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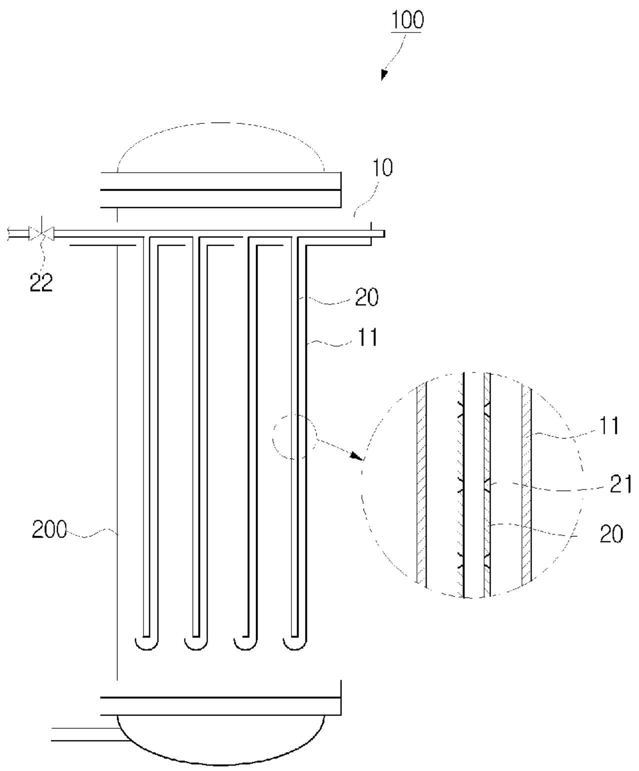
[Continued on next page]

(54) **Title**: A COOLING SYSTEM FOR ELIMINATION OF HEAT OF REACTION AT FISCHER-TROPSCH SLURRY BUBBLE COLUMN REACTOR

[Fig. 1]



(57) **Abstract**: Disclosed is a cooling system for removal of reaction heat from an FT slurry bubble column reactor such that the system receives syngas extracted from a coal and controls temperature of the reaction heat generated during reaction of the syngas with a catalyst. The cooling system includes an FT slurry bubble column reactor, a plurality of first cooling pipes inter-connected and arranged in a concentric structure on the top of the reactor, a plurality of second cooling pipes connected to the bottom of the first cooling pipes in a vertical downward direction, and a cooling water injection line having a diameter relatively smaller than an inner diameter of each of the first and second cooling pipes so as to be inserted into the same.

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— *with amended claims and statement (Art. 19(1))*

Description

A COOLING SYSTEM FOR ELIMINATION OF HEAT OF REACTION AT FISCHER-TROPSCH SLURRY BUBBLE COLUMN REACTOR

Technical Field

[1] The present invention relates to a cooling system for elimination of heat of reaction from a Fischer-Tropsch (F-T) slurry bubble column reactor and, more particularly, to a cooling system for removing heat of reaction from an FT slurry bubble column reactor wherein the system receives synthetic gas (often referred to as "syngas") extracted from coal and controls temperature of heat of reaction generated during reaction of the syngas with a catalyst.

Background Art

[2] It is well known that an indirect coal liquefaction system comprising a series of coal gasification, gas cleaning and liquefaction processes is employed to produce a wax type synthetic fuel from coal powder as a major raw material of the synthetic fuel so that the produced synthetic fuel is used as a raw material of fossil fuels.

[3] In this case, the gasification process is a process for conversion of coal into syngas primarily containing hydrogen and carbon monoxide.

[4] The gas cleaning process is a process for filtration and desulfurization of the syngas obtained from the gasification process and, in addition, for removing impurities and/or foreign materials.

[5] Lastly, the liquefaction process is a process for reaction of the clean syngas over a catalyst to convert the reaction product into a liquid phase synthetic fuel.

[6] In order to perform the liquefaction process, the syngas should be homogeneously dispersed into the FT slurry bubble column reactor to allow reaction of the syngas with an iron catalyst contained in a slurry of the reactor, thereby producing the synthetic fuel as a final product.

[7] The FT slurry bubble column reactor may perform a reaction of the syngas ($CO + H_2$) with the iron (Fe) catalyst to produce the synthetic fuel, wherein the reaction is an exothermic reaction and causes an internal temperature of the reactor to be increased.

