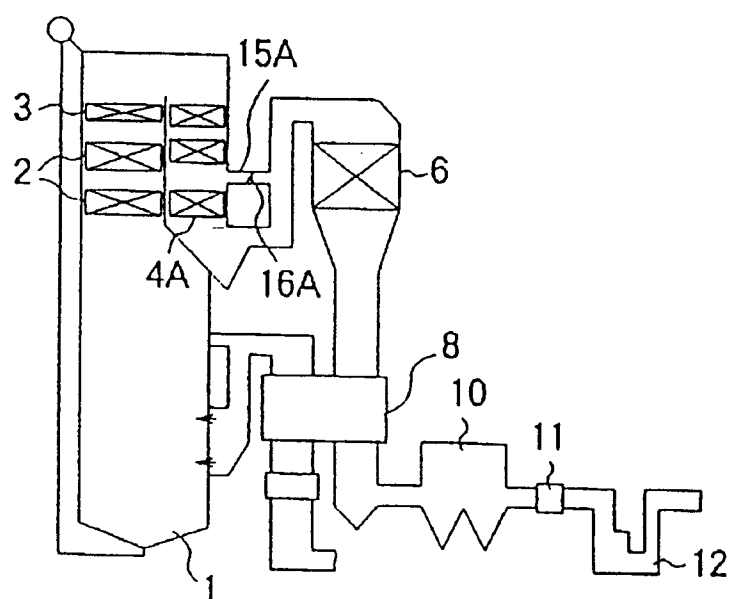


Fig. 7





European Patent
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EUROPEAN SEARCH REPORT

Application Number
EP 96 11 0432

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	US-A-5 423 272 (DUNN) * column 14, line 12 - column 16, line 34; figures *	1,2	F22B37/00 F22D1/00 F23J15/00
X	FR-A-2 360 045 (HITACHI SHIPBUILDING) * page 5, line 10 - page 6, line 15; figures *	1,2	
A	GB-A-2 082 085 (WESTINGHOUSE)		
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
			F22B F23J
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
THE HAGUE		17 October 1996	Van Gheel, J
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