(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 323 917 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC

(43) Date of publication:
02.07.2003 Bulletin 2003/27

(21) Application number: **01974662.7**

(22) Date of filing: **03.10.2001**

(51) Int Cl.[7]: **F02M 27/06**

(86) International application number:
PCT/JP01/08694

(87) International publication number:
WO 02/029237 (11.04.2002 Gazette 2002/15)

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE TR

(30) Priority: **04.10.2000 JP 2000304547**

(71) Applicant: **Takebe, Masayuki**
Kusatsu-shi, Shiga 525-0023 (JP)

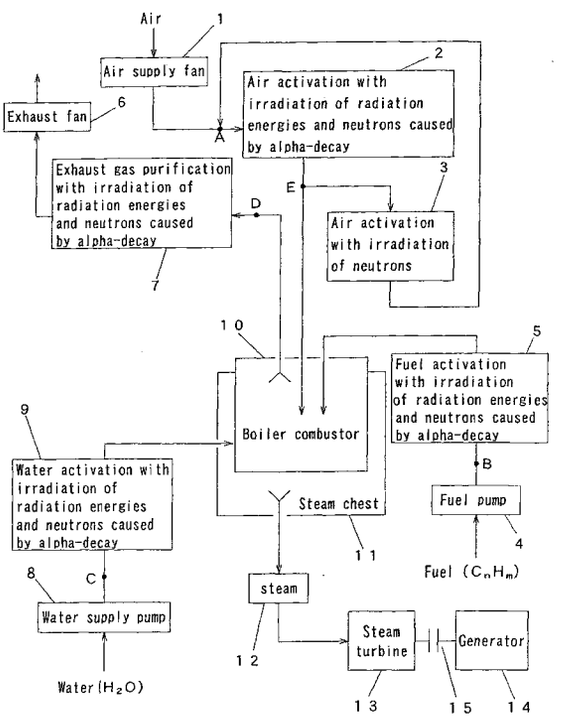
(72) Inventor: **Takebe, Masayuki**
Kusatsu-shi, Shiga 525-0023 (JP)

(74) Representative:
Lyndon-Stanford, Edward Willoughby Brooke
MARKS & CLERK,
57/60 Lincoln's Inn Fields
London WC2A 3LS (GB)

(54) METHOD AND APPARATUS FOR UTILIZING RADIATION ENERGY BY SG(a) DECAY IN ELECTRIC POWER GENERATING SYSTEM

(57) The present invention implements a power generation system in which an improved efficiency of fuel combustion and effective purification of exhaust gas can be attained with the use of radiation energies caused by alpha-decay of a natural radioactive element. Namely, radiation energies and neutrons caused by alpha-decay of the natural radioactive element which emits 0.6 becquerels/g or more of alpha rays are irradiated to a supply fuel and intake air, necessary for combustion in a combustion equipment in a power generation system using a fossil fuel, to transform oxygen contained in the intake air into active oxygen which is to be used in a fuel activator (5) and air activator (2) to implement a complete combustion of the mixture of the intake air and supply fuel. Also, a neutron irradiator (3) is provided to irradiate neutrons also caused by the alpha-decay. A water activator (9) with an aeration unit is provided to activate water supplied to a steam generator. In addition, an exhaust gas purifier (7) with an aeration unit is provided to purify the exhaust gas from the combustion equipment.

F I G. 1



EP 1 323 917 A1

Description

Field of the Invention

[0001] The present invention relates to utilization of radiation energies caused by alpha-decay of a natural radioactive element for improving the efficiency of fuel combustion and purifying the exhaust gas in a power generation system using fossil fuel.

Background Art

[0002] In the power generation systems using coal or petroleum as fuel, the boilers are of a supercritical pressure type and each of the turbines has a large capacity to improve the efficiency of power generation by an electrostatic precipitator, and a stack-gas desulfurization and denitration facility, etc. are used to purify the exhaust gas.

[0003] In the heat recovery combined-cycle power generation system consisting of a combination of a high-efficiency large-scale gas turbine using liquefied natural gas (LNG) and a steam turbine which recovers waste heat from the gas turbine, clean natural gas is used as a fuel and so the overall efficiency of power generation is as high as 50% and the exhaust gas is also clean. However, such a power plant discharges great volumes of CO_2 and NO_x.

[0004] In the conventional large-scale power generation system, the exhaust gas purification and improved efficiency of fuel combustion can be attained since many large equipment can be used. Regarding LNG, however, the district where it is usable and consumption thereof are limited. Thus, LNG cannot be used as a fuel in usable and consumption thereof are limited. Thus, LNG cannot be used as a fuel in any middle- or small-scale power generation system and discharges large amounts of NO_x and CO_2. With the recent technical advance of the micro gas turbine, power generation systems have been proposed which generate a power with the use of LNG as a fuel while making district cooling and heating by a exhaust gas recovery boiler. However, such a power generation system is not satisfactory in prevention of the environmental pollution by the exhaust gas.

Disclosure of the Invention

[0005] The present invention has an object to overcome the above-mentioned drawbacks of the prior art by providing an environmentally-friendly power generation system which needs not to be of any super-large scale and can generate a power at low costs with an improved purification of the exhaust gas and high efficiency of fossil-fuel combustion.

[0006] To accomplish the above object, radiation energies and neutrons caused by alpha-decay of a natural radioactive element which emits 0.6 becquerels/g or more of alpha rays are irradiated to a supply fuel and intake air, necessary for combustion in a combustion equipment in a power generation system using a fossil fuel, to transform oxygen contained in the intake air into active oxygen which is to be used in a fuel activator and air activator, provided in a fuel supply system and air supply system, respectively, to implement a complete combustion of the mixture of the intake air and supply fuel.