[8] Then, due to an increase in internal temperature, methane gas and carbon dioxide are increasingly generated in the FT slurry bubble column reactor to decrease selection of the synthetic fuel.

[9] Therefore, the above reactor basically requires maintaining the internal temperature of the FT slurry bubble column reactor at a desired level without variation.

[10] However, according to a conventional process as shown in FIG. 5, a cooling pipe 1

for circulation of water or steam is arranged inside an FT slurry bubble column reactor 200 in order to control an internal temperature thereof.

[11] However, such a construction of the reactor has problems in that a great amount of cooling water must be fed into the cooling pipe 1 and be continuously circulated within the reactor, thereby increasing energy consumption and, in addition, the construction exhibits very inferior cooling efficiencies.

Disclosure of Invention

Technical Problem

[12] Therefore, the present invention has been made in view of the above problems, and it is an object of the present invention to provide a cooling system for removal of heat of reaction (hereinafter referred to as "reaction heat") generated in an FT slurry bubble column reactor, wherein an injection line is arranged inside a cooling pipe to inject a small amount of cooling water into the cooling pipe under high pressure so as to control an exothermic temperature in the reactor by latent heat of evaporation, and the cooling water evaporated in the cooling pipe by heat in the reactor is discharged in a steam state so as to reduce energy consumption.

Technical Solution

[13] In order to accomplish the above object of the present invention, there is provided a cooling system for removal of reaction heat from an FT slurry bubble column reactor, including: an FT slurry bubble column reactor; a plurality of first cooling pipes interconnected and arranged in a concentric structure on the top of the reactor; a plurality of second cooling pipes connected to the bottom of the first cooling pipes in a vertical downward direction; a cooling water injection line that has a diameter relatively smaller than an inner diameter of each of the first and second cooling pipes so as to be inserted into the same.

[14]

Brief Description of Drawings

[15] The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

[16] FIG. 1 is a schematic diagram illustrating a cooling system for elimination of heat of reaction at fischer-tropsch slurry bubble column reactor according to the present invention;

[17] FIG. 2 is a first schematic top view illustrating the cooling system for elimination of heat of reaction at fischer-tropsch slurry bubble column reactor of FIG. 1;

[18] FIG. 3 is a second schematic top view illustrating the cooling system for elimination of heat of reaction at fischer-tropsch slurry bubble column reactor of FIG. 1;

[19] FIG. 4 is a schematic diagram illustrating operation of a cooling system for removal of reaction heat from an FT slurry bubble column reactor according to the present invention; and

[20] FIG. 5 is a schematic diagram illustrating a conventional cooling pipe for removal of reaction heat from an FT slurry bubble column reactor.

Best Mode for Carrying out the Invention

[21] Hereinafter, a detailed description will be given of exemplary embodiments of a cooling system for removal of reaction heat from an FT slurry bubble column reactor according to the present invention, with reference to the accompanying drawings.

[22] FIG. 1 is a schematic diagram illustrating a cooling system for removal of reaction heat from an FT slurry bubble column reactor according to the present invention; FIG. 2 is a first schematic top view illustrating the cooling system for removal of reaction heat from an FT slurry bubble column reactor of FIG. 1; and FIG. 3 is a second schematic top view illustrating the cooling system for removal of reaction heat from an FT slurry bubble column reactor of FIG. 1.

[23] As illustrated in FIGS. 1 to 3, the present invention provides a cooling system 100 for removal of reaction heat from an FT slurry bubble column reactor wherein the system receives syngas extracted from coal and controls temperature of the reaction heat generated during reaction of the syngas with a catalyst.

[24] Such a cooling system 100 generally comprises two parts, namely, a cooling pipe part and an injection line 20 inserted into the cooling pipe part.

[25] The cooling pipe part includes a plurality of first cooling pipes 10 and a plurality of second cooling pipes 11, wherein the first cooling pipes 10 are arranged on an inner top portion of the FT slurry bubble column reactor 200 in either a concentric structure (see FIG. 2) or a lattice structure (see FIG. 3) and are inter-connected together while the second cooling pipes 11 are connected to the bottom of the first cooling pipes 10 in a vertical downward direction.

