Title: A PROCESS OF DETECTION FOR A RADON GAS-DENSITY AND THE DEVICE

Abstract: The present invention is to measure a radon gas concentration in the atmosphere without being influenced by atmospheric factors and other parameters as demonstrated. A radon gas concentration in the atmosphere can be detected based on the difference relationship between the first measuring value and the second measuring value which are measured by a pair of proportional detection units connected in serial to each other, wherein one of the proportional detection units is provided with an alpha particle radiating material. According to the present invention, there is provided a method and apparatus for detecting a radon gas concentration. The apparatus comprises a first proportional detection unit 3 into which air is introduced by a pumping unit 2; a second proportional detection unit 6 which is connected in serial to the first proportional detection unit 3 through a connection pipe 4 and in which a alpha particle radiating material 5 is provided; and a calculation unit 7 which receives a first measuring value and a second measuring value and compares and processes them to detect a radon gas concentration in the atmosphere, wherein the first measuring value is a pulse count by the number of alpha particles of the radon gas decayed from the air introduced into the first proportional detection unit 3, and the second measuring value is a pulse count by the number of alpha particles of the radon gas decayed from the air introduced into the second proportional detection unit and the number of alpha particles decayed from the alpha particle radiating material.
[DESCRIPTION]

[Invention Title]

A PROCESS OF DETECTION FOR A RADON GAS-DENSITY AND THE DEVICE

[Technical Field]

The present invention relates to a method and apparatus for detecting a radon gas concentration capable of detecting a concentration of radon gas remaining in the atmosphere in real time, and more particularly, to a method and apparatus for detecting a radon gas concentration continuously, inexpensively and in real time without being influenced by atmospheric factors such as temperature and humidity of the atmosphere.

[Background Art]

Generally, the human body is exposed to and irradiated with natural radiation which exists in the nature as usual. The natural radiation includes alpha ray, beta ray, gamma ray and the like radiated from radioisotopes which exist in the atmosphere, the soils and the stones, and cosmic ray radiated from the cosmos and applied to the human body together with sunlight.

Further, in addition to the natural radiation, the human body has been currently irradiated with artificial radiation (medical radiation, or radiation generated from the electronic products, such as televisions, fluorescent lamps, computers, and the like, or all the products, such as machinery, transport means, and the like) generated from facilities of civilization.

Since the radiation with which the human body is irradiated as described above causes the human body to be affected, the International Atomic Energy Agency establishes a recommendation value of 3 mSv (a unit of radiation) per year. Accordingly, the maximum permissible limit for radiation safety guide by which the human body is not exposed to 1 mSv or more per year has been established in Korea.

Specifically, the irradiation of alpha ray due to radon gas included in the air occupies 50% or more of the total amount of the radiation, to which the human body is exposed, in the natural radiation as described above, and therefore, the irradiation of alpha ray due to radon gas included in the air has been specially managed. Conventionally, a
radon concentration in the atmosphere is recommended to be maintained about 60 to 200 Bq/m\(^3\) or less, which are varied from country to country. The upper limit of a radon concentration as the indoor air quality recommendation standard has been currently assigned to be 4 pCi/l (148 Bq/m\(^3\)) in Korea.

Radon gas, which is a primary source of radiation exposure to people, continuously moves onto the ground through the soils or gravels enclosing buildings and then infiltrates to the room through spaces of buildings or holes in concrete. As such, it has been known that the radon infiltrated from the environmental soils becomes a primary source of indoor radon and building materials such as concrete, plaster board, gravel, brick, and the like also become a pollution source of the indoor radon.

Further, since the radon is easily dissolved in water, it may be introduced into the room by movement of subterranean water. The indoor movement of radon through water is caused due to water pressure or capillary phenomenon through holes in concrete. As temperature of the room is high and pressure thereof is low, a large amount of radon gas is introduced into the room.

If the human body is irradiated with alpha particle rays radiated from radioisotopes such as radon gas which exists in the atmosphere as described above, the alpha particle rays are deposited to the lungs through the respiratory organs, thereby causing a cancer in the lungs and therefore causing the human body to undergo severe biological influence.