[0007] Also, for water supplied to a steam generator, a water activator is provided in a water supply system. An exhaust gas purifier is provided in an exhaust gas discharge system. Further, a neutron irradiator is provided at the outlet of the air activator to return the neutron-irradiated intake air to the air activator.

[0008] These objects and other objects, features, and advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments of the present invention when taken in conjunction with the accompanying drawings. It should be noted that the present invention is not limited to the embodiments but can freely be modified without departing from the scope and spirit thereof defined in the claims given later.

Brief Description of the Drawings

[0009]

FIG. 1 is a block diagram of a power generation system according to the present invention.
FIG. 2 schematically illustrates the construction of the air activator.
FIG. 3 schematically illustrates the construction of the fuel activator.
FIG. 4 schematically illustrates the construction of the exhaust gas purifier.
FIG. 5 schematically illustrates the construction of the water activator.
FIG. 6 schematically illustrates the construction of the neutron irradiator.

Best Mode for Carrying Out the Invention

[0010] Referring now to FIG. 1, there is illustrated in the form of a schematic block diagram the power generation system according to the present invention. As shown, a boiler combustor 10 included a combustion equipment is supplied with a fuel via a fuel pump 4 as well as with combustion air via an air supply fan 1. Exhaust gas caused by the combustion in the boiler combustor 10 is discharged via an exhaust fan 6. A steam chest 11 included in the combustion equipment is supplied with water via a boiler feed pump 8. Steam 12 generated by the combustion in the boiler combustor 10 drives to rotate a steam turbine 13 which drives a generator 14 coupled to a main shaft 15 of the steam turbine 13, to thereby generate an electric power.

[0011] An air activator 2 shown in FIG. 2 is provided in a place A in an air supply system of the combustion equipment, and a fuel activator 5 shown in FIG. 3 is provided in a place B in a fuel supply system. Also, a water activator 9 shown in FIG. 5 is provided in a place C in a water supply system which supplies water to the steam chest 11, and an exhaust gas purifier 7 shown in FIG. 4 is provided in a place D in an exhaust gas discharge system. Further, a neutron irradiator 3 shown in FIG. 6 is provided at a split-flow point E in the air supply system.

[0012] The present invention uses ceramic balls formed by solidifying, with a coagulant, granules or powder of an ore containing 100 ppm/g to 1 g/g (100%) of a natural radioactive element which emits 0.6 becquerels/g or more of radiation energies by alpha-decay and shaping them into the form of balls of about 100 mm in diameter.

[0013] The fuel activator 5 is constructed as shown in FIG. 3. A fuel supplied from the inlet of the fuel activator 5 by means of the fuel pump 4 flows down in contact with the ceramic balls, indicated with a reference 20, laid dispersedly on multiple mesh-like shelf stages 21 and is fed to the boiler combustor 10 from the outlet of the fuel activator 5. While the fuel is flowing down in repeated contact with many ceramic balls 20 in the fuel activator 5, it is activated by radiation energies and neutrons caused by alpha-decay.

[0014] Note that since the air activator 2, exhaust gas purifier 7 and water activator 9 are identical in inner construction to each other, description will be made solely of the air activator 2. As mentioned above, the air activator 2 has provided therein the mesh-like shelves 21 on which the ceramic balls 20 are laid dispersedly. Each of the shelves 21 has fixed on the bottom thereof an aeration pipe 22 having aeration holes formed therein. In addition, there is provided an aeration unit including a box 25 having also ceramic balls 21 placed therein and an aeration air supply fan 24. Aeration air flowing into the aeration unit gets in contact with the ceramic balls 21 while being sucked by the aeration air supply fan 24 and is irradiated with radiation energies caused by alpha-decay. The aeration air taken into the air activator 2 from the aeration air supply fan 24 is split into the aeration pipes 22 branched from a main aeration pipe 23, and blown out of the aeration holes in the aeration pipes 22. Air flowing in from the inlet of the air activator 2 flows down in contact with the ceramic balls 20 laid dispersedly on the mesh-like shelves 21 and is mixed with the aeration air blown out from the aeration pipes 22.

[0015] Thus, the air supplied from the air activator 2 to the boiler combustor 10 is a mixture of the air having flowed into the air activator 2 and having been irradiated with the radiation energies and neutrons from the ceramic balls 20 and aeration air supplied from the aeration pipes 22 and having been irradiated with the radiation energies and neutrons from the ceramic balls 20 in the aeration unit. It should be noted that when a part of the air from the outlet of the air activator 2 is split and recirculated as the aeration air, the air is considerably activated. Since the exhaust gas purifier 7 is also provided with such an aeration unit, the recirculation of the exhaust gas will assure a similar effect to that in the air activator 2.

[0016] The neutron irradiator 3 provided at the split-flow point E at the outlet of the air activator 2 is constructed as schematically illustrated in FIG. 6. Air flowing into the neutron irradiator 3 from the outlet of the air activator 2 flows down in contact with ceramic balls 20' laid dispersedly on the mesh-like shelves 21. The ceramic balls 20' are formed from forming a mixture of an ore containing 100 ppm/g or more of a natural radioactive element and an ore containing beryllium to balls having a diameter of about 100 mm. The beryllium will emit neutrons when it is irradiated with the radiation energies caused by alpha-decay of the natural radioactive element. Thus, the inflow air in contact with the ceramic balls 20' is activated by the neutrons. It should be noted that the outlet of the neutron irradiator 3 is connected to the inlet of the air activator 2 to recirculate the inflow air for promotion of its activation.