[26] In this regard, inlets of the first cooling pipes 100 connected to the FT slurry bubble column reactor 200 are closed while outlets of the same are open.

[27] The injection line 20 constructed so as to be inserted in both the first cooling pipes 10 and the second cooling pipes 11 is provided to inject the cooling water into inner circumferential faces of the second cooling pipes 11, thus cooling the same.

[28] Accordingly, the injection line 20 duly has a smaller diameter than an inner diameter of each of the first and the second cooling pipes 10 and 11.

[29] In addition, the injection line 20 is coupled with a valve 22 for adjusting pressure of the cooling water in order to inject the same under a high pressure and an end part of the injection line 20 is closed to generate a pre-determined internal pressure therein.

[30] The injection line 20 placed in the second cooling pipes 11 has a plurality of injection ports 21 to inject high pressure cooling water into the injection line by opening the valve 22.

[31] Each injection port 21 has a diameter extending from an inner side to an outer side of the port so that the cooling water is injected and widely dispersed in the cooling pipe.

[32] Hereinafter, a brief description will be given of a process for operating the cooling system for removal of reaction heat from an FT slurry bubble column reactor according to the present invention, with reference to related drawings.

[33] FIG. 4 is a schematic diagram illustrating operation of cooling system for removal of reaction heat from an FT slurry bubble column reactor according to the present invention.

[34] As illustrated in FIG. 4, syngas flows into the FT slurry bubble column reactor 200 and is combined with a slurry flowing in the reactor 200 to react with a catalyst, thus producing a synthetic fuel.

[35] As to production of the synthetic fuel, the FT slurry bubble column reactor 200 performs a reaction of the syngas ($CO + H_2$) with an iron (Fe) catalyst wherein the reaction is an exothermic reaction and causes an internal temperature of the reactor to be increased.

[36] However, the internal temperature occurred by the reaction between the syngas and the iron catalyst must be maintained in the range of about 200 to 350℃ in the FT slurry bubble column reactor. Otherwise, methane gas and carbon dioxide are increasingly generated, thereby causing a decrease in selection of the synthetic fuel.

[37] Therefore, it is necessary to reduce the internal temperature of the FT slurry bubble column reactor 200 to a desired level and constantly maintain the same temperature. For this purpose, the present invention adopts a plurality of cooling pipes.

[38] First of all, a cooling process is conducted by passing the cooling water through the injection line 20 before flowing into the FT slurry bubble column reactor 200, so as to increase the internal pressure to a desired level at which the cooling water can be injected via the valve 22.

[39] Such an internal pressure may be more easily attained according to a shape of the injection line 20 closed at the end thereof.

[40] Subsequently, the cooling water flows throughout a cross-section of the FT slurry bubble column reactor 200 via the injection line 20 placed in the first cooling pipes 10 and the cooling water flow is transported into each injection line 20 placed in the second cooling pipes 11.

[41] Such transported cooling water passes through injection ports 21 of the injection line 20 and is injected to an inner circumferential face of each second cooling pipe 11.

[42] Following that, the cooling water injected to the second cooling pipe 11 may reduce

the temperature of the second cooling pipe 11 by latent heat of evaporation which in turn decreases the temperature of the FT slurry bubble column reactor 200.

[43] The evaporated cooling water is converted into steam by the high temperature and the steam is discharged out of the outlet of the first cooling pipe 10.

[44] The above cooling process is advantageous in that a small amount of cooling water is injected into the cooling pipe under a high pressure so as to control an exothermic temperature in the reactor by latent heat of evaporation, and the cooling water evaporated in the cooling pipe by heat in the reactor is discharged in a steam state which may be used as an alternative energy source and may reduce energy consumption.

Industrial Applicability

[45] As is apparent from the above, the cooling system for removal of reaction heat from an FT slurry bubble column reactor according to the present invention has beneficial features in that an injection line is arranged inside a cooling pipe to inject a small amount of cooling water into the cooling pipe under high pressure so as to control an exothermic temperature in the reactor by latent heat of evaporation and, in addition, the cooling water evaporated in the cooling pipe by heat in the reactor is discharged in a steam state which may be used as an alternative energy source and may reduce energy consumption.

[46] Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various changes and/or modifications are possible, without departing from the scope and spirit of the invention. Therefore, these modifications and/or changes may be included in the scope of the invention, as defined in the accompanying claims.

