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

(11) **EP 3 886 116 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
29.09.2021 Bulletin 2021/39

(21) Application number: **19887211.1**

(22) Date of filing: **20.11.2019**

(51) Int Cl.:
G21F 9/12 *(2006.01)* ***G01T 7/08*** *(2006.01)*
G01N 1/10 *(2006.01)* ***G01N 1/28*** *(2006.01)*
G01T 1/167 *(2006.01)*

(86) International application number:
PCT/KR2019/015942

(87) International publication number:
WO 2020/106058 (28.05.2020 Gazette 2020/22)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **21.11.2018 KR 20180144557**
23.10.2019 KR 20190132518

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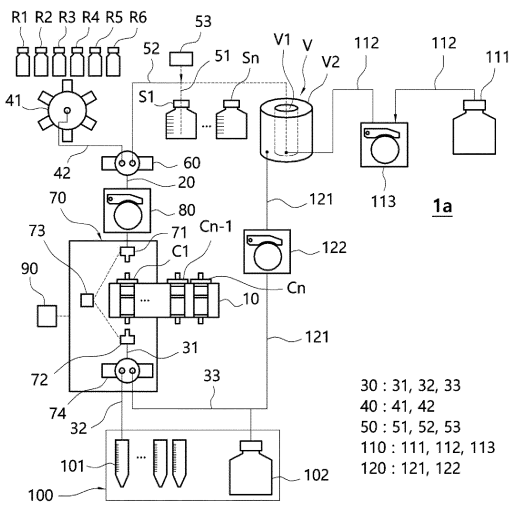
(54) NUCLIDE SEPARATING DEVICE

(57) A nuclide separating device is disclosed. A nuclide separating device according to one aspect of the present invention comprises: a column arrangement part in which a plurality of columns are arranged; a first fluid channel through which a reagent or a sample to be introduced into each of the columns arranged in the column arrangement part is transferred; a second fluid channel through which a purified sample or waste discharged from the column is delivered to a collection part; a fluid channel forming part for connecting or disconnecting the first fluid channel and the second fluid channel to or from a random column arranged in the column arrangement part; a main pump for supplying pressure to introduce the reagent or the sample into the first fluid channel and to discharge the purified sample or waste from the column; and a transfer part for transferring the fluid channel forming part so that the fluid channel forming part can connect or disconnect the first fluid channel and the second fluid channel to or from another random column arranged in the column arrangement part.

【FIG. 1】



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Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to and the benefit of Korean Patent Application No. 10-2018-0144557, filed on November 21, 2018 and Korean Patent Application No. 10-2019-0132518, filed on October 23, 2019 the disclosure of which is incorporated herein by reference in its entirety.

[Technical Field]

[0002] The present invention relates to a nuclide separating device, and more specifically, the present invention relates to a nuclide separating device that separates a nuclide of interest from a sample for performing the evaluation of radioactive properties of radioactive waste, decommissioned waste, and the like.

[Background Art]

[0003] The evaluation of radioactive properties of radioactive waste (solids, soil, water, *etc.)* or decommissioned waste (concrete, metal, *etc.)* is a very important factor in the disposal of radioactive waste or the decommissioning of nuclear power plants. This is because disposal strategies and disposal costs vary depending on the radioactive concentrations derived through the evaluation of radioactive properties.

[0004] The evaluation of radioactive properties of radioactive waste and decommissioned waste is based on the results of gamma nuclide analysis and alpha/beta nuclide analysis. Among these, in the case of alpha/beta nuclides, chemical separation must be required due to the radioactive characteristics and the properties of detectors. The chemical separation technique used in recent years is based on the extraction chromatography method, and the extraction chromatography method is a method of separating nuclides of interest and interfering ions after filling a column with resin.

[0005] As such, the chemical separation process is complicated and takes a long time, and the difference in separation efficiency may be large depending on the skill of the analyst. In order to solve such a problem, an automatic nuclide separating device that automatically performs nuclide separation using chemical separation technology has been introduced.

[0006] However, the automatic nuclide separating device according to the prior art has a limitation in terms of throughput, because the maximum number of samples that can be continuously separated is eight. Accordingly, there is a need to develop a nuclide separating device capable of increasing the efficiency of a process in which a large number of samples are generated, such as a process for evaluating radioactive characteristics of decommissioned wastes in which 40 or more samples are generated per day and the like.

[Disclosure]

[Technical Problem]

[0007] The present invention is to solve the problems of the prior art described above, and the present invention aims to provide a nuclide separating device capable of continuously performing nuclide separation for a number of samples.

[Technical Solution]

[0008] According to an aspect of the present invention, provided is a nuclide separating device including a column arrangement part in which a plurality of columns are arranged; a first fluid channel through which a reagent or sample to be introduced into each of the columns arranged in the column arrangement part is transferred; a second fluid channel through which a purified sample or waste discharged from the column is delivered to a collection part; a fluid channel forming part for connecting or disconnecting the first fluid channel and the second fluid channel to or from a random column arranged in the column arrangement part; a main pump for supplying pressure to introduce the reagent or the sample into the first fluid channel and to discharge the purified sample or waste from the column; and a transfer part for transferring the fluid channel forming part so that the fluid channel forming part can connect or disconnect the first fluid channel and the second fluid channel to or from another random column arranged in the column arrangement part.

[0009] In this case, the transfer part may be capable of transferring the fluid channel forming part back and forth, and left and right.

[0010] In addition, the fluid channel forming part may include a first fluid channel connection part disposed above the column to connect or disconnect the first fluid channel to or from the upper portion of the column; a second fluid channel connection part disposed below the column to connect or disconnect the second fluid channel to or from the lower portion of the column; and an operational part for lowering or raising the first fluid channel connection part to connect or disconnect the first fluid channel to or from the upper portion of the column, and raising or lowering the second fluid channel connection part to connect or disconnect the second fluid channel to or from the lower portion of the column.

[0011] In addition, the collection part may include a purified sample collection container in which the purified sample is collected, and a waste collection container in which the waste is collected, and the fluid channel forming part may further include a discharge selection valve for selectively connecting the second fluid channel connection part to any one of the purified sample collection container and the waste collection container.

[0012] In addition, the nuclide separating device may further include a reagent supply part for selecting a ran-

dom reagent among a plurality of reagents and supplying the same to the first fluid channel; a sample supply part for supplying the sample to the first fluid channel; and an inlet selection valve disposed in the first fluid channel to selectively connect the first fluid channel to any one of the reagent supply part and the sample supply part.

[0013] In addition, the sample supply part may include a needle for penetrating into a sample container containing the sample; a sample supply fluid channel formed between the needle and the inlet valve; and a needle transfer part for transferring the needle.

[0014] In addition, the sample supply part may further include a washing solution container containing a washing solution for washing the sample supply fluid channel, the first fluid channel, and the second fluid channel, and the needle transfer part may be capable of transferring the needle to penetrate into the washing solution container.

[0015] In addition, the sample supply part may include a plurality of sample containers for containing each different sample, and the needle and the needle transfer part may be controlled in a predetermined manner so that the samples in a plurality of sample containers and a washing solution in the washing solution container are supplied to the sample supply fluid channel according to a predetermined order.

[0016] In addition, the collection part may include a purified sample collection container in which the purified sample is collected, and a waste collection container in which the waste is collected; and a residual washing solution discharge part for transferring the residual washing solution in the washing solution container to the waste collection container.

[0017] In addition, the residual washing solution discharge part may include a washing solution discharge fluid channel formed between the washing solution container and the waste collection container; and a residual washing solution discharge pump for supplying pressure so that the residual washing solution is introduced into the washing solution discharge fluid channel.

[Advantageous Effects]

[0018] According to an exemplary embodiment of the present invention, extraction of a plurality of columns can be efficiently performed through a fluid channel forming part for connecting or disconnecting a random column disposed in the column arrangement part to or from a transfer part for transferring the fluid channel forming part.

[Description of Drawings]

[0019]

FIG. 1 is a configurational diagram of a nuclide separating device according to an exemplary embodiment of the present invention.

FIG. 2 is a view showing an implementation example of a column arrangement part according to an exemplary embodiment of the present invention.

FIG. 3 is a view showing an embodiment of the fluid channel forming part of a nuclide separating device according to an exemplary embodiment of the present invention.