[0017] Next, it will be discussed how the radiation energies caused by alpha-decay of the natural radioactive element react with air. The natural radioactive element will spontaneously change into another element, then into still another element, ... while emitting radiation energies such as alpha-rays, beta-rays and gamma-rays, and finally into lead which will not change any more. When air is irradiated with such radiation energies caused by alpha-decay, diatomic oxygen in the air is reduced by a negative electron and transformed into a powerful oxidizing active oxygen as in the following:

$$O_2 + e^- \rightarrow \bullet O_2^-$$

[0018] Air contains oxygen in about 21% and nitrogen in about 78%. When irradiated with the alpha-rays, the nitrogen

atom having an atomic number 14 will undergo a fission-transmission into a highly reactive oxygen atom having an atomic number 17 and hydrogen atom having an atomic number 1 as in the following:

$$^{14}_{7}N + ^{4}_{2}He \rightarrow ^{17}_{8}O + ^{1}_{1}H$$

[0019] At this time, a very small amount of neutron is emitted. When irradiated with the neutrons, the nitrogen atom having an atomic number 14 will undergo a fission-transformation into carbon atom having an atomic number 12 and hydrogen atom having an atomic number 1 as in the following:

$$^{14}_{7}N + ^{1}_{0}n \rightarrow ^{14}_{6}C + ^{1}_{1}H$$

[0020] The monatomic oxygen ($^{17}_{8}O$) produced due to the atomic nucleus-transformation of the nitrogen will react with the carbon monoxide (CO) to produce carbon dioxide as in the following. In other words, the fuel will be completely burnt.

$$CO + O \rightarrow CO_2$$

[0021] Also, the active monatomic hydrogen ($^{1}_{1}H$) will easily combine with carbon and react with the hydrocarbon (HC), as in the following, to produce methane:

$$HC + 3H \rightarrow CH_4$$

[0022] The active oxygen ($\bullet O_2^-$) will react with the methane, resulting in complete combustion. That is, the hydrocarbon (HC) produced due to incomplete combustion is changed, due to the monatomic hydrogen, into a hydrocarbon (C_nH_m) and will burn again as a fuel.

[0023] The ceramic balls 20' laid dispersedly in the neutron irradiator 3 provided at the outlet of the air activator 2 are formed from a mixture of a natural radioactive element and beryllium and emit neutrons as in the following:

$$^{9}_{4}Be + ^{4}_{2}He \rightarrow ^{12}_{6}C + ^{1}_{0}n$$

[0024] Further, the nitrogen atom having an atomic number 14 in the air having been irradiated with the neutrons emitted from the ceramic balls 20' will undergo a fission-transformation into carbon atom having an atomic number 12 and hydrogen atom having an atomic number 1 as in the following:

$$^{14}_{7}N + ^{1}_{0}n \rightarrow ^{14}_{6}C + ^{1}_{1}H$$

[0025] In the passage downstream of the air inlet, the hydrocarbon will be burnt according to the following:

$$C_nH_m + (n+m/4)O_2 + 3.76(n+m/4)N_2 \rightarrow nCO_2 + (m/2)H_2O + 3.76(n+m/4)N_2$$

[0026] In air, each element is in an excited condition in which it shows a powerful oxidizing reaction. Also, since active oxygen, which is capable of a power oxidizing reaction, is used, incomplete combustion can be prevented to improve the combustion efficiency of a combustion equipment.

[0027] Each of the aforementioned activators has provided therein many ceramic balls 20 containing 100 ppm/g to 1 g/g (100%) of a natural radioactive element which emits 0.6 becquerels/g or more of radiation energies by alpha-decay.

[0028] Therefore, to protect the human body against irradiation of the radiation energies and neutrons caused by alpha-decay, the apparatus has to be fully housed in a box made of a lead plate having a thickness of about 100 mm. Also the neutron irradiator 3 to emit neutrons should be provided with the above protective feature. It should be noted that there may be provided a plurality of the above-mentioned activator stages and a recirculation circuit to further improve the effect of activation. Industrial Applicability

[0029] As having been described in the foregoing, owing to the irradiation with the radiation energies caused by alpha-decay of a natural radioactive element, diatomic oxygen in the supply air can be changed into a powerful oxidizing active oxygen, and nitrogen in the air undergoes fission-transformation into monatomic oxygen and monatomic hydrogen, resulting in an increased oxygen content in the air. Also, owing to irradiation with neutrons, a part of the nitrogen in the air undergoes fission-transformation into monatomic carbon and monatomic hydrogen. The irradiation of alpha-rays, beta-rays and gamma-rays to the hydrocarbon in a fuel promotes the decomposition and bridging reactions. Since the above active oxygen permits complete combustion of the fuel, it is possible to reduce toxic components of exhaust gas and purify the exhaust gas at low costs. That is, the power generation system according to the present invention needs no large space for installation, and is environmentally friendly since the complete combustion of a fossil fuel contributes to an improved efficiency of combustion.

Claims

1. A method of improving the efficiency of fuel combustion and purifying exhaust gas resulted from the combustion, in a power generation system using a fossil fuel, with the use of radiation energies caused by alpha-decay of a natural radioactive element, wherein the radiation energies and neutrons simultaneously caused by alpha-decay of the natural radioactive element are irradiated to a supply fuel and intake air, necessary for the fuel to be burnt in a combustion equipment of the power generation system, to transform oxygen contained in the intake air into active oxygen which is to be used for activating the supply fuel and intake air for combustion.