Claims

[1] A cooling system for removal of reaction heat from an FT slurry bubble column reactor such that the system receives syngas extracted from coal and controls temperature of the reaction heat generated during reaction of the syngas with a catalyst, including:
a plurality of first cooling pipes inter-connected and arranged in a concentric structure on the top of an FT slurry bubble column reactor;
a plurality of second cooling pipes connected to the bottom of the first cooling pipes in a vertical downward direction; and
a cooling water injection line having a diameter relatively smaller than an inner diameter of each of the first and second cooling pipes so as to be inserted into the same.

[2] The cooling system according to claim 1, wherein the first cooling pipes are arranged in a concentric structure or a lattice structure.

[3] The cooling system according to claim 1, wherein the injection line is closed at an end part thereof to generate a predetermined internal pressure therein.

[4] The cooling system according to claim 1, wherein the injection line is coupled with a valve for adjusting pressure of the cooling water.

[5] The cooling system according to claim 1, wherein the injection line has a plurality of injection ports to inject the water into the injection line.

[6] The cooling system according to claim 3, wherein each injection port has a diameter extending from an inner side to an outer side of the port so that the cooling water is injected and widely dispersed in the cooling pipe.

AMENDED CLAIMS
received by the International Bureau on 15 May 2009 (15.05.2009)

1.(Amended) A cooling system for removal of reaction heat from an FT slurry bubble column reactor such that the system receives syngas extracted from coal and controls temperature of the reaction heat generated during reaction of the syngas with a catalyst, including:

a plurality of first cooling pipes inter-connected and arranged in a concentric structure on the top of an FT slurry bubble column reactor;

a plurality of second cooling pipes connected to the bottom of the first cooling pipes in a vertical downward direction; and

a cooling water injection line having a diameter relatively smaller than an inner diameter of each of the first and second cooling pipes so as to be inserted into the same;

wherein the injection line is closed at an end part thereof to generate a predetermined internal pressure therein.

2. (No Changes)

3. (Canceled)

4. (No Changes)

5. (No Changes)

6. (Amended) The cooling system according to claim 5, wherein each injection port has a diameter extending from an inner side to an outer side of the port so that the cooling water is injected and widely dispersed in the cooling pipe.

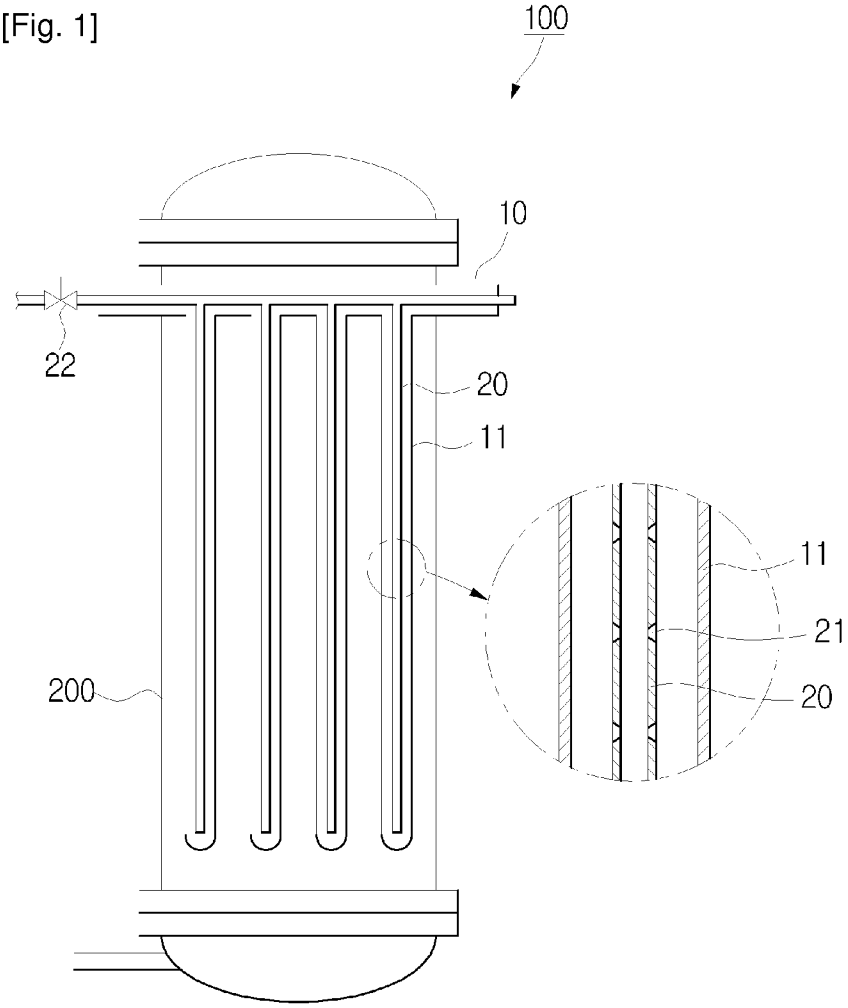
STATEMENT UNDER PCT ARTICLE 19(1)