FIG. 4 is a view briefly showing the arrangement of columns and the transfer of the fluid channel forming part in a nuclide separating device according to an exemplary embodiment of the present invention.

FIGS. 5 and 6 are perspective views of a nuclide separating device according to another exemplary embodiment of the present invention.

FIG. 7 is a perspective view of the fluid channel structure of a separation part of a nuclide separating device according to another exemplary embodiment of the present invention.

FIGS. 8 and 9 are views showing the operational process of a nuclide separating device according to another exemplary embodiment of the present invention.

[Modes of the Invention]

[0020] Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings such that those skilled in the art to which the present invention pertains may easily practice. The present invention may be implemented in many different forms and is not limited to the exemplary embodiments described herein. In order to clearly describe the present invention, parts not relevant to the description in the drawings are omitted, and like reference numerals are assigned to the same or similar constitutional elements throughout the specification.

[0021] In the present specification, terms such as "include" or "have" are intended to describe the presence of features, numbers, steps, operations, components, parts, or a combination thereof described in the specification, but it is to be understood that it does not preclude the possibility of the presence or addition of one or more other features, numbers, steps, operations, components, parts, or a combination thereof.

[0022] FIG. 1 is a configurational diagram of a nuclide separating device according to an exemplary embodiment of the present invention.

[0023] The nuclide separating device according to an exemplary embodiment of the present invention is intended to be used in the nuclide analysis required for the evaluation of radioactive properties of radioactive waste and decommissioned waste, and in particular, it may be used for chemical separation of alpha/beta nuclides. More specifically, the nuclide separating device according to an exemplary embodiment of the present invention allows that continuous chemical separation may be performed after filling the column with resin for a number of samples according to the extraction chromatography

method of separating nuclides of interest and interference ions.

[0024] Referring to FIG. 1, the nuclide separating device 1a according to an exemplary embodiment of the present invention includes a column arrangement part 10, a first fluid channel 20, a second fluid channel 30, a reagent supply part 40, a sample supply part 50, an inlet selection valve 60, a fluid channel forming part 70, a main pump 80, a transfer part 90, a collection part 100, a washing solution supply part 110, and a residual washing solution discharge part 120.

[0025] A plurality of columns C1 to Cn are arranged in the column arrangement part 10. The column arrangement part 10 allows a plurality of columns C1 to Cn to be simultaneously arranged such that separation of a plurality of samples may be continuously performed.

[0026] The column arrangement part 10 may be formed of a tray having a plurality of column arranging holes 11 formed in a shape penetrated up and down to expose the upper and lower portions of the arranged column. Referring to FIG. 2, in an exemplary embodiment of the present invention, the column arrangement part 10 is formed of a rectangular tray. Other than the above, depending on the shape of the transfer part 90 to be described below, the column arrangement part 10 may be formed of a tray of another type such as an annular shape and the like.

[0027] The columns C1 to Cn are disposed by one in each column arrangement hole 11 of the column arrangement part 10. The columns C1 to Cn are members into which reagents and samples are introduced. Resin is filled in the columns C1 to Cn, and reagents and samples are introduced therein to separate the purified sample including nuclides of interest and other wastes.

[0028] The first fluid channel 20 is a fluid channel through which reagents or samples to be introduced into the column disposed in the column arrangement part 10 are transferred. The first fluid channel 20 is connected to the reagent supply part 40, the sample supply part 50, and the inflow selection valve 60. Depending on the operation of the inflow selection valve 60, the first fluid channel 20 may be selectively connected to any one of the reagent supply unit 40 and the sample supply unit 50.

[0029] The second fluid channel 30 delivers the purified sample or waste discharged from the column to the collection part 100. The second fluid channel 30 has one end connected to the fluid channel forming part 70 and the other end connected to the collecting part 100.

[0030] The second fluid channel 30 includes Fluid Channel 2-1 through which the purified sample or waste discharged from the column is introduced, Fluid Channel 2-2 32 for connecting a discharge selection valve 74 of a fluid channel forming part 70 to a purified sample collection container 101 of the collection part, and Fluid Channel 2-3 for connecting a discharge selection valve 74 of a fluid channel forming part 70 to a waste collection container 102 of a collection part 100.

[0031] The reagent supply part 40 selects a random reagent among a plurality of reagents and supplies the same to the first fluid channel 20. In an exemplary embodiment of the present invention, the reagent supply part 40 may supply six reagents R1 to R6, and the reagent selection valve 41 selects one reagent of the above and supplies the same to the first fluid channel.

[0032] Assuming that three reagents are used in the nuclide separating device according to an exemplary embodiment of the present invention, the first reagent R1 may be for column optimization, the second reagent R2 may be for washing and removing of interfering nuclides, and the third reagent R3 may be for extracting the nuclide of interest.

[0033] Meanwhile, when there are many interfering nuclides, more reagents may be used for washing and removing interfering nuclides, and accordingly, more reagents may be used. Furthermore, the number of reagents that the reagent supply part 40 may supply or the form of the reagent selection valve 41 may be changed as necessary.

[0034] The sample supply part 50 supplies a sample to the first fluid channel 20. Herein, the sample is obtained from radioactive waste and decommissioned waste, and it is a subject for which it is necessary to determine whether nuclides of interest are included, the amount thereof, and the like.

[0035] The sample supply part 50 may include a plurality of sample containers S1 to Sn containing samples, a needle 51 for penetrating into the sample container containing the sample, a sample supply fluid channel 52 formed between the needle 51 and the inflow selection valve 60, and a needle transfer part 53 for transferring the needle.

[0036] When the sample contained in any one of the sample containers is supplied to the first fluid channel 20 and the extraction of the nuclide of interest is performed, the needle transfer part 53 may transfer the needle 51 such that the sample contained in the other sample container may be supplied to the first fluid channel 20.

[0037] The sample supply part 50 may further include a washing solution container V containing a washing solution for washing the fluid channel. For accurate analysis, after extracting a nuclide of interest for one sample and before supplying another sample to the first fluid channel 20, it is necessary to wash the sample supply fluid channel 52, the first fluid channel 20, the second fluid channel 30, and the like, and the needle transfer part 53 may transfer the needle 51 to penetrate into the washing solution container V.

[0038] Meanwhile, the sample supply part 50 may be automated by a computer program. For example, the needle 51 and the needle transfer part 53 are controlled by a computer program to continuously perform the separation of the nuclide of interest for a plurality of samples to operate such that the sample in a plurality of sample containers S1 to Sn and the washing solution in the washing solution container V are supplied to the fluid channel in a predetermined order.

[0039] The inflow selection valve 60 selectively connects the first fluid channel 20 to any one of the reagent supply part 40 and the sample supply part 50. The inflow selection valve 60 may be connected to one end of the first fluid channel 20 to connect the first fluid channel 20 to the reagent supply part 40 or the sample supply part 50.

[0040] The fluid channel forming unit 70 connects or disconnects the first fluid channel 20 and the second fluid channel 30 to or from a random column arranged in the column arrangement part 10. In an exemplary embodiment of the present invention, the fluid channel forming part 70 includes a first fluid channel connection part 71, a second fluid channel connection part 72, an operational part 73, and a discharge selection valve 74.

[0041] The first fluid channel connection part 71 is disposed above the column to connect or disconnect the first fluid channel 20 to or from the upper portion of the column. The second fluid channel connection part 73 is disposed below the column to connect or disconnect the second fluid channel 30 to or from the lower portion of the column. The operational part 73 lowers or raises the first fluid channel connection part 71 to connect or disconnect the first fluid channel 20 to or from the upper portion of the column, and raises or lowers the second fluid channel connection part 72 to connect or disconnect the second fluid channel 30 to or from the lower portion of the column.

[0042] Meanwhile, the discharge selection valve 74 selectively connects the second fluid channel connection part 72 with any one of the purification sample collection container 101 and the waste collection container 102 of the collection unit 100. More specifically, the discharge selection valve 74 connects the second fluid channel connection part 72 to the waste collection container 102 in the process of optimizing the column and separating interfering nuclides, and connects the second fluid channel connection part 72 to the purified sample collection container 101 in the process of extracting the nuclide of interest.

[0043] FIG. 3 is a view showing an embodiment of the fluid channel forming part of a nuclide separating device according to an exemplary embodiment of the present invention.

