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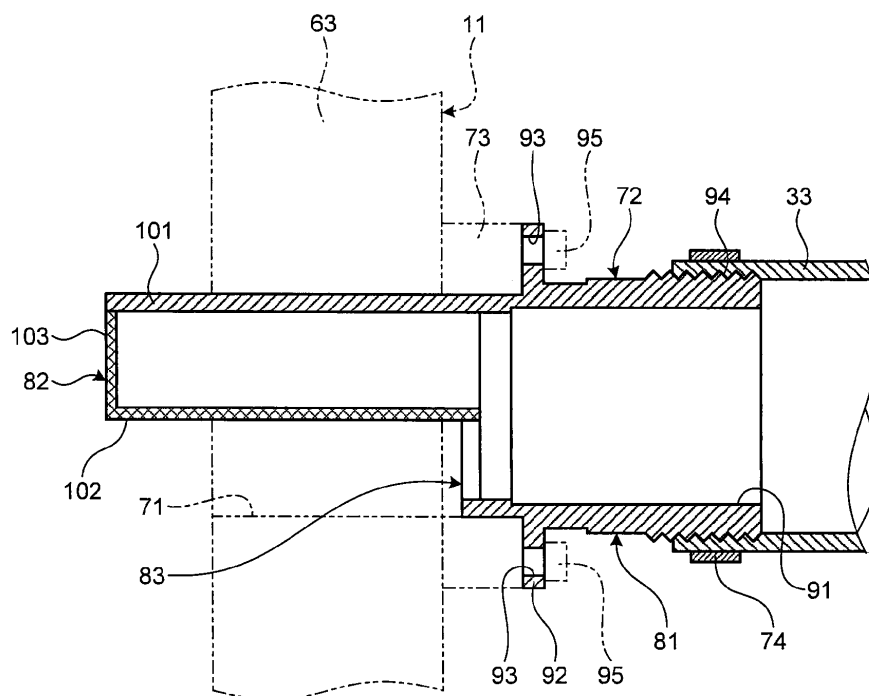
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(54) **Shielding material collecting nozzle, shielding vessel, and shielding material collecting device and method**

(57) A shielding material collecting nozzle includes: a nozzle main body (81) having an opening (91); a covering portion (82) which is provided so as to cover a part of the opening (91) and through which a fluid can pass

and a shielding material cannot pass; and a passing portion (83) which is provided outside a region covered with the covering portion (82) in the opening (91) and through which the fluid and the shielding material can pass.

FIG.2



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Description

Field

[0001] The present invention relates to a shielding vessel used in, for example, the inspection or repair of an atomic power plant or the like, a shielding material collecting nozzle attached to this shielding vessel, and shielding material collecting device and method. Background

[0002] For example, a pressurized water reactor (PWR) in the atomic power plant uses light water as the nuclear reactor cooler or the neutron decelerator to produce high-temperature and high-pressure water that does not boil throughout the reactor internal, sends this high-temperature and high-pressure water to a steam generator to generate steam through heat exchange, and sends this steam to a turbine power generator, thereby generating power.

[0003] In such an atomic power plant, it is necessary to inspect the structure and the like on the regular basis in order to ensure sufficient safety and reliability. If the trouble is found as a result of the inspection, the portion having the trouble is repaired as necessary. In the case where such work is executed in the atomic power plant, it is necessary to reduce the radiation dosage on an operator.

[0004] An example of the conventional radiation shielding device is disclosed in Patent Literature 1. In the radiation shielding device disclosed in Patent Literature 1, a hollow vessel is disposed at a predetermined portion of a body to be shielded, a fluid is sent into the vessel through a hose by a fluid sending unit and granular shielding materials are supplied to the fluid by a shielding material supply unit, thereby filling the vessel with the shielding materials through the hose, and the body to be shielded is provided with the vessel filled with the shielding materials, thereby conducting the shielding.

Citation List

Patent Literature

[0005] Patent Literature 1: Japanese Patent Application Laid-open No. 2010-156615

Summary

Technical Problem

[0006] In the aforementioned radiation shielding device, the vessel is filled with the fluid and the granular shielding materials by sending the fluid into the vessel with a pump. On the other hand, by sending the fluid into the vessel with the pump, the granular shielding materials inside in addition to the fluid are discharged out of the vessel. In this case, the vessel is internally provided with a jet nozzle and an intake member; while the shielding

materials are dispersed by the fluid jet from the jet nozzle, the fluid and the shielding materials are discharged by the intake member.