As described above, in order to precisely evaluate a radon concentration in the air, which immensely affects the health of the human body, various types of detectors and various detection methods and apparatuses have been widely developed and used.

In methods and apparatuses for measuring and detecting a radon concentration in the atmosphere as described above, a majority of methods and apparatuses such as a scintillation counter, a gas detector such as a Geiger gas detector and a proportional gas detector, a solid state junction counter, and the like, measures the alpha particles.

The scintillation counter has a configuration, in which scintillation caused by radiation is received into a photocathode and amplified via a photomultiplier and the amplified signal is changed into an electric signal to be transferred to a counter circuit in
which the electric signal is detected, so that a scintillation material is processed by the photocathode of the photomultiplier, which amplifies the signal to provide information on the energy and the amount of alpha particles.

The scintillation material is opaque coated so that any ambient light may not be infiltrated into the measuring device, and its coating is so thin that any scratch may cause the ambient light to be infiltrated.

The alpha detector, which is filled with the gas as described above, includes a Geiger counter, an ionization counter or a proportional counter, in which specific gas is used as a detection material. In this case, the gas for detecting alpha particles or radon is should be surely sealed.

In the gas detector as described above, alpha particles are introduced through a plastic or metal window which is thin and frangible, and reach an ionization region. Using the fact that a pulse flowing between two electrodes depending on the ionization amount is proportional to the energy of incident X ray photons, the measurement of the pulse count may determine the intensity of the radiation. The output signal is constant in a Geiger counter region, whereas it is associated with energy of the alpha particles in an ionization and proportional counter region.

However, since in the aforementioned gas detector, a sensitive window of an inlet through which alpha particles are introduced is easily frangible, there is a problem in that the alpha detector which is filled with gas is insufficient to continuously detect radon.

Further, since electrons are captured by environmental charged elements or molecules when air is used as the measuring gas, the amplitude of the output signal is very small. Also, there are problems in that a reaction surface should be free from moisture or dust and the information may be changed depending on ambient atmospheric conditions such as temperature or humidity.

The junction counter as described above is a counter in which ionized charges are collected from alpha particles passing through a depletion layer, as a solid reverse-biased p-n junction semiconductor, so that it can be manufactured to be small-sized and movable. However, there are problems in that the junction counter has a strict necessary condition that a metal electrode surface of a detector should not be scratched or peeled and a scratch
causes light to be infiltrated even if such an electrode is sensitive to light and the surface coating may prevent the ambient light from being infiltrated.

【Disclosure】

【Technical Problem】

The present invention is conceived to solve the aforementioned problems of the conventional methods and apparatuses for detecting radon gas in the atmosphere. An object of the present invention is to provide a method and apparatus for detecting a radon gas concentration continuously, inexpensively and in real time without being influenced by atmospheric factors such as temperature and humidity of the atmosphere.

【Technical Solution】

A method for detecting a radon gas concentration according to the present invention for achieving the objects comprises an introduction step of allowing air in the atmosphere to be introduced into a first proportional detection unit by air pumping; a first detection step of obtaining a first measuring value, which is a pulse count by the number of alpha particles of radon gas decayed from the air introduced into the first proportional detection unit through the introduction step; a second detection step of obtaining a second measuring value, which is a pulse count by the number of alpha particles of radon gas decayed from the air introduced through the first proportional detection unit into a second proportional detection unit, in which an alpha particle radiating material is provided, and the number of alpha particles decayed from the alpha particle radiating material; and a calculation step of allowing a calculation unit to calculate a difference relationship between the first measuring value measured through the first detection step and the second measuring value measured through the second detection step thereby detecting a radon gas concentration in the atmosphere.

The calculation step is performed with a calculating formula which is expressed as follows:

\[ n_1 = n_3 \times \frac{N_1}{(N_2 - N_1)} \]

where \( n_1 \) is the number of alpha particles in the first detecting step, \( n_3 \) is the number of alpha particles emitted from the alpha particle radiating material, \( N_1 \) is the first measuring value and \( N_2 \) is the second measuring value.
Each of the first and second measuring values may be amplified by a pre-amplification unit and an amplification unit to be applied to the calculation unit.