Please replace original claims 1, 3, 6 by amended claims 1 and 6 and canceled claim 3 of the Replacement sheets attached hereto.

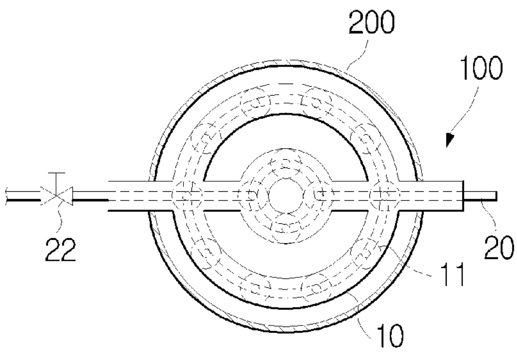
"Claims 1 and 6 are amended; Claim 3 is cancelled; all other claims are unchanged"

In the Replacement sheets, claims 1 and 6 are replaced by amended claims bearing the same numbers and claim 3 is cancelled. All other claims 2, 4, 5 are unchanged. These amendments should have no effect on the description and drawings

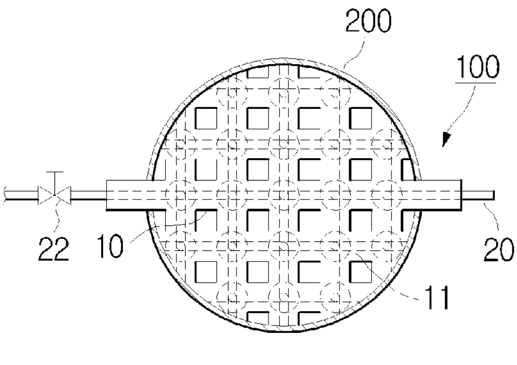
[Fig. 1]



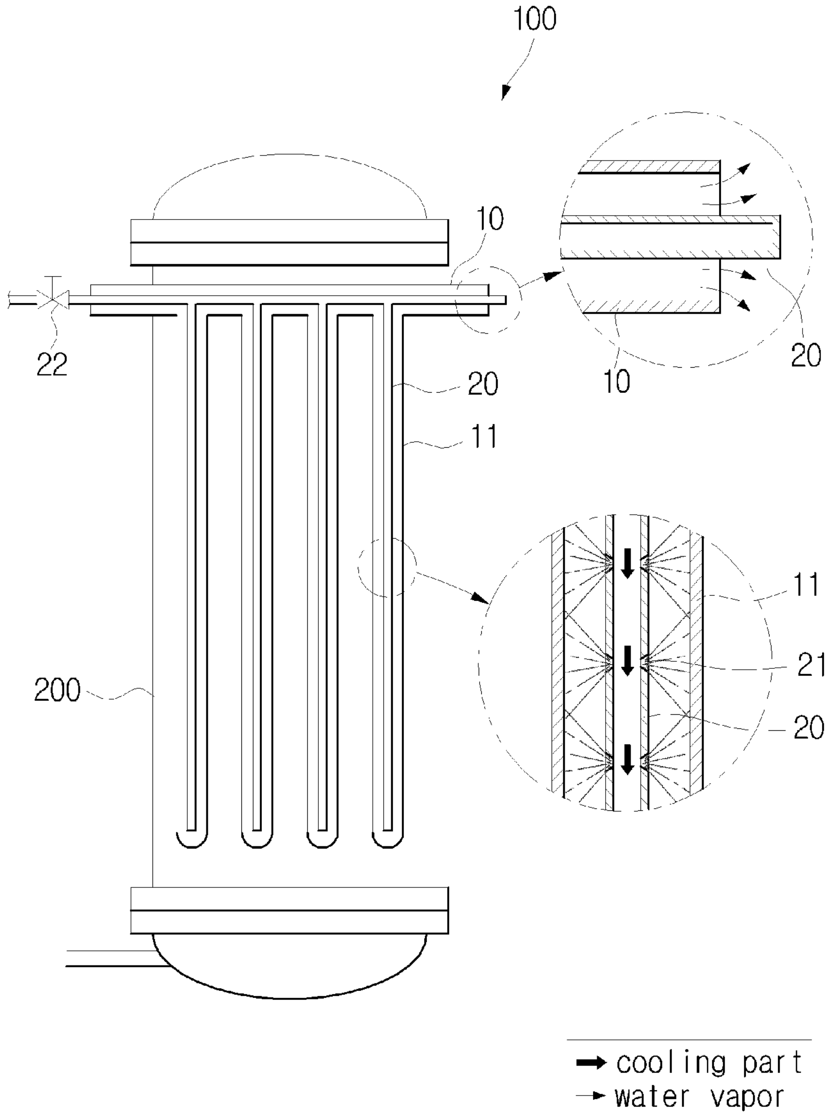
[Fig. 2]