2. A method of improving the efficiency of fuel combustion and purifying exhaust gas resulted from the combustion, in a combustion equipment included in a power generation system, with the use of radiation energies caused by alpha-decay of a natural radioactive element, wherein the radiation energies and neutrons simultaneously caused by alpha-decay of the natural radioactive element are irradiated to a supply water to a steam generator in the combustion equipment to activate the supply water.

3. A method of improving the efficiency of fuel combustion and purifying exhaust gas resulted from the combustion, in a combustion equipment included in a power generation system, with the use of radiation energies caused by alpha-decay of a natural radioactive element, wherein the radiation energies and neutrons simultaneously caused by alpha-decay of the natural radioactive element are irradiated to exhaust gas discharged from the combustion equipment to purify the supply water.

4. In a power generation system, an apparatus for improving the efficiency of fuel combustion and purifying exhaust gas resulted from the combustion, in a combustion equipment included in the power generation system, with the use of radiation energies caused by alpha-decay of a natural radioactive element, wherein:

   ceramic balls formed from a substance containing a natural radioactive element are laid dispersedly on a plurality of mesh-like shelf stages defining a fuel intake passage; and
   a fuel activator is provided in a fuel supply system of the combustion equipment to activate the fuel flowing in contact with the ceramic balls.

5. In a power generation system, an apparatus for improving the efficiency of fuel combustion and purifying exhaust gas resulted from the combustion, in a combustion equipment included in the power generation system, with the use of radiation energies caused by alpha-decay of a natural radioactive element, comprising:

   an air activator provided in an air supply system of the combustion equipment to activate intake air flowing in contact with ceramic balls formed from a substance containing a natural radioactive element and laid dispersedly on a plurality of mesh-like shelf stages defining a fuel intake passage by mixing the intake air with aeration air supplied from an aeration unit filled with such ceramic balls and blown out from a plurality of split aeration pipes provided on the bottom of the plurality of mesh-like shelves.

6. In a power generation system, an apparatus for improving the efficiency of fuel combustion and purifying exhaust gas resulted from the combustion, in a combustion equipment included in the power generation system, with the use of radiation energies caused by alpha-decay of a natural radioactive element, comprising:

   a water activator provided in a water supply system to a boiler of the combustion equipment to activate supply water flowing in contact with ceramic balls formed from a substance containing a natural radioactive element

and laid dispersedly on a plurality of mesh-like shelf stages defining a water intake passage by mixing the supply water with aeration air supplied from an aeration unit filled with such ceramic balls and blown out from a plurality of split aeration pipes provided on the bottom of the plurality of mesh-like shelves.

7. In a power generation system, an apparatus for improving the efficiency of fuel combustion and purifying exhaust gas resulted from the combustion, in a combustion equipment included in the power generation system, with the use of radiation energies caused by alpha-decay of a natural radioactive element, comprising:

an exhaust gas purifier provided in an exhaust gas discharge system of the combustion equipment to purify exhaust gas flowing in contact with ceramic balls formed from a substance containing a natural radioactive element and laid dispersedly on a plurality of mesh-like shelf stages defining an exhaust gas intake passage by mixing the exhaust gas with aeration air supplied from an aeration unit filled with such ceramic balls and blown out from a plurality of split aeration pipes provided on the bottom of the plurality of mesh-like shelves.

8. In a power generation system, an apparatus for improving the efficiency of fuel combustion and purifying exhaust gas resulted from the combustion, in a combustion equipment included in the power generation system, with the use of radiation energies caused by alpha-decay of a natural radioactive element, comprising:

an air activator to activate intake air; and
a neutron irradiator provided at the outlet of the air activator to irradiate to a split flow of activated intake air from the outlet of the air activate neutrons emitted from beryllium irradiated with radiation energies caused by alpha-decay of a natural radioactive element in order to further activate the air with the neutrons;
the intake air delivered from the neutron irradiator being recirculated to the inlet of the air activator.

9. The apparatus according to either claim 5 or 7, wherein air from the outlet of the air activator and exhaust gas from the outlet of the exhaust gas purifier are split and recirculated as aeration air to the aeration unit.

10. The apparatus according to any one of claims 1 to 9, wherein the natural radioactive element emits 0.6 becquerels or more of alpha-rays.