[0007] Therefore, in the conventional radiation shielding device, the jet nozzle and the intake member need to be fixed inside the vessel, so that the structure becomes complicated and the vessel gets heavier; as a result, it is difficult to convey the device. Moreover, the space in the vessel where the jet nozzle and the intake member are disposed cannot be filled with the shielding materials, and this space may be unable to shield the radiation sufficiently.

[0008] The present invention has been made in order to solve the above problem, and an object is to provide a shielding material collecting nozzle, a shielding vessel, and shielding material collecting device and method, which are for simplifying the structure and reducing the weight thereof and moreover improving the shielding function. Solution to Problem

[0009] According to an aspect of the present invention, a shielding material collecting nozzle includes: a nozzle main body having an opening; a covering portion which is provided so as to cover a part of the opening and through which a fluid can pass and a shielding material cannot pass; and a passing portion which is provided outside a region covered with the covering portion in the opening and through which the fluid and the shielding material can pass.

[0010] Therefore, the fluid is discharged through the entire regions of the opening including the covering portion and the passing portion, and the shielding materials cannot pass through the covering portion and are discharged through the passing portion only. This can restrict the amount of shielding materials passing through the opening to make the density of the shielding materials to the fluid the appropriate density, whereby the shielding materials can be collected efficiently in a short time. By merely providing the covering portion so as to covering a part of the opening in this manner, the passing portion can be secured and the structure can be simplified and reduced in weight and moreover the shielding function can be improved.

[0011] Advantageously, in the shielding material collecting nozzle, an area of the covering portion is larger than an area of the passing portion.

[0012] Therefore, by securing the sufficient area for the covering portion, the block of the covering portion due to the shielding materials can be suppressed and the shielding materials can be collected efficiently.

[0013] Advantageously, in the shielding material collecting nozzle, a region of the covering portion in the opening is larger than a region of the passing portion.

[0014] Therefore, by securing the sufficient area for the covering portion, the shielding materials can be collected efficiently in a short time.

[0015] Advantageously, in the shielding material collecting nozzle, the covering portion is formed of a mesh material.

[0016] Therefore, by forming the covering portion with the use of the mesh material, the structure can be simplified and the cost can be reduced.

[0017] Advantageously, in the shielding material collecting nozzle, the covering portion of the nozzle main body extends toward an entrance.

[0018] Therefore, by having the covering portion extending toward the entrance, the amount of projecting toward the exit can be reduced and the enlargement of the device can be suppressed.

[0019] Advantageously, in the shielding material collecting nozzle, a protection portion is provided above the covering portion.

[0020] Therefore, if the shielding material drops from above, the dropped material collides with the protection plate, thereby suppressing the contact with the covering portion and preventing the damage of the covering portion.

[0021] Advantageously, in the shielding material collecting nozzle, the opening is circular, the protection portion has an arc-like shape along an upper edge of the opening, and the covering portion has at least a first covering portion provided below the protection portion.

[0022] Therefore, since the protection plate has the arc-like shape along the upper edge of the opening, it is possible to suppress that the shielding materials dropped from above are deposited on the protection plate; thus, the shielding materials can be collected as appropriate.

[0023] Advantageously, in the shielding material collecting nozzle, the covering portion has a second covering portion provided at an end of the protection portion and the first covering portion.

[0024] Therefore, when the covering portion includes the first covering portion provided below the protection plate and the second covering portion provided at an end of the protection plate, a sufficient area for the covering portion can be secured.

[0025] According to another aspect of the present invention, a shielding vessel includes: a vessel main body having a hollow shape; a supply unit that can supply a fluid and a shielding material to the inside of the vessel main body; and a discharge unit that can discharge the fluid and the shielding material out of the vessel main body, wherein the shielding material collecting nozzle according to the invention is attached to the discharge unit.

[0026] Therefore, by the supply of the fluid from the supply unit to the inside of the vessel main body, the pressure in the vessel main body increases, whereby the fluid and the shielding materials in the vessel main body are extruded from the discharge unit. On this occasion, the fluid is discharged through the entire regions of the opening including the covering portion and the passing portion and the shielding materials cannot pass through the covering portion and are discharged from the passing portion only. Therefore, the amount of the shielding materials passing through the opening can be restricted to make the density of the shielding materials to the fluid the appropriate density, and the shielding materials can

be collected efficiently in a short time. Thus, by merely providing the covering portion so as to cover a part of the opening in this manner, the passing portion can be secured and since the large structure is not necessary to be provided in the vessel main body, the structure can be simplified and reduced in weight and moreover the shielding function can be improved.