[0044] Referring to FIG. 3, the fluid channel forming part 70 is formed in a '⊏' shape and is implemented on a plate 701 in a shape in which a column may be arranged between the upper end and the lower end of one side. The first fluid channel connection part 71, the second fluid channel connection part 72, and the discharge selection valve 74 are disposed to be connected with the operational part 73.

[0045] The operational part 73 includes a guide rail 731 provided in the vertical direction on the other side of the plate 701, an upper operational body 732 disposed in a shape that may be raised and lowered from the top of the guide rail 731, and a lower operational body 733 disposed in a shape that may be raised and lowered from the bottom of the guide rail 731. In this case, the upper operational body 732 and the lower operational body 733 may include a servo motor.

[0046] The first fluid channel connection part 71 is coupled to a portion of the upper operational body 732 that extends to one side of the plate 701, and the second fluid channel connection part 72 is coupled to a portion of the lower operational body 733 that extends to one side of the plate 701. In addition, the discharge selection valve 74 may be coupled to the lower operational body 733 to be integrally operated with the lower operational body 733.

[0047] When the upper operational body 732 descends and the lower operational body 733 rises, the first fluid channel connection part 71 and the second fluid channel connection part 72 are coupled to the upper and lower portions of the column, respectively, to connect the column, the first fluid channel 20, and the second fluid channel 30. In this connected state, the reagent or sample is supplied to the column, and optimization of the column, removal of interfering nuclides, extraction and washing of the nuclides of interest, and the like are performed.

[0048] When the upper operational body 732 rises and the lower operational body 733 descends, the first fluid channel connection part 71 and the second fluid channel connection part 72 are separated from the upper and lower portions of the column, respectively, to separate the column, the first fluid channel 20, and the second fluid channel 30. In this separated state, the fluid channel forming part 70 may be transferred to any random column disposed in the column arrangement part 10 by the transfer part 90.

[0049] The main pump 80 supplies pressure such that the reagent or sample is introduced into the first fluid channel 20, and the purified sample or waste is discharged from the column. The main pump 80 may be disposed on the first fluid channel 20.

[0050] While the inflow selection valve 60 connects the first fluid channel 20 to the reagent supply part 40, the main pump 80 supplies the reagent to the first fluid channel 20, and while the inlet selection valve 60 connects the first fluid channel 20 to the sample supply part 50, the main pump 80 supplies the sample to the first fluid channel 20.

[0051] The transfer part 90 transfers a fluid channel forming part 70 such that the fluid channel forming part 70 may connect or disconnect the first fluid channel 20 and the second fluid channel 30 to or from any random column arranged in the column arrangement part 10.

[0052] In an exemplary embodiment of the present invention, the transfer part 90 may transfer the fluid channel forming part 70 back and forth, and left and right while the fluid channel forming part 70 is separated from the first fluid channel 20 and the second fluid channel 30. When the fluid channel forming part 70 is implemented in the same manner as in FIG. 3, the transfer unit 90 may transfer the plate 701 of the fluid channel forming part 70 back and forth, and left and right through a ball screw

method, a method of using a motor and a guide rail, or the like. That is, the transfer part 90 may be formed of a ball screw structure, a motor, a guide rail structure, or the like

[0053] FIG. 4 is a view briefly showing the arrangement of columns and the transfer of the fluid channel forming part in a nuclide separating device according to an exemplary embodiment of the present invention.

[0054] Referring to FIG. 4, extraction of a nuclide of interest for one column C1 is performed in the transfer unit 90, and when the first fluid channel connection part 71 and the second fluid channel connection part 72 of the fluid channel forming part 70 are separated from the column C1, the fluid channel forming part 70 may be transferred along the X-axis or the Y-axis. Accordingly, the fluid channel forming part 70 may be transferred to one column C1 and a column C2 arranged adjacent to the X-axis direction or a column C3 arranged adjacent to the Y-axis direction, and the corresponding column C2 or C3 and the first fluid channel 20 and the second fluid channel 30 may be connected. Accordingly, continuous extraction for a plurality of columns may be efficiently performed.

[0055] The collection part 100 is a part for collecting a purified sample or waste discharged through the second fluid channel 30. The collection part 100 includes a purified sample collection container 101 in which purified samples are collected and a waste collection container 102 in which wastes are collected.

[0056] In an exemplary embodiment of the present invention, the purified sample collection container 101 may be arranged to correspond one-to-one with the column disposed in the column arrangement part 10. That is, the purified sample collection container 101 may be arranged in a tray-shaped purified sample collection part (not illustrated) having a purified sample collection container insertion hole at a position corresponding to the column position of the column arrangement part 10. Through this arrangement, continuous separation of nuclides of interest for multiple samples may be performed more efficiently.

[0057] The washing solution supply part 110 supplies a washing solution to the washing solution container V of the sample supply part 50. The washing solution supply part 110 includes a washing solution tank 111, a washing solution supply fluid channel 112, and a washing solution supply pump 113.

[0058] In an exemplary embodiment of the present invention, the washing solution container V may include an inner container V1 and an outer container V2 surrounding the inner container V1. The inner container V1 is a portion in which the washing solution for washing the sample supply fluid channel 52, the first fluid channel 20, and the second fluid channel 30 is stored, and the outer container V2 is a portion in which the washing solution overflowing in the inner container V1 is stored.

[0059] On the premise that the washing solution container V is configured as above, the washing solution supply fluid channel 112 is formed as the inner container V1 of the washing solution container V in the washing solution tank 111. That is, the washing solution in the washing solution tank 111 is supplied to the inner container V1 according to the operation of the washing solution supply pump 113.

[0060] The residual washing solution discharge part 120 transfers the residual washing solution in the washing solution container V to the waste collection container 102. Herein, the residual washing solution refers to a washing solution overflowing from the inner container V1 and remaining in the outer container V2.

[0061] After washing is performed once, when washing before extraction of the nuclide of interest for another sample is performed after the extraction of the nuclide of interest for one sample is performed, using the residual washing solution remaining during the previous washing may have a risk of contamination, and it is preferable to use a washing solution newly supplied from the washing solution tank 111.

[0062] The residual washing solution discharge part 120 transfers the residual washing solution in the outer container V2 of the washing solution container V to the waste collection container 102 of the collection unit 100 to block the possibility of contamination during the next washing.

[0063] The residual washing solution discharge part 120 may include a washing solution discharge fluid channel 121 formed between the washing solution container V and the waste collection container 102, and a residual washing solution discharge pump 122 disposed in the washing solution discharge fluid channel 121 to supply pressure to introduce the residual washing solution into the washing solution discharge fluid channel 121.

[0064] According to an exemplary embodiment of the present invention, the residual washing solution is discharged to the waste collection container 102 of the collection part 100 rather than a separate waste collection container. Accordingly, the size of the device may be reduced, and space efficiency may be secured.

[0065] The operational process of the nuclide separating device according to an exemplary embodiment of the present invention is described as follows.

[0066] First, when the analysis of the first sample is started, the inflow selection valve 60 is connected to the sample supply part 50, while the first fluid channel 20, the column, and the second fluid channel 30 are connected by the fluid channel forming part 70. In this case, the washing solution is supplied through the sample supply part 50 to wash the first fluid channel 20, the main pump 80, the column, the second fluid channel 30, and the discharge selection valve 74.

[0067] In the washing process, the washing solution in the washing solution tank 111 is supplied to the inner container V1 according to the operation of the washing solution supply pump 113, and the residual washing solution in the outer container V2 is discharged through the washing solution discharge fluid channel 121 to the waste

collection container 102 of the collection part 100, according to the operation of the washing solution discharge pump 122.

[0068] Meanwhile, at the end of the washing process, the needle 51 of the sample supply part 50 is transferred to the outside of the washing solution container V such that air is inflowed into the fluid channel to perform the drying of the fluid channel.

[0069] Next, the inlet selection valve 60 is connected to the reagent supply part 40, and according to the operation of the main pump 80, a reagent for optimizing the column, that is, a first reagent is supplied to the column, and waste discharged to the lower portion of the column is collected into the waste collection container 102 of the collection part 100.

[0070] Subsequently, the inflow selection valve 60 is connected to the sample supply part 50, and the sample is injected into the column according to the operation of the main pump 80. In addition, the inlet selection valve 60 is connected to the reagent supply part 40 again, and according to the operation of the main pump 80, one or more reagents for the removal of interfering nuclides are supplied to the column, and waste discharged to the bottom of the column is collected in the waste collection container 102 of the collection part 100.