FIG. 1

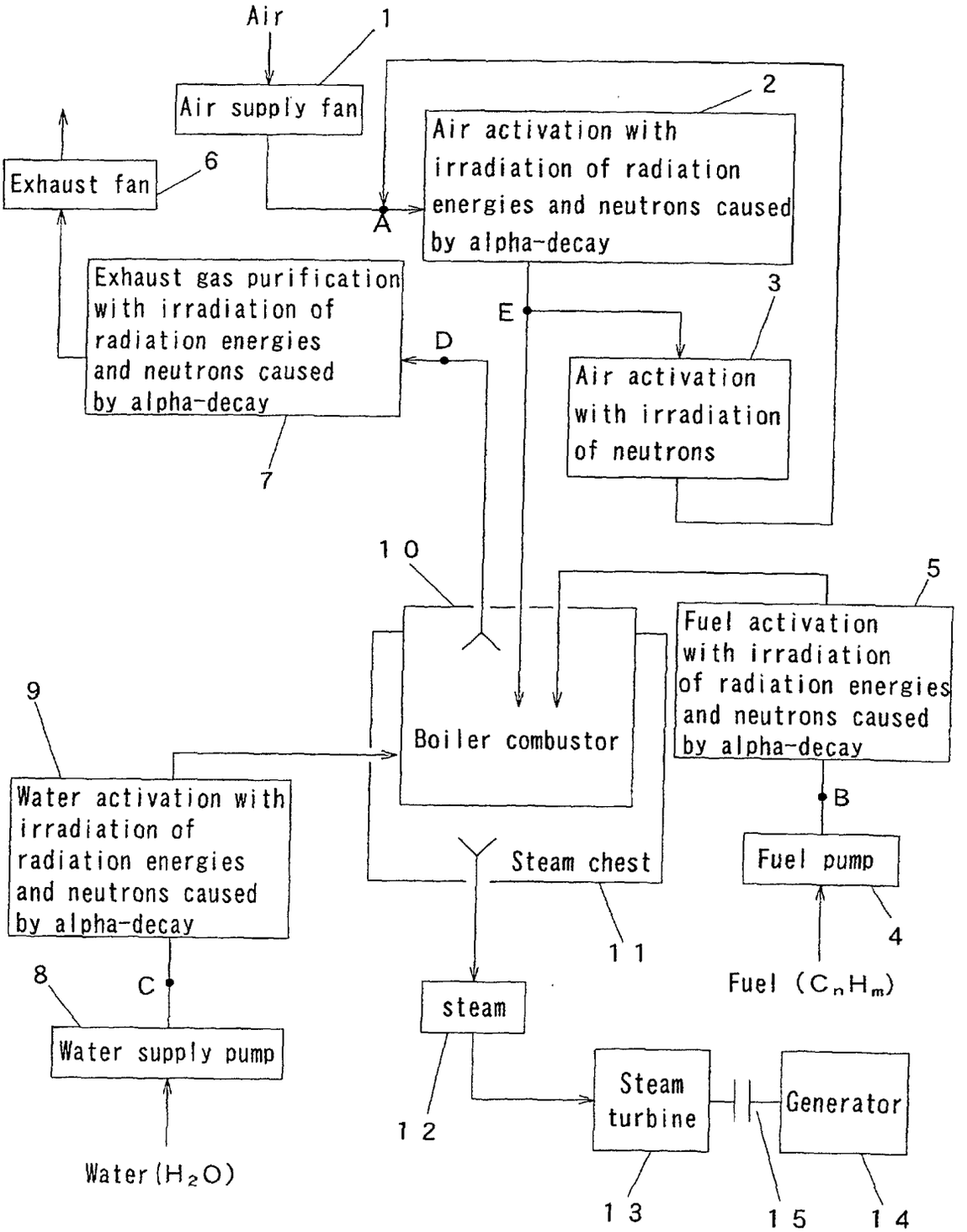

Air
1
Air supply fan
2
Air activation with irradiation of radiation energies and neutrons caused by alpha-decay
Exhaust fan
6
A
Exhaust gas purification with irradiation of radiation energies and neutrons caused by alpha-decay
E
3
D
Air activation with irradiation of neutrons
7
10
5
Fuel activation with irradiation of radiation energies and neutrons caused by alpha-decay
Boiler combustor
9
Water activation with irradiation of radiation energies and neutrons caused by alpha-decay
B
Steam chest
Fuel pump
11
4
Fuel (C_nH_m)
8
C
steam
Water supply pump
12
Steam turbine
Generator
Water (H_2O)
13
15
14