The method may further comprise a display unit receiving and displaying data on the radon gas concentration derived via the calculation step.

The display unit may include an analog display unit.

The display unit may include a digital display unit.

The display unit may include an alarm unit for making the data be visually recognized.

The display unit may include an alarm unit for making the data be audibly recognized.

An apparatus for detecting a radon gas concentration according to the present invention for achieving the objects comprises a first proportional detection unit into which air is introduced by a pumping unit; a second proportional detection unit which is connected in serial to the first proportional detection unit through a connection pipe and in which a alpha particle radiating material is provided; and a calculation unit which receives a first measuring value and a second measuring value and compares and processes them to detect a radon gas concentration in the atmosphere, wherein the first measuring value is a pulse count by the number of alpha particles of the radon gas decayed from the air introduced into the first proportional detection unit, and the second measuring value is a pulse count by the number of alpha particles of the radon gas decayed from the air introduced into the second proportional detection unit and the number of alpha particles decayed from the alpha particle radiating material.

Each pair of pre-amplification and amplification units may be interposed between the first proportional detection unit and the calculation unit and between the first proportional detection unit and the calculation unit.

The apparatus may further comprise a display unit receiving and displaying data on the radon gas concentration derived via the calculation step.

【Advantageous Effects】

A method and apparatus for detecting a radon gas concentration according to the present invention as described above has an effect in that a concentration of radon gas in
the atmosphere can be detected continuously, inexpensively and in real time without being influenced by atmospheric factors such as temperature and humidity of the atmosphere.

【Description of Drawings】

Fig. 1 is an exemplary schematic view illustrating a method and apparatus for detecting a radon gas concentration according to an embodiment of the present invention.

【Best Mode】

Hereinafter, a method and apparatus for detecting a radon gas concentration of a preferred embodiment according to the present invention will be described in detail with reference to the accompanying drawings.

Fig. 1 is a view showing a method and apparatus for detecting a radon gas concentration according to an embodiment of the present invention. The method for detecting a radon gas concentration comprises an introduction step of allowing air in the atmosphere to be introduced into a first proportional detection unit 3 by air pumping; a first detection step of obtaining a first measuring value, which is a pulse count by the number of alpha particles of radon gas decayed from the air introduced into the first proportional detection unit 3 through the introduction step; a second detection step of obtaining a second measuring value, which is a pulse count by the number of alpha particles of radon gas decayed from the air introduced through the first proportional detection unit into a second proportional detection unit 6, in which an alpha particle radiating material 5 is provided, and the number of alpha particles decayed from the alpha particle radiating material 5; and a calculation step of allowing a calculation unit 7 to calculate a difference relationship between the first measuring value measured through the first detection step and the second measuring value measured through the second detection step thereby detecting a radon gas concentration in the atmosphere.

Each of the first and second measuring values is allowed to be amplified by a pre-amplification unit 8 and an amplification unit 9 to be applied to the calculation unit 7.

There is further provided a display unit 14, which receives and displays the data on the radon gas concentration derived via the calculation step.

The display unit 14 may include an analog display unit or a digital display unit. Alternatively, the display unit may include an alarm unit for making the data on the radon
gas concentration be visually or audibly recognized.

In addition, an apparatus 1 for detecting a radon gas concentration according to this embodiment comprises the first proportional detection unit 3 into which air is introduced by a pumping unit 2; the second proportional detection unit 6 which is connected in serial to the first proportional detection unit 3 through a connection pipe 4 and in which the alpha particle radiating material 5 is provided; and the calculation unit 7 which receives the first measuring value and the second measuring value and compares and processes them to detect a radon gas concentration in the atmosphere, wherein the first measuring value is a pulse count by the number of alpha particles of the radon gas decayed from the air introduced into the first proportional detection unit 3, and the second measuring value is a pulse count by the number of alpha particles of the radon gas decayed from the air introduced into the second proportional detection unit and the number of alpha particles decayed from the alpha particle radiating material.

Each pair of the pre-amplification and amplification units 8 and 9 is interposed between the first proportional detection unit 3 and the calculation unit 7 and between the first proportional detection unit 3 and the calculation unit 7.