[0071] Afterwards, the sample supply part 50 supplies a reagent for separation of the nuclides of interest, and the purified sample is discharged to the bottom of the column according to the operation of the main pump 80. In this case, the discharge selection valve 74 forms a fluid channel such that the purified sample is introduced into the purified sample collection container 101 of the collection part 100.

[0072] Afterwards, the inflow selection valve 60 is connected to the sample supply part 50, and again the washing of the fluid channel using the washing solution proceeds as described above.

[0073] Finally, after washing, while the fluid channel forming part 70 and the first fluid channel 20 are separated and the column and the second fluid channel 30 are separated, the fluid channel forming part 70 is transferred to a different column by the transfer part 90. After the fluid channel forming part 70 is transferred to another column, the first fluid channel 20, the other column, and the second fluid channel 30 are connected by the fluid channel forming unit 70, and it may proceed from the optimization of columns.

[0074] As described above, the nuclide separating device 1a according to an exemplary embodiment of the present invention forms or releases a fluid channel by connecting or disconnecting the upper and lower portions of the column to or from other components while the first fluid channel connection part 71 and the second fluid channel connection part 72 are operated. In addition, the transfer part 90 transfers the fluid channel forming part 70 while the fluid channel is released. Accordingly, extraction may be continuously performed by connecting a random column to the sample and connecting another column to the sample after extraction is completed.

[0075] Hereinafter, a nuclide separating device 1b according to another exemplary embodiment of the present invention will be described.

[0076] FIGS. 5 and 6 illustrate perspective views of a nuclide separating device according to another exemplary embodiment of the present invention. The nuclide separating device 1b according to another exemplary embodiment of the present invention is to be used in the analysis of nuclides required for the evaluation of radioactive properties of radioactive waste and decommissioned waste, as in the exemplary embodiment of the present invention, and in particular, it may be used for the chemical separation of alpha/beta nuclides.

[0077] Referring to FIGS. 5 and 6, the nuclide separating device 1b according to another exemplary embodiment of the present invention includes a column holding part 1010 in which a column 1011 is disposed, a collection tube holding part 1020 in which a collection tube 1021 is disposed, a waste discharge part 1030, a separation part 1040, a connection part 1050, and a transfer part 1060.

[0078] The column 1011 is a member through which reagents and samples are introduced. The column 1011 is filled with resin, and reagents and samples are introduced therein to separate the purified sample including the nuclides of interest and other wastes. Samples and reagents may be stored in separate sample tanks (not illustrated) and reagent tanks (not illustrated), respectively, and these may be transferred by a pump (not illustrated) and introduced into the column 1011.

[0079] A plurality of columns 1011 are disposed in the column holding part 1010. The column holding part 1010 allows a plurality of columns 1011 to be simultaneously disposed such that separation of a plurality of samples may be continuously performed. The column holding part 1010 may be formed such that a plurality of columns 1011 are arranged in an annular shape. Specifically, the column holding part 1010 may include any one of a disc-shaped member, an annular member, and a saw-toothed wheel-shaped member, and may be configured to be fixed by inserting the column 1011 at regular intervals along the rim thereof. For example, the column holding part 1010 may be configured such that 20 columns are simultaneously disposed along the edge thereof.

[0080] Meanwhile, the column holding part 1010 may be integrally connected to the collection tube holding part 1020 through a support part 1070. The column holding part 1010 may be integrally moved with the collection tube holding part 1020 by being connected to the collection tube holding part 1020 through the support part 1070.

[0081] The collection tube 1021 is a container in which the purified sample that has passed through the column 1011, in other words, the purified sample extracted from the column 1011 is collected. The collection tube 1021 is disposed corresponding to the lower portion of each column 1011 disposed in the column holding part 1010. That is, the collection tube 1021 is disposed in a one-to-one correspondence to the lower portion of each column

1011 such that the purified sample extracted from one column 1011 may be collected from the lower portion thereof.

[0082] The collection tube holding part 1020 is arranged to be spaced apart from the lower portion of the column holding unit 1010 such that the collection tube 1021 is disposed corresponding to the lower portion of each column 1011 disposed in the column holding unit 1010. In another exemplary embodiment of the present invention, the collection tube holding part 1020 may be configured such that the collection tube 1021 corresponding to each column 1011 is arranged in an annular shape, similar to the column holding part 1010. For example, when the column holding part 1010 is configured to simultaneously arrange 20 columns 1011 in an annular shape, the collection tube holding part 1020 correspondingly has 20 collection tubes 1021 arranged in an annular shape.

[0083] The collection tube holding part 1020 may include any one of a disc-shaped member, an annular member, and a saw-toothed wheel-shaped member. Looking more specifically, the collection tube holding part 1020 may include a disc-shaped upper plate 1022 supporting the upper portion of the collection tube 1021 and a lower plate 1023 in the form of a saw-toothed wheel supporting the lower end of the collection tube 1021.

[0084] As described above, the collection tube holding part 1020 may be integrally connected to the column holding part 1010 through the support part 1070. In this case, the support part 1070 may include a column member for connecting the lower plate 1023 of the collection tube holding part 1020 to the upper plate 1022, and a column member for connecting the upper plate 1022 of the collection tube holding part 1020 to the column holding part 1010, and a plurality of these may be provided at regular intervals for stable coupling between the column holding part 1010 and the collection tube holding part 1020.

[0085] In another exemplary embodiment of the present invention, the centers of the column holding part 1010 and the collection tube holding part 1020 are disposed on the same axis, and the column holding part 1010 and the collection tube holding part 1020 have a form that may be rotated integrally around the axis.

[0086] The waste discharge part 1030 discharges waste discharged from the column 1011 to the outside. Separation of the purified sample and waste is performed in the column 1011, and the purified sample is collected in the collection tube 1021, and the waste is discharged to the outside through the waste discharge part 1030. In another exemplary embodiment of the present invention, the waste discharge part 1030 may be formed of a discharge pipe connected to the valve 1042 of the separation part 1040, and the waste discharge part 1030 may be connected to a waste storage tank (not illustrated).

[0087] The separation part 1040 may be disposed between the column holding part 1010 and the collection tube holding part 1020, and when connected to the column 1011 and the collection tube 1021, the purified sample is introduced into the collection tube 1021, and the waste is separated to be discharged to the waste discharge part 1030. The separation part 1040 includes a fluid channel structure 1041 and a valve 1042.

[0088] FIG. 7 shows a perspective view of the fluid channel structure of a separation part of a nuclide separating device according to another exemplary embodiment of the present invention. Referring to FIG. 7, the fluid channel structure 1041 has a rectangular block shape as a whole. The fluid channel structure 1041 includes a column connection part 1411, a first fluid channel 1412, a second fluid channel 1412, and a collection tube connection part 1414. The column connection part 1411 is formed on the upper portion of the fluid channel structure 1041 and has a hole shape that may be connected to the lower portion of the column 1011. The first fluid channel 1412 is a fluid channel formed toward the valve 1042 from the column connection part 1411 such that the purified sample or waste introduced through the column connection part 1411 may be transferred to the valve 1042. In addition, the second fluid channel 1413 is a fluid channel formed between the valve 1042 and the collection tube connection part 1414 such that the purified sample passing through the valve 1412 may be introduced into the collection tube 1021. Meanwhile, the collection tube connection part 1414 is formed at the lower portion of the fluid channel structure 1041, and has a shape of a tube that may be connected to the upper portion of the collection tube 1021. The collection tube connection part 1414 communicates with the second fluid channel 1413.

[0089] In another exemplary embodiment of the present invention, the fluid channel structure 1041 is connected to a frame F and is installed on a plate 1043 disposed between the column holding part 1010 and the collection tube holding part 1020. More specifically, the fluid channel structure 1041 is provided with through holes 1415 penetrated in the vertical direction at each corner, and a guide pin member 1431 coupled to the plate 1043 is inserted into each through hole 1415. Through this, the fluid channel structure 1041 has a shape in which sliding is possible in the vertical direction on the plate 1043.