FIG. 2

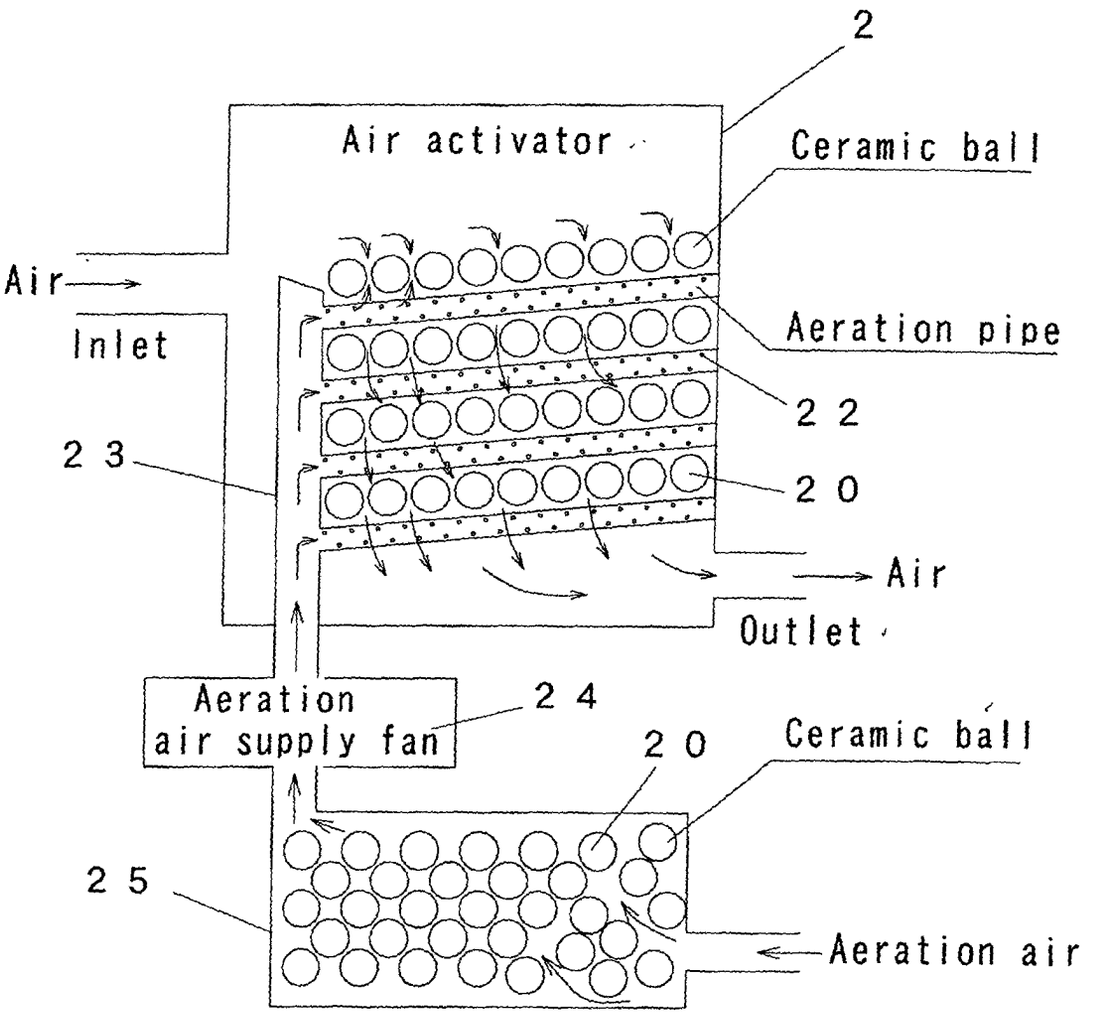

2
Air activator
Ceramic ball
Air
Inlet
Aeration pipe
22
23
20
Air
Outlet
Aeration
air supply fan
24
20
Ceramic ball
25
Aeration air