Each of the first and second proportional detection units 3 and 6 is configured to have a structure of a conventional proportional counter.

Each of the first and second proportional detection units 3 and 6 is configured to be positioned in a conventional metal box in order not to be influenced by external electromagnetic radiation, in which a negative electrode 10 is conventionally formed of an aluminum cylinder with a diameter of 50 mm and a length of 250 mm, and an Mo wire with a diameter of 6.5µm is provided as a positive electrode 11 in the center of the cylinder.

Further, the negative electrode 10 is provided with two small insulated tubes 12, and a distal end of the negative electrode is connected to a silicone tube 13 through which air is pumped and introduced.

In addition, the positive electrode 11 is connected to the pre-amplification unit 8 which is housed in a small metal box in order not to be influenced by external electromagnetic radiation, wherein the pre-amplification unit 8 is interposed between and connected to the amplification unit 9 and the first or second proportional detection unit 3 or
6.

The pre-amplification unit 8 includes a conventional preamplifier, and it is most preferable that an amplification factor be 75.

It is most preferable that the detection time of the first or second proportional detection unit 3 or 6 be 2 to 5 minutes when the alpha particle radiating material 5 has a radioactivity of 3 to 5 Bq.

The radioactivity emitted from the alpha particle radiating material 5 is so small that it is absolutely safe, and the alpha particle radiating material may be composed of various radioisotopes. For example, about 1 to 3 mg of uranium salt may be used.

In order to detect a concentration of radon gas in the atmosphere by the method and apparatus for detecting a radon gas concentration according to this embodiment so configured, the pumping unit 2 first causes air to be introduced into the first proportional detection unit 3 and the second proportional detection unit 6. Then, the first proportional detection unit 3 detects the number n1 of alpha particles of the radon gas decayed in the air introduced therein for a predetermined time, and the second proportional detection unit 6 detects the number n3 of alpha particles decayed from the alpha particle radiating material 5 and the number n2 of alpha particles decayed from the radon gas introduced therein for the same predetermined time, so that the first proportional detection unit 3 and the second proportional detection unit 6 count the pulses N1 and N2 according to the numbers of alpha particles, respectively.

The pulses N1 and N2 as described above are counted as follows:

\[ N1 = n1 * k * K(h, t^0, p, ...) \]
\[ N2 = n2 * k * K(h, t^0, p, ...) + n3 * k * K(h, t^0, p, ...) \]

where k is a measuring efficiency coefficient of the first and second proportional detection units 3 and 6, K(h, t^0, p, ...) is a coefficient which reflects various parameters, such as humidity h of air, temperature t^0 of air, atmospheric pressure p, an measurement limitation value due to a low signal of an electronic device, a voltage value of a high voltage generator, and the like.

Since n1 = n2 in the above equations, N2/N1 may be represented as follows:

\[ N2/N1 = (n2 * k * K(h, t^0, p, ...) + n3 * k * K(h, t^0, p, ...))/ n1 * k * K(h, t^0, p,...) \]
\[(n1 + n3)/n1 = 1 + n3/n1\]

The equation is not influenced by the properties of the atmosphere and other factors but depends only on the concentration of the radon gas, so that \( n1 \) may be arranged as follows:

\[ n1 = n3 \times \frac{N1}{(N2 - N1)} \]

When \( n1 \) is calculated, an error \( \delta \) is influenced by statistical errors of \( N1 \) and \( N2 \). Since a statistical error in a Poisson distribution function is represented as \( \delta N / N = 1/\sqrt{N} \), the radioactivity of the alpha particle radiating material 5 should be large that the influence of the statistical error of \( N2 \) can be sufficiently prevented when \( n1 \) is calculated. Thus, it can be understood that when the measuring rate is at least 1000 cpm (counts per minute), the following relationship is satisfied:

\[ N2 \gg N1 \]

As described above, the concentration of radon gas in the atmosphere which is measured and calculated by this embodiment can be detected without being influenced by the atmospheric factors (temperature and humidity) and other parameters, which will be described in detail through following experimental examples.