[0090] The valve 1042 separates the purified sample and waste introduced from the column 1011 through the first fluid channel 1412 when the fluid channel structure 1041 is connected to the column 1011 and the collection tube 1021, but the purified sample is sent to the collection tube 1021 through the second fluid channel 1413, and the waste is discharged to the waste discharge unit 1030. That is, the valve 1042 is connected to the first fluid channel 1412 serving as an input fluid channel, the second fluid channel 1413 serving as an output fluid channel, and the waste discharge part 1030, and when the fluid introduced through the first fluid channel 1412 is a purified sample, a fluid channel is formed through the second fluid channel 1413, and when the fluid introduced through

the first fluid channel 1412 is waste, a fluid channel is formed to the waste discharge part 1030.

[0091] The connection part 1050 allows connection between the column 1011, the separation part 1040, and the collection tube 1021 for separation, and when separation is completed, it releases the connection between the column 1011, the separation part 1040, and the collection tube 1021. In another exemplary embodiment of the present invention, the connection part 1050 raises the collection tube 1021 to make a connection between the fluid channel structure 1041, the column 1011, and the collection tube 1021, and by lowering the collection tube 1021, it allows the connection between the fluid channel structure 1041, the column 1011, and the collection tube 1021 to be released.

[0092] Referring to FIG. 6, in another exemplary embodiment of the present invention, the connection part 1050 includes an actuator 1051, a power transmission part 1052, a ball screw part 1053, and a lifting part 1054. The actuator 1051 may be formed of a servo motor, and the power transmission part 1052 may transmit a rotational operating force to a ball screw part 1053 through pulleys and belts. In addition, the ball screw part 1053 includes a screw rotating by the power transmitted through the power transmission part 1052, and a ball nut coupled to the screw and linearly moving according to the rotation of the screw, but the ball nut may be disposed to move along the vertical direction. Meanwhile, the lifting part 1054 is connected to the ball screw part 53 and is disposed to rise or descend along the vertical direction, and it has a form capable of gripping the collection tube 21.

[0093] In another exemplary embodiment of the present invention, the lifting part 1054 may include a gripping part 1451 for gripping the collection tube 1021 and an actuator 1542 that transmits power to the gripping part 1451. In this case, the gripping part 1541 is formed in a shape that may pass through a space between the saw teeth of the lower plate 1023 in the form of a saw-toothed wheel that supports the lower end of the collection tube 1021.

[0094] When the separation of one column (1011) is completed such that the separation of a plurality of samples is performed continuously, the transfer part 1060 transfers the other column 1011 and the collection tube 1021 disposed corresponding thereto to a position connectable to the separation unit 1040. The transfer part 1060 may be configured to rotate the collection tube holding part 1020 and the column holding part 1010 integrally connected together, and may include an actuator disposed below the collection tube holding part 1020.

[0095] As described above, in another exemplary embodiment of the present invention, the centers of the column holding part 1010 and the collection tube holding part 1020 are disposed on the same axis, and the transfer part 1060 rotates the collection tube holding part 1020 about the axis, and accordingly, the column holding part 1010 may rotate integrally with the collection tube holding part 1020 about the axis.

[0096] FIGS. 8 and 9 are views showing the operational process of a nuclide separating device according to another exemplary embodiment of the present invention. Referring to FIGS. 8 and 9, the operational process of the nuclide separating device 1b according to another exemplary embodiment of the present invention will be described as follows.

[0097] First, a process in which the connection between the column 1011, the separation part 1040 and the collection tube 1021 is made in the nuclide separating device 1b will be described with reference to FIG. 8.

[0098] The lifting part 1054 of the connection part 1050 grips the collection tube 1021 while the column 1011 to be separated and the collection tube 1021 corresponding thereto are disposed on the upper and lower portions, respectively, and as the actuator 1051 of the connection part 1050 rotates in one direction, the lifting part 1054 is raised. As a result, the open top of the collection tube 1021 is coupled to a collection tube coupling part 1414 formed at the bottom of a fluid channel structure 1041 of a separation part 1040, and at the same time, the lower portion of the column 1011 is inserted into the column coupling part 1411 formed on the upper portion of the fluid channel structure 1041. In this case, the fluid channel structure 1041 may also be pushed up as the collection tube 1021 is raised such that the collection tube 1021, the fluid channel structure 1041, and the column 1011 maybe coupled.

[0099] Simultaneously or sequentially, samples and reagents may be introduced through the upper portion of the column 1011. The inflow of the sample and the reagent into the column 1011 is made through an inlet part 1080, and as shown in FIG. 6, the inlet part 1080 may include an actuator 1081, a power transmission part 1082, a ball screw part 1083, and an injection part 1084.

[0100] The actuator 1081 may be formed of a servo motor, and the power transmission part 1082 may transmit a rotational operating force to a ball screw part 1083 through pulleys and belts. In addition, the ball screw part 1083 includes a screw rotating by the power transmitted through the power transmission part 1082, and a ball nut coupled to the screw and linearly moving according to the rotation of the screw, but the ball nut may be disposed to move along the vertical direction. Meanwhile, the injection part 1084 is connected to the ball screw part 1083 and is disposed to rise or descend along the vertical direction, and may be connected to a fluid channel (not illustrated) through which a sample and a reagent are introduced.

[0101] As the actuator 1081 rotates in one direction, the injection part 1084 descends, and accordingly, the injection part 1084 is coupled to the upper portion of the column 1011. In addition, the coupling between the column 1011 and the fluid channel structure 1041 of the separation part 1040 is more stably performed while the column 1011 is pressed downward as the injection part 1084 descends.

[0102] Next, a process in which the connection between the column 1011, the separation part 1040, and the collection tube 1021 is released in the nuclide separating device 1b will be described with reference to FIG. 9.

[0103] When the separation for one column 1011 is completed, the lifting portion 1054 is lowered as the actuator 1051 of the connection part 1050 rotates in the other direction. As a result, the coupling of the collection tube 1021 and the collection tube coupling portion 1414 is released, and at the same time, the lower portion of the column 11 is also detached from the column coupling portion 1411 formed on the upper portion of the fluid channel structure 1041. In this case, the fluid channel structure 1041 is also lowered by its own weight as the collection tube 1021 descends, and the coupling of the collection tube 1021, the fluid channel structure 1041, and the column 1011 is released.

[0104] In this case, as shown in FIG. 9, the lifting part 1054 descends to the bottom of the lower plate 1023 of the collection tube holding part 1020. Accordingly, the collection tube holding part 1020 and the column holding part 1010 may be rotated by the transfer part 1060, and as a result, separation for the next column 1011 is prepared.

[0105] Meanwhile, simultaneously or sequentially, as the actuator of the inflow part 1080 rotates in the other direction, the injection part 1084 is also spaced apart from the upper portion of the column 1011, and the coupling between the injection part 1084 and the column 1011 is also released.

[0106] The nuclide separating device 1b according to another exemplary embodiment of the present invention may form or release a fluid channel by connecting or disconnecting different configurations of the upper and lower portions of the column through the inlet portion 80 disposed at the upper portion of the column and the connection part 50 disposed at the lower portion of the column. More specifically, the connection part 50 connects or releases the separation part 40 and the lower portion of the column, and the inlet part 80 is connected to the upper portion of the column in a descending state such that a reagent or sample is injected into the column, and in a rising state, it is separated from the top of the column. Accordingly, after transferring the column, in which extraction is completed, connected to the sample from the fluid channel forming position, another column in which new extraction proceeds may be disposed at the fluid channel forming position.

[0107] Although exemplary embodiments of the present invention have been described above, the spirit of the present invention is not limited to the exemplary embodiments presented in the present specification, and those skilled in the art who understand the spirit of the present invention will be able to easily propose other exemplary embodiments by supplementing, changing, deleting, or adding components within the scope of the same spirit, but it will be said that these are also within the scope of the spirit of the present invention.

Claims

1. A nuclide separating device, comprising:

a column arrangement part in which a plurality of columns are arranged;
a first fluid channel through which a reagent or sample to be introduced into each of the columns arranged in the column arrangement part is transferred;
a second fluid channel through which a purified sample or waste discharged from the column is delivered to a collection part;
a fluid channel forming part for connecting or disconnecting the first fluid channel and the second fluid channel to or from a random column arranged in the column arrangement part;
a main pump for supplying pressure to introduce the reagent or the sample into the first fluid channel and to discharge the purified sample or waste from the column; and
a transfer part for transferring the fluid channel forming part so that the fluid channel forming part can connect or disconnect the first fluid channel and the second fluid channel to or from another random column arranged in the column arrangement part.