FIG. 3

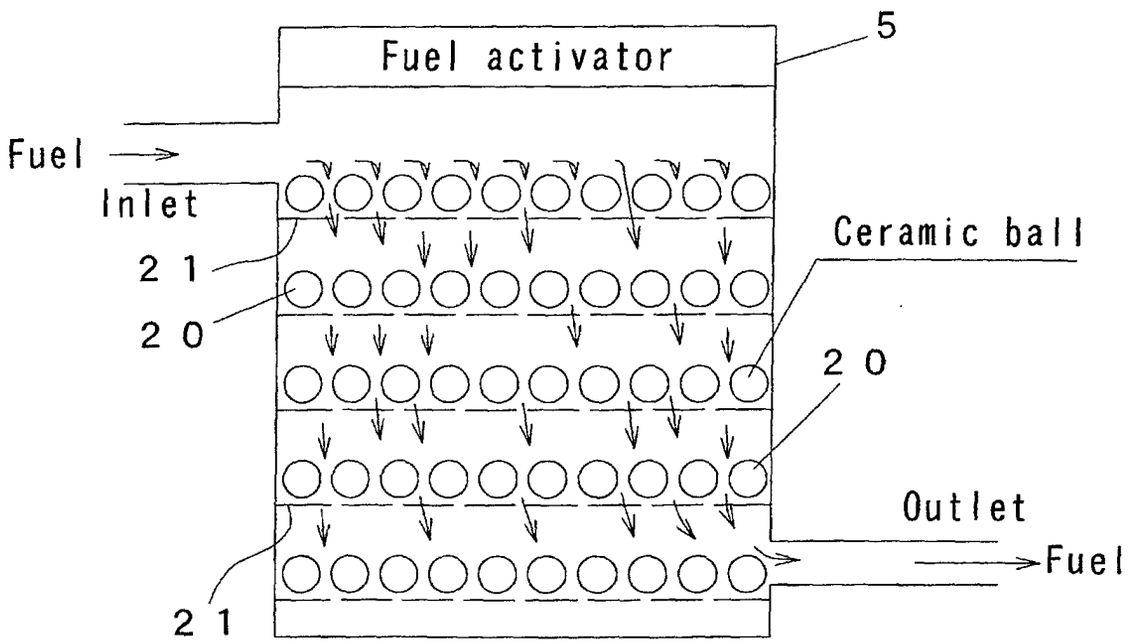

Fuel activator
5
Fuel
Inlet
21
20
Ceramic ball
20
Outlet
Fuel
21

FIG. 4

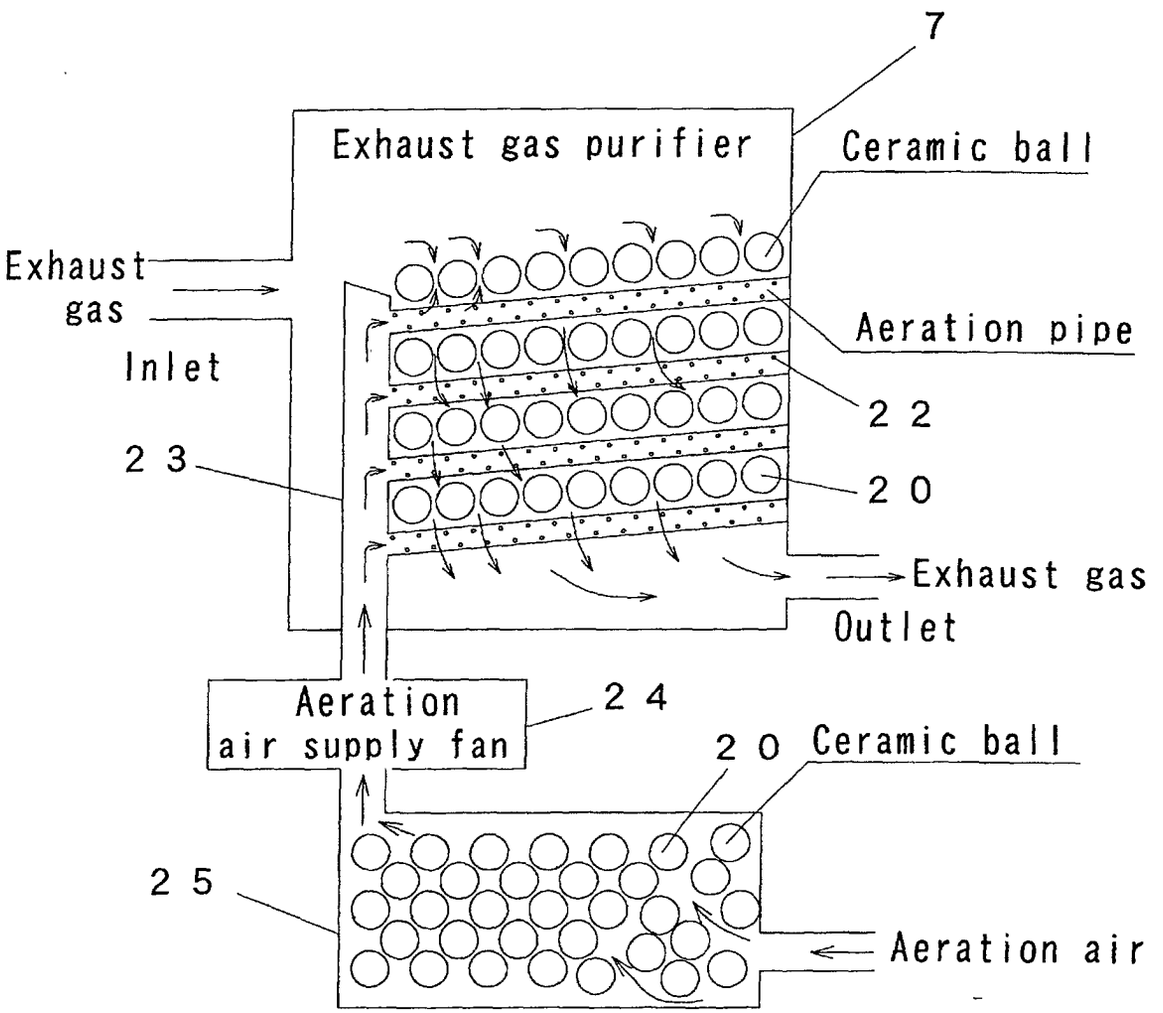

7
Exhaust gas purifier
Ceramic ball
Exhaust gas Inlet
Aeration pipe
22
23
20
Exhaust gas Outlet
Aeration air supply fan
24
20 Ceramic ball
25
Aeration air