【Mode for Invention】

(Experimental Example 1)

The following graph shows that the proportional detection units proportionally operate when a voltage \( V \) of the positive electrode ranges from 2750 to 3050 V. The characteristics of the proportional detection units were examined under a positive voltage \( V \) of 2600 to 3100 V (at an interval of 50 V), and uranium salt \((UO_2(NO_3)_2)\) of 3 mg was used as the alpha particle radiating material 5.
(Experimental Example 2)

When a change in temperature and humidity has been detected, the influence on the stability was evaluated in a chamber in which weather may be changed. To this end, another alpha particle radiating material 5 is also provided in the first proportional detection unit 3 to be measured.

The atmospheric condition is specified as a humidity of 28 to 95% and a temperature of 25 to 40 °C in the atmosphere, and the measuring time is 10 minutes. The measuring result has been detected as Table 1.

<table>
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<tr>
<th>No.</th>
<th>t° [°C]</th>
<th>H [%]</th>
<th>N1 ±</th>
<th>N2 ±</th>
<th>N1/N2</th>
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<tr>
<td>1</td>
<td>25</td>
<td>28</td>
<td>1890±44</td>
<td>2172±46</td>
<td>0.87±0.04</td>
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<tr>
<td></td>
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<td>31</td>
<td>1831±43</td>
<td>2129±46</td>
<td>0.86±0.04</td>
</tr>
<tr>
<td></td>
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<td>32</td>
<td>1804±42</td>
<td>2050±45</td>
<td>0.88±0.04</td>
</tr>
<tr>
<td>2</td>
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<td>2082±46</td>
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<tr>
<td></td>
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<tr>
<td>3</td>
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<td>1650±41</td>
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As described in Table 1, the number of respective measured pulses is changed by about 20% whereas N1/N2 value is shown to be constant within its measuring error.

Further, the calibration of the proportional detection units was performed with the air which passes through a small chamber with a volume of 5 ml containing UO₂(NO₃)₂ with its weight ranging between 3 mg and 3 g, and the radioactivity was measured using RRA-01M-01 and a generally developed detector.

The measurements were performed five times on each UO₂(NO₃)₂ of 3 mg, 15 mg, 150 mg, 750 mg and 3g in weight. The measurement results were used to determine an error Δ (with 95 % reliability) of the measured radon concentration to a radon concentration C.

The calibration curve for the proportional detection units may be approximately represented as the following function.

\[ C = 3\frac{N1}{(N2-N1)} \]

where C is a radon concentration represented as Bq.

(Experimental Example 3)

The following graph shows an error distribution of the measured radon concentration to the radon concentration C.
(Experimental Example 4)

In order to examine the influence of the solid-type radon daughter nuclides which are deposited onto a surface of the negative electrode of the proportional detection unit, air is pumped to a detector for 30 minutes through a chamber containing 3 g of UO$_2$(NO$_3$)$_2$ and then the chamber is removed.

After 5 minutes, the detection apparatus according to this embodiment detected N1 and N2 values of 2 Bq/m$^3$. However, there were no values measured by the conventional radioactive measurement apparatus RRA-01M-01 for 5 hours.

The present invention is to measure a radon gas concentration in the atmosphere without being influenced by atmospheric factors and other parameters as demonstrated through the detailed experimental examples. In the method and apparatus for detecting a radon gas concentration according to the present invention, one proportional detection unit is provided with an alpha particle radiating material, and the radon gas concentration in the atmosphere is detected based on the difference relationship between the first measuring value and the second measuring value which are measured by a pair of proportional detection units. The present invention is not limited to the aforementioned embodiment. It will be apparent that those skilled in the art can make various modifications and changes
thereto without departing from the scope of the invention defined by the claims. In addition, such modifications are included in the scope of the appended claims.