2. The nuclide separating device of claim 1, wherein the transfer part is capable of transferring the fluid channel forming part back and forth, and left and right.

3. The nuclide separating device of claim 1, wherein the fluid channel forming part comprises:

a first fluid channel connection part disposed above the column to connect or disconnect the first fluid channel to or from the upper portion of the column;
a second fluid channel connection part disposed below the column to connect or disconnect the second fluid channel to or from the lower portion of the column; and
an operational part for lowering or raising the first fluid channel connection part to connect or disconnect the first fluid channel to or from the upper portion of the column, and raising or lowering the second fluid channel connection part to connect or disconnect the second fluid channel to or from the lower portion of the column.

4. The nuclide separating device of claim 3, wherein the collection part comprises a purified sample collection container in which the purified sample is collected, and a waste collection container in which the waste is collected, and
wherein the fluid channel forming part further com-

prises a discharge selection valve for selectively connecting the second fluid channel connection part to any one of the purified sample collection container and the waste collection container.

5. The nuclide separating device of claim 1, further comprising:

a reagent supply part for selecting a random reagent among a plurality of reagents and supplying the same to the first fluid channel;
a sample supply part for supplying the sample to the first fluid channel; and
an inlet selection valve disposed in the first fluid channel to selectively connect the first fluid channel to any one of the reagent supply part and the sample supply part.

6. The nuclide separating device of claim 5, wherein the sample supply part comprises:

a needle for penetrating into a sample container containing the sample;
a sample supply fluid channel formed between the needle and the inlet valve; and
a needle transfer part for transferring the needle.

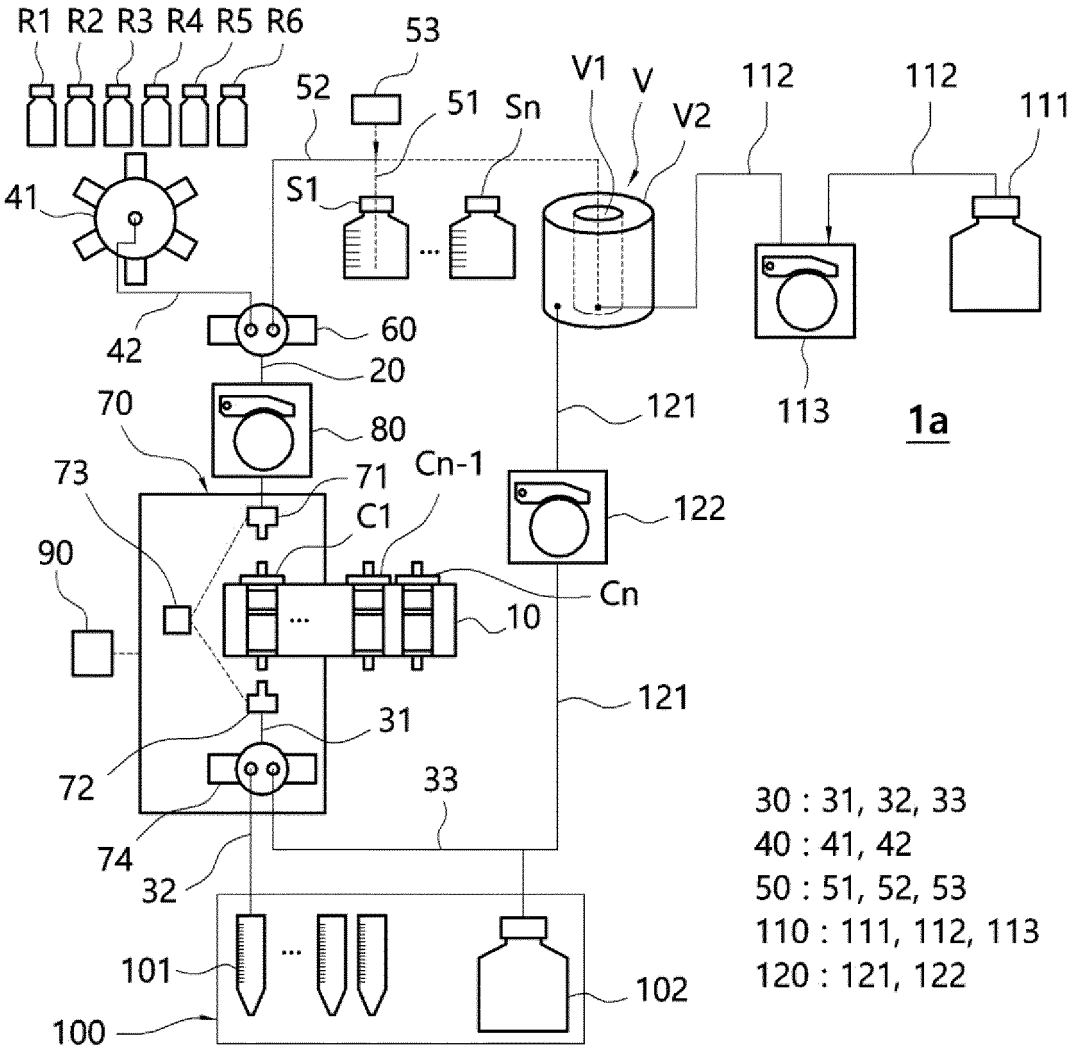
7. The nuclide separating device of claim 6, wherein the sample supply part further comprises a washing solution container containing a washing solution for washing the sample supply fluid channel, the first fluid channel, and the second fluid channel, and
wherein the needle transfer part is capable of transferring the needle to penetrate into the washing solution container.

8. The nuclide separating device of claim 7, wherein the sample supply part comprises a plurality of sample containers for containing each different sample, and
wherein the needle and the needle transfer part are controlled in a predetermined manner so that the samples in a plurality of sample containers and a washing solution in the washing solution container are supplied to the sample supply fluid channel according to a predetermined order.

9. The nuclide separating device of claim 7, wherein the collection part comprises a purified sample collection container in which the purified sample is collected, and a waste collection container in which the waste is collected; and
a residual washing solution discharge part for transferring the residual washing solution in the washing solution container to the waste collection container.

10. The nuclide separating device of claim 9, wherein the residual washing solution discharge part comprises a washing solution discharge fluid channel formed between the washing solution container and the waste collection container; and
a residual washing solution discharge pump for supplying pressure so that the residual washing solution is introduced into the washing solution discharge fluid channel.

【FIG. 1】


R1 R2 R3 R4 R5 R6
53
52
51
Sn
V1
V
V2
112
112
111
41
S1
42
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80
121
113
1a
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Cn
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33
74
32
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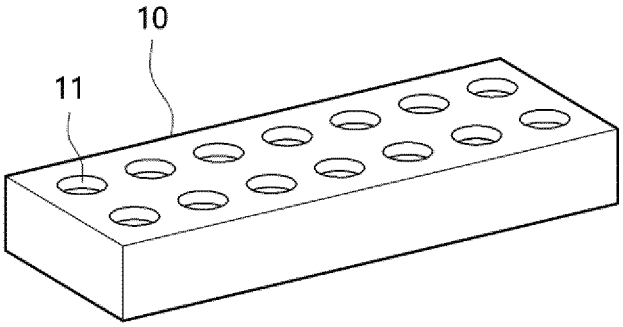
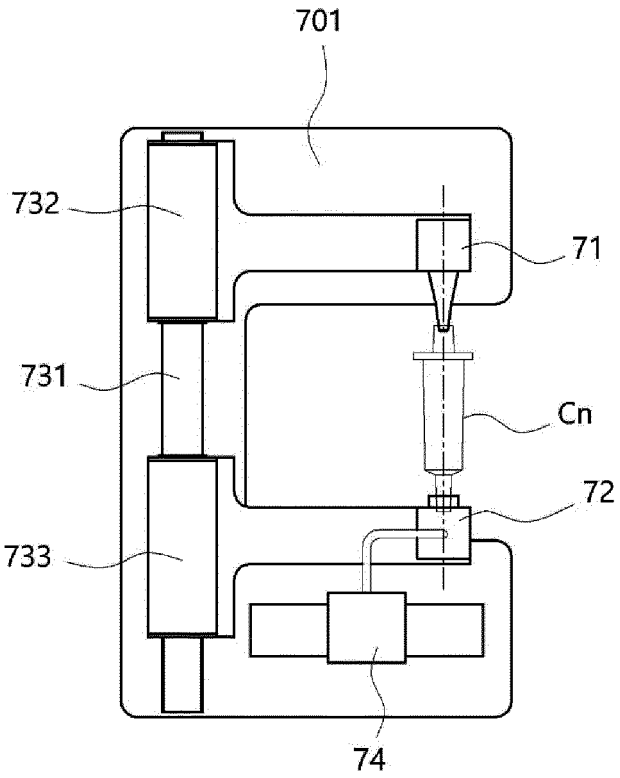
40 : 41, 42
50 : 51, 52, 53
110 : 111, 112, 113
120 : 121, 122