[0027] Advantageously, in the shielding vessel, the covering portion extends toward the inside of the vessel main body as compared with an inner wall surface of the vessel main body.

[0028] Therefore, by having the covering portion extending toward the entrance, the amount of projecting toward the exit can be reduced and the covering portion can be disposed at the opening of the wall of the vessel main body; thus, the amount of projecting toward the inside of the vessel main body can be reduced and the enlargement of the device can be suppressed.

[0029] Advantageously, in the shielding vessel, the supply unit includes a first supply unit that is provided at an upper part of the vessel main body and that can supply the fluid and the shielding material and a second supply unit that is provided at a lower part of the vessel main body and that can supply only the fluid, and the discharge unit includes a first discharge unit that is provided at the upper part of the vessel main body and that can discharge only the fluid and a second discharge unit that is provided at the lower part of the vessel main body and that can discharge the fluid and the shielding material.

[0030] Therefore, by providing the first supply unit and the first discharge unit for filling the inside of the vessel main body with the shielding materials and providing the second supply unit and the second discharge unit for collecting the shielding materials inside the vessel main body, the vessel main body can be filled with the shielding materials and the shielding material can be collected from the vessel main body both efficiently.

[0031] Advantageously, in the shielding vessel, the second supply unit and the second discharge unit are disposed to face each other horizontally.

[0032] Therefore, the fluid supplied from the second supply unit to the inside of the vessel main body is jet toward the second discharge unit, and by guiding the shielding materials inside the vessel main body to the second discharge unit, the shielding materials can be collected efficiently.

[0033] According to still another aspect of the present invention, a shielding material collecting device includes: a supply line that can supply a fluid to a shielding vessel; a pump provided for the supply line; a discharge line that can discharge the fluid and a shielding material out of the shielding vessel; and the shielding material collecting nozzle according to the invention that is provided for a discharge unit of the shielding vessel and connected to the discharge line.

[0034] Therefore, upon the supply of the fluid from the supply unit to the inside of the vessel main body through the supply line by the pump operation, the pressure in

the shielding vessel increases, thereby extruding the fluid and the shielding materials in the shielding vessel from the discharge unit to the discharge line. On this occasion, the fluid is discharged through the entire regions of the opening including the covering portion and the passing portion, and the shielding materials cannot pass through the covering portion and are discharged through the passing portion only. As a result, the amount of shielding materials passing through the opening can be restricted to make the density of the shielding materials relative to the fluid the appropriate density, and the shielding materials can be collected efficiently in a short time. Thus, by merely providing the covering portion so as to cover a part of the opening in this manner, the passing portion can be secured and since the large structure is not necessary to be provided in the vessel main body, the structure can be simplified and reduced in weight and moreover the shielding function can be improved.

[0035] According to still another aspect of the present invention, a shielding material collecting method includes: a first step of supplying a fluid from a supply unit to the inside of a shielding vessel and increasing an internal pressure; and a second step of pumping the fluid and a shielding material in the shielding vessel through a discharge unit to the outside by the internal pressure of the shielding vessel by the use of the shielding material collecting nozzle according to the invention.

[0036] Therefore, the amount of shielding materials passing through the opening can be restricted to make the density of the shielding materials relative to the fluid the appropriate density, and the shielding materials can be collected efficiently in a short time. Thus, by merely providing the covering portion so as to cover a part of the opening in this manner, the passing portion can be secured and since the large structure is not necessary to be provided in the vessel main body, the structure can be simplified and reduced in weight and moreover the shielding function can be improved.

Advantageous Effects of Invention

[0037] According to the shielding material collecting nozzle, the shielding vessel, and the shielding material collecting device and method of the present invention, the covering portion which is provided to cover a part of the opening and through which the fluid can pass but the shielding materials cannot pass, and the passing portion which is provided outside a region to be covered with the covering portion in the opening and through which the fluid and the shielding materials can pass are provided. Thus, the structure can be simplified and reduced in weight, and moreover the shielding function can be improved.

Brief Description of Drawings

[0038]

FIG. 1 is a sectional view illustrating a main part of a shielding vessel according to an embodiment of the present invention.

FIG. 2 is a sectional view illustrating a shielding material collecting nozzle according to this embodiment.

FIG. 3 is a front view illustrating the shielding material collecting nozzle according to this embodiment.