FIG. 5

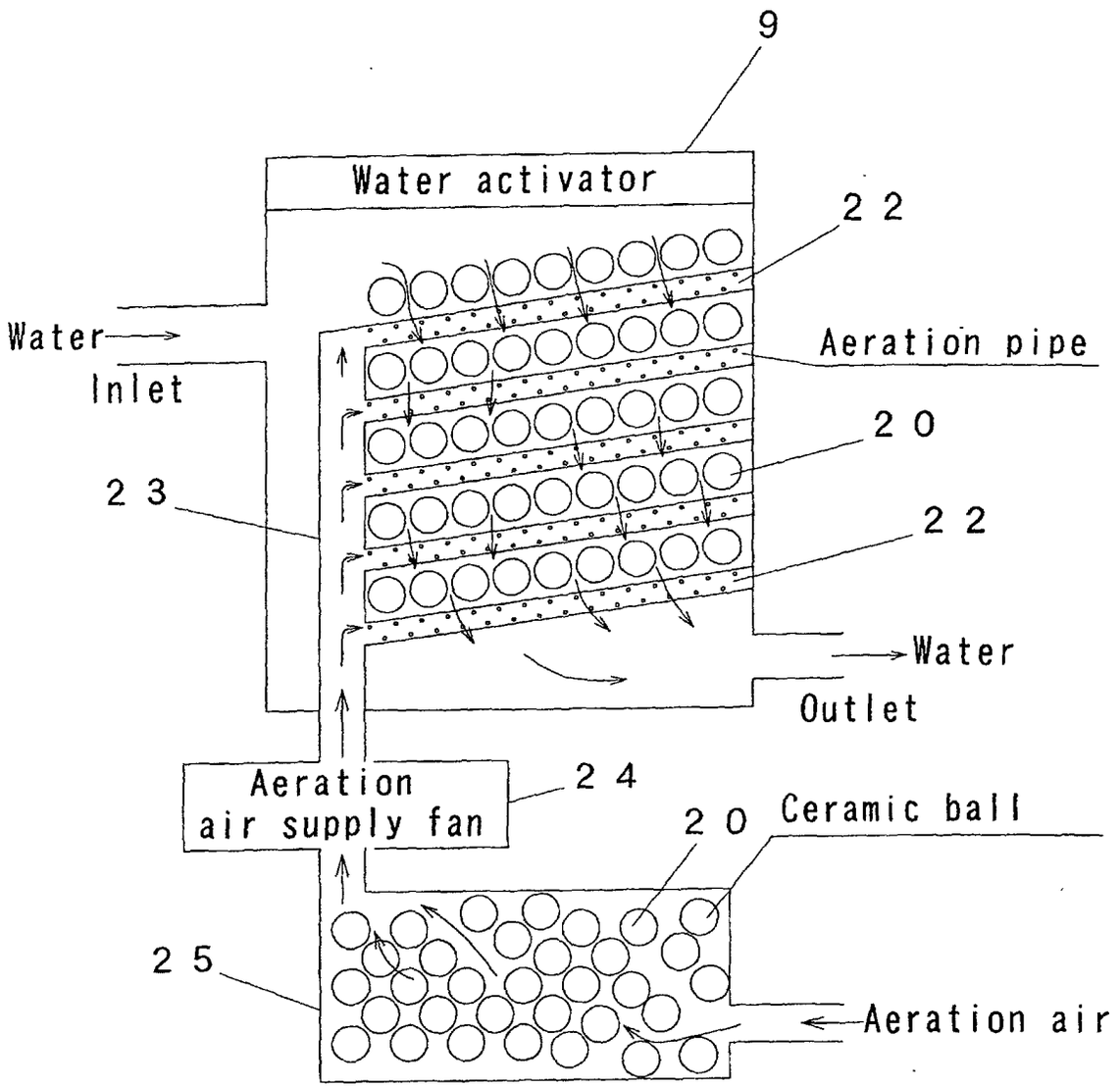
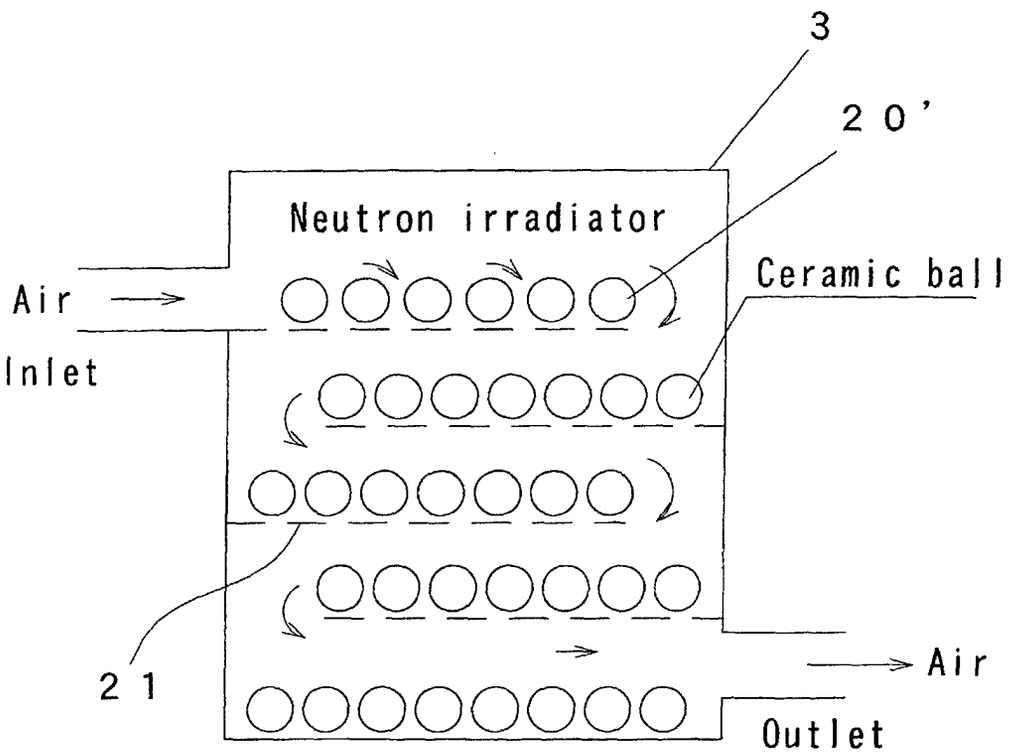

9
Water activator
22
Water
Inlet
Aeration pipe
20
23
22
Water
Outlet
Aeration
air supply fan
24
20
Ceramic ball
25
Aeration air

FIG. 6


3
20'
Neutron irradiator
Ceramic ball
Air
Inlet
21
Air
Outlet

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP01/08694

A. CLASSIFICATION OF SUBJECT MATTER
Int.Cl[7] F02M 27/06

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)
Int.Cl[7] F02M 27/06

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2001
Kokai Jitsuyo Shinan Koho 1971-2001 Jitsuyo Shinan Toroku Koho 1996-2001

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 53-16118 A (Jirou ASAHINA), 14 February, 1978 (14.02.78), Full text; Figs. 1 to 6 (Family: none)	1 2-4,10 5-9
X Y A	JP 10-288101 A (Morihiro NUMATA), 27 October, 1998 (27.10.98), Full text; Figs. 1 to 3 (Family: none)	1 2-4,10 5-9
Y A	WO 84/4565 A1 (Masahisa MIURA), 22 November, 1984 (22.11.84), Full text & JP 59-206660 A & AU 2828184 A	1-3 4-10
X Y A	WO 00/30124 A1 (W. F. N. Co., Ltd.), 25 May, 2000 (25.05.00), Full text; Figs. 1 to 7 & JP 12-19296 A & EP 1049107 A1	1,3 2,4,10 5-9
Y A	JP 08-42409 A (Mikio YAKUSHIJI), 13 February, 1996 (13.02.96), Full text; Figs. 1 to 4 (Family: none)	4 1-3,5-10

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 December, 2001 (25.12.01)	15 January, 2002 (15.01.02)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP01/08694

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2000-161154 A (Eco Clean Network K.K.), 13 June, 2000 (13.06.00), Full text; Figs. 1 to 3 (Family: none)	4 1-3,5-10
Y A	EP 1020215 A2 (Masayuki TAKEBE), 19 July, 2000 (19.07.00), Full text; Figs. 1 to 4 & JP 12-205062 A & AU 721636 A1 & BR 9902383 A	4 1-3,5-10

Form PCT/ISA/210 (continuation of second sheet) (July 1992)