【Industrial Applicability】

The present invention can provide a method and apparatus for detecting a radon gas concentration in the atmosphere continuously, inexpensively and in real time without being influenced by atmospheric factors such as temperature and humidity of the atmosphere.
【CLAIMS】

【Claim 1】

A method for detecting a radon gas concentration, comprising:

an introduction step of allowing air in the atmosphere to be introduced into a first proportional detection unit by air pumping;

a first detection step of obtaining a first measuring value, the first measuring value being a pulse count by the number of alpha particles of radon gas decayed from the air introduced into the first proportional detection unit through the introduction step;

a second detection step of obtaining a second measuring value, the second measuring value being a pulse count by the number of alpha particles of radon gas decayed from the air introduced through the first proportional detection unit into a second proportional detection unit having an alpha particle radiating material provided therein and the number of alpha particles decayed from the alpha particle radiating material; and

a calculation step of allowing a calculation unit to calculate a difference relationship between the first measuring value measured through the first detection step and the second measuring value measured through the second detection step thereby detecting a radon gas concentration in the atmosphere.

【Claim 2】

The method as claimed in claim 1, wherein the calculation step is performed with a calculating formula which is expressed as follows:

\[ n_1 = n_3 \times \frac{N_1}{(N_2 - N_1)} \]

where \( n_1 \) is the number of alpha particles in the first detecting step, \( n_3 \) is the number of alpha particles emitted from the alpha particle radiating material, \( N_1 \) is the \( n_1 \) and \( N_2 \) is the second measuring value.

【Claim 3】

The method as claimed in claim 1, wherein each of the first and second measuring values is amplified by a pre-amplification unit and an amplification unit to be applied to the calculation unit.

【Claim 4】
The method as claimed in claim 1, wherein data on the radon gas concentration derived via the calculation step is received in and displayed on a display unit.

【Claim 5】

The method as claimed in claim 4, wherein the display unit includes an analog display unit.

【Claim 6】

The method as claimed in claim 4, wherein the display unit includes a digital display unit.

【Claim 7】

The method as claimed in claim 4, wherein the display unit includes an alarm unit for making the data be visually recognized.

【Claim 8】

The method as claimed in claim 4, wherein the display unit includes an alarm unit for making the data be audibly recognized.

【Claim 9】

An apparatus for detecting a radon gas concentration, comprising:

a first proportional detection unit allowing air to be introduced thereinto by a pumping unit;

a second proportional detection unit connected in serial to the first proportional detection unit through a connection pipe, the second proportional detection unit having an alpha particle radiating material provided therein; and

a calculation unit receiving a first measuring value and a second measuring value and comparing and processing them to detect a radon gas concentration in the atmosphere, wherein the first measuring value is a pulse count by the number of alpha particles of the radon gas decayed from the air introduced into the first proportional detection unit, and the second measuring value is a pulse count by the number of alpha particles of the radon gas decayed from the air introduced into the second proportional detection unit and the number of alpha particles decayed from the alpha particle radiating material.

【Claim 10】
The apparatus as claimed in claim 9, wherein each pair of pre-amplification and amplification units is interposed between the first proportional detection unit and the calculation unit and between the first proportional detection unit and the calculation unit.

【Claim 11】

The apparatus as claimed in claim 9, further comprising a display unit receiving and displaying data on the radon gas concentration derived via the calculation step.
A. CLASSIFICATION OF SUBJECT MATTER

G01T 7/02(2006.01)ji

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 8 G01T 7/02

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

Korean Utility models and applications for Utility models since 1975
Japanese Utility models and applications for Utility models since 1975

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

eKIPASS (KIPO internal)

Keywords: "radon", "alpha", "pump", and similar terms.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<td>A</td>
<td>US 4864143 A (P.AI. HSIIANG L.) 5 September 1989 see abstract; column 3, line 59-column 4, line 2; figure 1</td>
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<td>A</td>
<td>US 4055762 A (DURKIN, JOHN) 25 October 1977 see abstract; column 1, lines 39-55; figure 1</td>
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☐ 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
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"&" document member of the same patent family

Date of the actual completion of the international search
28 OCTOBER 2008 (28.10.2008)

Date of mailing of the international search report
28 OCTOBER 2008 (28.10.2008)

Name and mailing address of the ISA/KR

Korean Intellectual Property Office
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Facsimile No. 82-42-472-7140

Authorized officer

Kim, Sang Hee

Telephone No. 82-42-481-5499

Form PCT/ISA/210 (second sheet) (July 2008)
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