FIG. 4 is a perspective view illustrating the shielding material collecting nozzle according to this embodiment.

FIG. 5 is a schematic view illustrating the supply system and the discharge system for water and shielding materials in a shielding device according to this embodiment.

Description of Embodiment

[0039] A preferred embodiment of a shielding material collecting nozzle, a shielding vessel, and shielding material collecting device and method according to the present invention is hereinafter described in detail with reference to the attached drawings. Note that the present invention is not limited to the embodiment below, and if there are multiple embodiments, the embodiments may be combined.

[Embodiment]

[0040] FIG. 1 is a sectional view illustrating a main part of a shielding vessel according to an embodiment of the present invention. FIG. 2 is a sectional view illustrating a shielding material collecting nozzle according to this embodiment. FIG. 3 is a front view illustrating the shielding material collecting nozzle according to this embodiment. FIG. 4 is a perspective view illustrating the shielding material collecting nozzle according to this embodiment. FIG. 5 is a schematic view illustrating the supply system and the discharge system for water and shielding materials in a shielding device according to this embodiment.

[0041] A shielding material collecting nozzle, a shielding vessel, and shielding material collecting device and method of this embodiment are applied to an atomic power plant such as a pressurized water reactor (PWR) or a boiling water reactor (BWR); in particular, this embodiment is preferable for the inspection or repair of the atomic power plant.

[0042] A radiation shielding device according to this embodiment includes a shielding vessel 11 to be disposed at a particular portion of a body to be shielded P, a shielding material filling device 12 that supplies a fluid and shielding materials into this shielding vessel 11, and a shielding material collecting device 13 that collects the fluid and the shielding materials filling the inside of the shielding vessel 11, as depicted in FIG. 5.

[0043] In this case, the shielding vessel 11 is formed in the hollow shape, and is composed of, for example, a

rigid body such as stainless steel, or a flexible and expandable material such as plastic or urethane rubber. The shielding material is granular and is desirably tungsten-contained pellet formed by hardening tungsten powder with a resin material to be granular, stainless steel granules formed by processing stainless steel to be granular, lead granules formed by processing lead to be granular, depleted uranium granules formed by processing depleted uranium to be granular, or the like, for example. The spheres or granules of the shielding material are preferably have the same size so that the spheres or granules are uniformly deposited in the shielding vessel 11. Water is the optimum as the fluid; however, pure water, boric acid solution, polyvinyl alcohol, silicone oil, air, or the like may be used instead of water.

[0044] The shielding material filling device 12 is a supply line of supplying the fluid and the shielding materials to the shielding vessel 11, and includes a tank unit 21, a first supply tube 22, a pump 23, a second supply tube 24, a shielding material supply hopper 25, and a third supply tube 26. The second supply tube 24 and the third supply tube 26 are provided with switch valves 27 and 28 for switching the supply of the fluid, respectively. A supply tube 29 that connects the second supply tube 24 and the shielding material supply hopper 25 is provided with an opening/closing valve 30.

[0045] The shielding material collecting device 13 is a collection line of collecting the fluid and the shielding materials from the shielding vessel 11, and includes the tank unit 21, a first discharge tube 31, a second discharge tube 32, and a third discharge tube 33. The first discharge tube 31 and the third discharge tube 33 are provided with switch valves 34 and 35 for switching between the discharge of the fluid and the discharge of the fluid and the shielding materials, respectively.

[0046] Note that the first discharge tube 31 and the second discharge tube 32 in the collection line also function as the shielding material filling device 12. Moreover, the first supply tube 22, the pump 23, and the third supply tube 26 in the supply line also function as the shielding material collecting device 13.

[0047] In other words, the tank unit 21 has a water storage portion 41 that supplies the fluid to the shielding vessel 11 and stores the fluid discharged from the shielding vessel 11, and a separation portion 42 that separates the shielding materials collected from the shielding vessel 11 from the fluid. The first supply tube 22 has one end connected to the water storage portion 41 of the tank unit 21, and the other end branched into the second supply tube 24 and the third supply tube 26. The first supply tube 22 has the pump 23 attached thereto, and the second supply tube 24 and the third supply tube 26 have the switch valves 27 and 28 attached thereto, respectively.

[0048] The shielding material supply hopper 25 stores a large amount of shielding materials and drops every certain amount of shielding materials from the funnel-type bottom thereof that can be opened. This shielding material supply hopper 25 is connected to the second

supply tube 24 through the supply tube 29, and this supply tube 29 has the opening/closing valve 30 attached thereto.