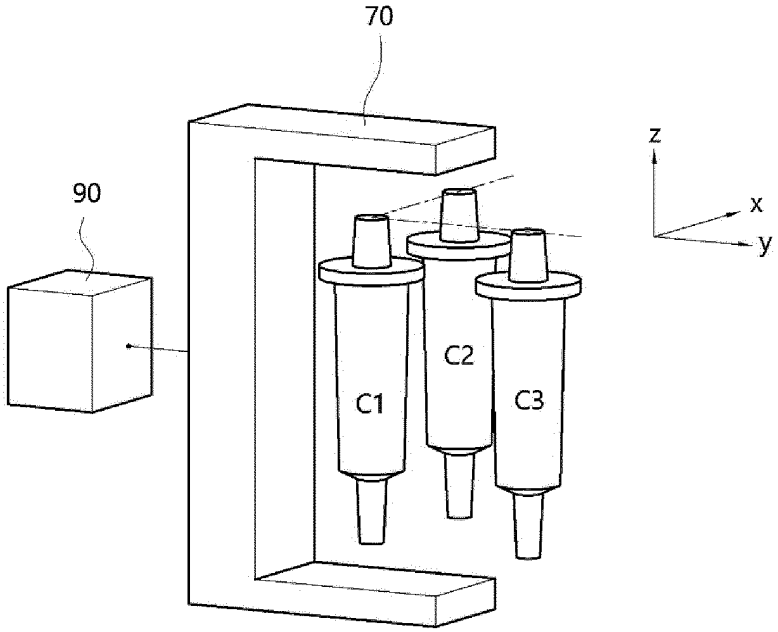
【FIG. 2】



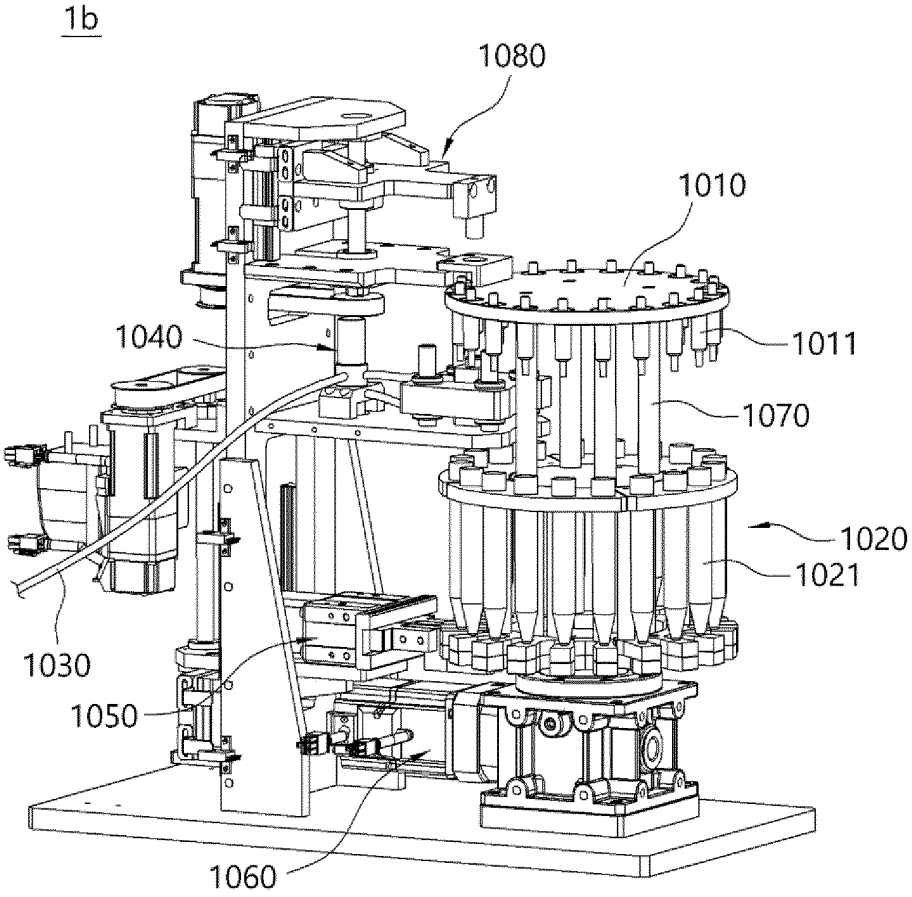
【FIG. 3】



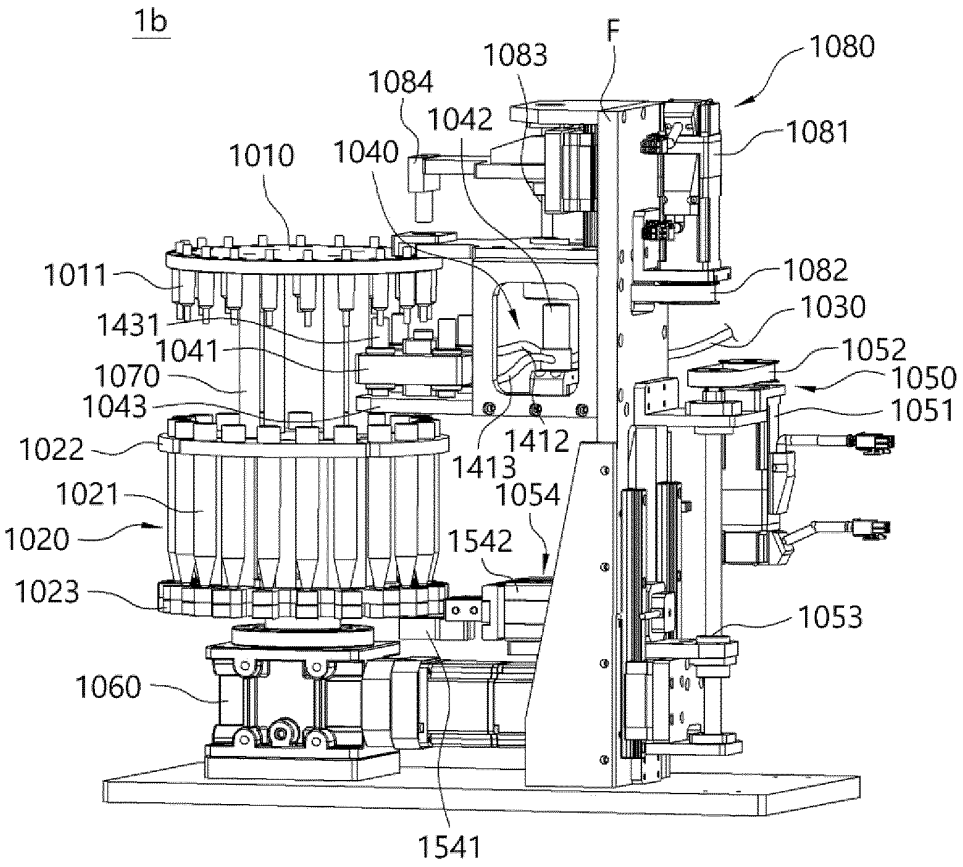
【FIG. 4】


70
90
z
x
y
C1
C2
C3

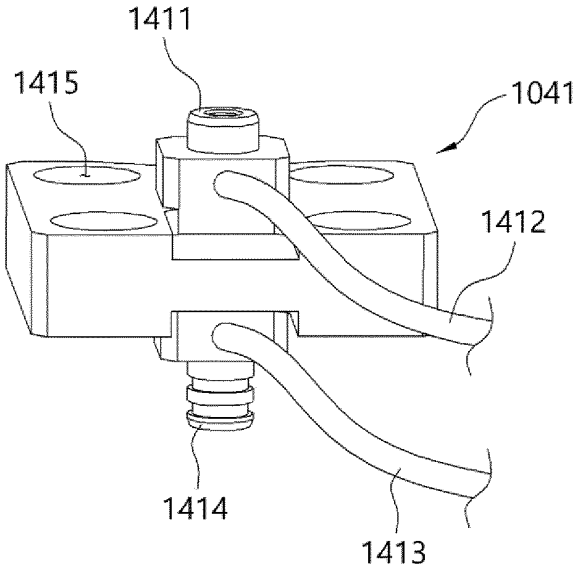
【FIG. 5】


1b
1080
1010
1040
1011
1070
1020
1021
1030
1050
1060

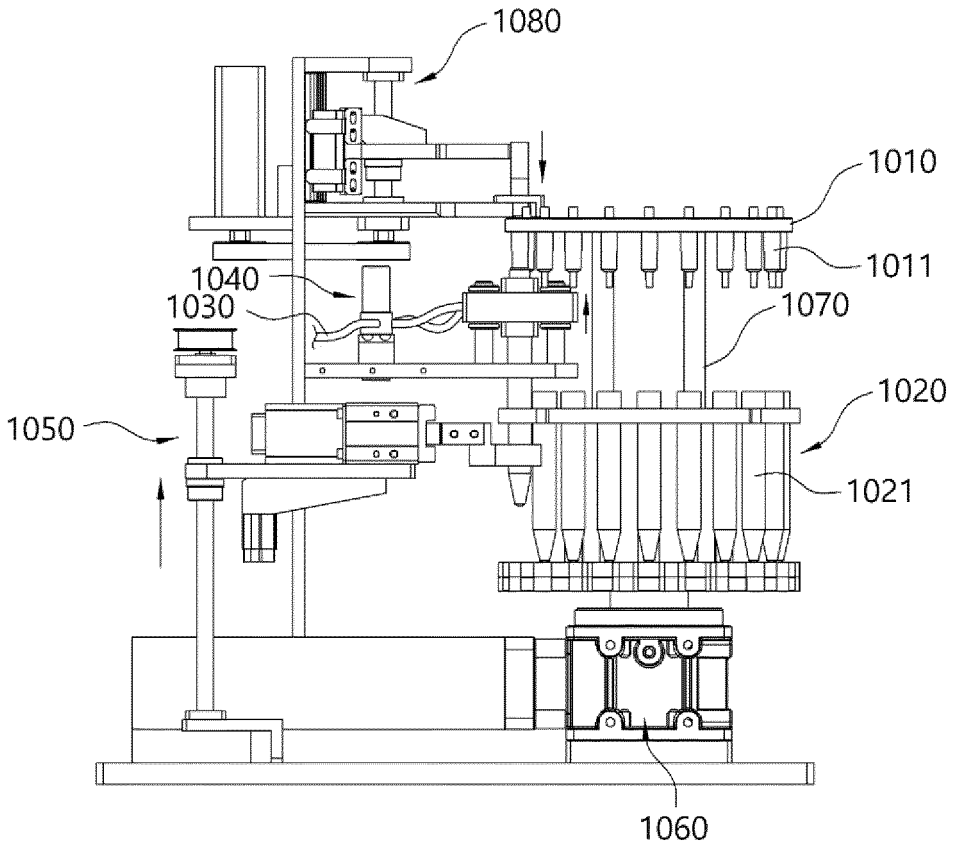
【FIG. 6】


1b
F
1083
1080
1084
1042
1081
1010
1040
1011
1082
1431
1030
1041
1052
1070
1050
1043
1051
1022
1412
1413
1021
1054
1020
1542
1023
1053
1060
1541

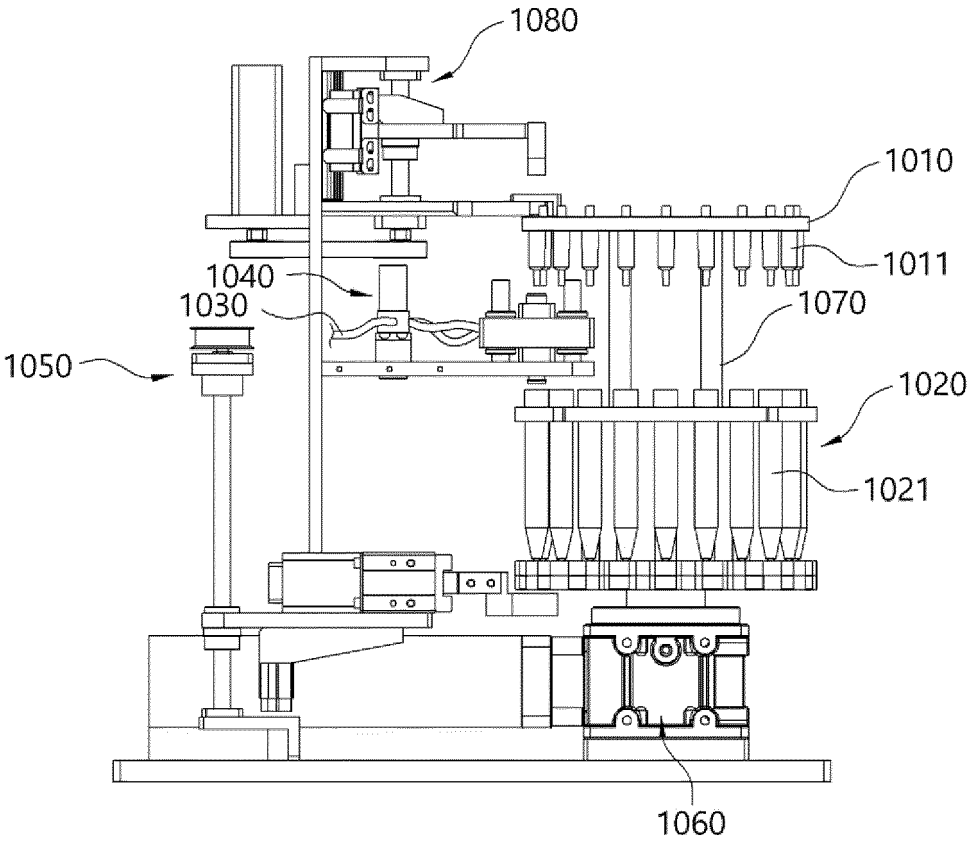
【FIG. 7】


1411
1415
1041
1412
1414
1413

【FIG. 8】



【FIG. 9】



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2019/015942

A. CLASSIFICATION OF SUBJECT MATTER

G21F 9/12(2006.01)i, G01T 7/08(2006.01)i, G01N 1/10(2006.01)i, G01N 1/28(2006.01)i, G01T 1/167(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)

G21F 9/12; B01D 19/00; B01D 59/00; B01J 3/00; B01J 39/18; G01N 1/00; G01N 35/08; G01N 35/10; G01N 37/00; G21G 1/04; G01T 7/08; G01N 1/10; G01N 1/28; G01T 1/167

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: IPC as above
Japanese utility models and applications for utility models: IPC as above

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

eKOMPASS (KIPO internal) & Keywords: radionuclide, extraction, flow path, column, valve

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	KR 10-2017-0127234 A (KOREA ATOMIC ENERGY RESEARCH INSTITUTE) 21 November 2017 See paragraphs [25]-[31], and figures 2-3.	1-10
Y	JP 6269848 B2 (SHIMADZU CORP.) 31 January 2018 See paragraphs [60]-[63], and figure 8.	1-10
Y	JP 2001-242181 A (SHIMADZU CORP.) 07 September 2001 See paragraph [11], and figure 1.	6-10
Y	JP 2012-068233 A (ARKRAY INC.) 05 April 2012 See paragraphs [27]-[29], and figure 1.	9-10
A	KR 10-0742639 B1 (KOREA INSTITUTE OF NUCLEAR SAFETY) 25 July 2007 See the entire document.	1-10

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

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"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
03 MARCH 2020 (03.03.2020)	**03 MARCH 2020 (03.03.2020)**

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Facsimile No. +82-42-481-8578

Authorized officer

Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2019/015942

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		WO 2007-083856 A1	26/07/2007

Form PCT/ISA/210 (patent family annex) (January 2015)

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- KR 1020190132518 **[0001]**