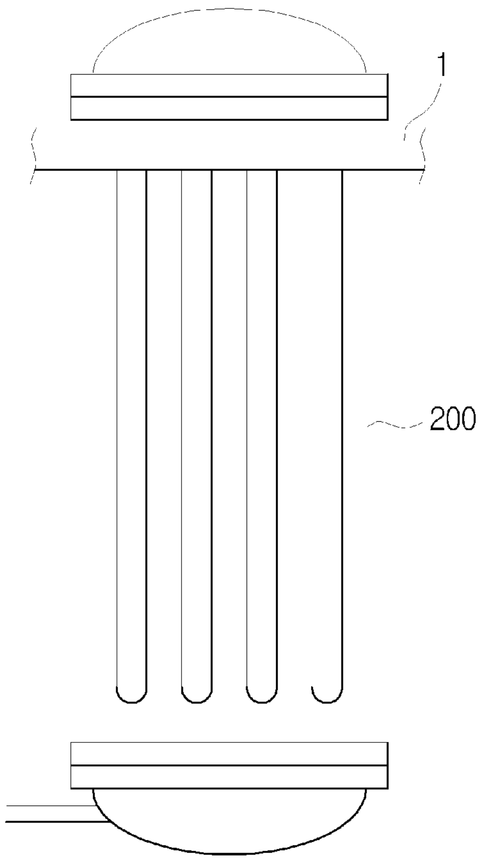
[Fig. 3]



[Fig. 4]



[Fig. 5]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2008/006592

A. CLASSIFICATION OF SUBJECT MATTER

C10B 39/04(2006.01)i

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)

IPC C10B 39/04, C07C 27/06, G21B 1/00, B29C 47/88, B29C 47/90

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

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

e-KIPASS (KIPO internal) and keywords: cooling tube, reactor, spray, nozzle, inner tube, and similar terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 6-258467 A (TOSHIBA CORP.) 16 SEPTEMBER 1994 See abstract, claim 1, paragraph 0011, and figures 1-3	1, 2, 4-6
A		3
Y	US 2005/0080147 A1 (HAWTHORNE, W. H. et al.) 14 APRIL 2005 See abstract and figures 1-3	1, 2, 4-6
A		3
A	KR 1990-0005829 B1 (KOLON CO.) 13 AUGUST 1990 See abstract and figure 1	1-6

☐ 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 application or patent but published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 MARCH 2009 (31.03.2009)	**31 MARCH 2009 (31.03.2009)**

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Facsimile No. 82-42-472-7140	Telephone No. 82-42-481-8274

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2008/006592

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 06-258467 A	16.09.1994	NONE	
US 2005-0080147 A1	14.04.2005	AU 2004-279824 A1	21.04.2005
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