[0049] The second discharge tube 32 has one end connected to the separation portion 42 of the tank unit 21, and the other end branched into the first discharge tube 31 and the third discharge tube 33. The first discharge tube 31 and the third discharge tube 33 have the switch valves 34 and 35 attached thereto, respectively.

[0050] The shielding vessel 11 includes a vessel main body 51 having a hollow shape, a supply unit 52 that can supply a fluid and shielding materials to the inside of the vessel main body 51, and a discharge unit 53 that can discharge the fluid and the shielding materials out of the vessel main body 51.

[0051] In the shielding vessel 11, as the supply unit 52, a first supply unit 54 that can supply a fluid and shielding materials is provided at the upper part of the vessel main body 51 and a second supply unit 55 that can supply only the fluid is provided at the lower part of the vessel main body 51. In the shielding vessel 11, moreover, as the discharge unit 53, a first discharge unit 56 that can discharge only the fluid is provided at the upper part of the vessel main body 51 and a second discharge unit 57 that can discharge the fluid and the shielding materials is provided at the lower part of the vessel main body 51.

[0052] The vessel main body 51 is provided with a filter (not shown) that discharges only the fluid to the first discharge unit 56 and does not discharge the shielding materials. The vessel main body 51 is provided with a collecting nozzle 72 (see FIG. 1) as described later, which discharges not just water but also the shielding materials to the second discharge unit 57.

[0053] In the shielding vessel 11, the second supply tube 24 is connected to the first supply unit 54 and the third supply tube 26 is connected to the second supply unit 55. In the shielding vessel 11, moreover, the first discharge tube 31 is connected to the first discharge unit 56 and the third discharge tube 33 is connected to the second discharge unit 57.

[0054] Here, detailed description is made of the second supply unit 55 and the second discharge unit 57 in the shielding vessel 11. As depicted in FIG. 1, the vessel main body 51 is composed of vertical walls 62 and 63 fixed facing each other on both sides of a bottom 61, and the second supply unit 55 is provided on the vertical wall 62 side and the second discharge unit 57 is provided on the vertical wall 63 side. The second supply unit 55 and the second discharge unit 57 are disposed to face each other in the horizontal direction.

[0055] In the second supply unit 55, the vertical wall 62 is provided with a supply port 64 with a circular shape at a predetermined position, and this supply port 64 is provided with a jet nozzle 65. This jet nozzle 65 has a jet port 66 whose diameter increases toward the inside of the vessel main body 51. An outer wall surface of the vertical wall 62, which corresponds to the supply port 64, is provided with an attachment stand 67, and the third

supply tube 26 is connected to this attachment stand 67 via a connection tube 68 and fixed thereto with a locking ring 69.

[0056] On the other hand, in the second discharge unit 57, the vertical wall 63 is provided with a discharge port 71 with a circular shape at a predetermined position, and this discharge port 71 is provided with the collecting nozzle (shielding material collecting nozzle) 72. An outer wall surface of the vertical wall 63, which corresponds to the discharge port 71, is provided with an attachment stand 73, the collecting nozzle 72 is fixed to this attachment stand 73, and the third discharge tube 33 is connected to this attachment stand 73 via the collecting nozzle 72 and fixed thereto with a locking ring 74.

[0057] Note that on the bottom 61 of the vessel main body 51, a bottom plate 61a is disposed, and the height of the lower surface of the supply port 64, the height of the lower surface of the discharge port 71, and the height of the upper surface of the bottom plate 61a are approximately equal to each other.

[0058] As depicted in FIG. 1 to FIG. 4, this collecting nozzle 72 has a nozzle main body 81, a covering portion 82, and a passing portion 83.

[0059] The nozzle main body 81 is provided with an opening 91 having a cylindrical shape and forming a circular shape on the inside. In the nozzle main body 81, a plurality of (four in this example) attachment holes 93 is provided for an outer peripheral flange 92 having the shape of a circular plate and a screw portion 94 to which an end of the third discharge tube 33 is fitted is formed on the outer peripheral surface of the end of the nozzle main body 81 on the exit side (right side in FIG. 2). Therefore, the collecting nozzle 72 is fitted to the discharge port 71 of the vertical wall 63 from the outside of the vessel main body 51, and in the state that the outer peripheral flange 92 is in close contact with the outer surface of the attachment stand 73, a plurality of (four in this example) bolts 95 is provided penetrating through the attachment holes 93 to be engaged with the attachment stand 73, whereby the collecting nozzle 72 is fixed to the vessel main body 51.

[0060] The covering portion 82 is provided so as to cover a part of the opening 91 of the nozzle main body 81 on the entrance side (left side in FIG. 2), thereby enabling the passing of the fluid but preventing the passing of the shielding materials. The passing portion 83 is provided outside the region to be covered with the covering portion 82 in the opening 91 of the nozzle main body 81, thereby enabling the passing of the fluid and the shielding materials.

[0061] The nozzle main body 81 has its upper part on the entrance side extending to the inside of the vessel main body 51 over a predetermined angle range, thereby forming a protection plate (protection portion) 101. This protection plate 101 forms an arc-like shape along the upper edge of the opening 91 and projects toward the inside of the vessel main body 51 by a predetermined distance as compared with the inner surface of the ver-

tical wall 63.

[0062] The covering portion 82 includes a first covering portion 102 provided below the protection plate 101 and a second covering portion 103 provided at an end of the protection plate 101 and the first covering portion 102. The first covering portion 102 is formed of a mesh material (for example, wire netting) in a rectangular and planar shape, and is fixed to cover a space below the protection plate 101 whose front shape is an approximately semicircular (FIG. 3). The second covering portion 103 is formed of a mesh material (for example, wire netting) in an approximately semicircular and planar shape, and is fixed to cover an anterior part of the protection plate 101 and the first covering portion 102 whose front shape is an approximately semicircular (FIG. 3).

[0063] Thus, when the covering portion 82 including the first covering portion 102 and the second covering portion 103 is formed extending from the nozzle main body 81 toward the entrance, the covering portion 82 is disposed in the discharge port 71 in the vertical wall 63 of the vessel main body 51, the end of the covering portion 82 is disposed projecting to the inside of the vessel main body 51 as compared with the inner wall surface of the vertical wall 63, and the protection plate 101 is disposed above this covering portion 82.

[0064] The passing portion 83 is provided outside the region to be covered with the covering portion 82 in the opening 91 of the nozzle main body 81, i.e., below the covering portion 82 and has an approximately semicircular shape.

[0065] In this embodiment, the area (surface area) of the covering portion 82 (first covering portion 102 and second covering portion 103) is larger than the area (opening area) of the passing portion 83. In this case, assuming that the opening area of the opening 91 of the nozzle main body 81 is 100%, the area (surface area) of the covering portion 82 is desirably 140% or more, optimally 150%. When the area (surface area) of the covering portion 82 is less than 140%, the amount of passing fluid may decrease to interrupt the appropriate discharge of the shielding materials. When the area (surface area) of the covering portion 82 is more than 150%, the discharge materials can be discharged as appropriate but the amount of passing fluid may increase, in which case it takes a long time to collect the shielding materials.

[0066] In this embodiment, the region of the covering portion 82 in the opening 91 of the nozzle main body 81 is set to be larger than the region of the passing portion 83. In other words, when the collecting nozzle 72 is viewed from the front (FIG. 3), the appearance area of the covering portion 82 is set to be larger than the area of the passing portion 83. In this case, assuming that the opening area of the opening 91 of the nozzle main body 81 is 100%, the area of the passing portion 83 is desirably 30 to 50%, optimally 40%. In other words, as depicted in FIG. 3, when the center O of the opening 91 of the nozzle main body 81 is at the intersection between the central lines C1 and C2, the first covering portion 102 is disposed

below the horizontal central line C2. When the area of the passing portion 83 is less than 30%, the shielding materials can be discharged as appropriate but the amount of passing shielding materials may decrease, in which case it takes a long time to collect the shielding materials. When the area of the passing portion 83 is more than 50%, the amount of passing shielding materials may increase to interrupt the appropriate discharge of the shielding materials.

[0067] Moreover, in this embodiment, the shielding material is formed to be spherical and has an outer diameter of 3 mm. Therefore, it is necessary that the size of one opening of the covering portion 82 is smaller than 3 mm at which the shielding material can pass. On the other hand, the passing portion 83 needs to be larger than 3 mm at which the shielding material can pass. The opening 91 of the nozzle main body 81 has an inner diameter of 50 mm, and the density of the shielding materials flowing through the third discharge tube 33 after being discharged through the opening 91 relative to the fluid is desirably approximately 60%.

[0068] A shielding material filling method by the shielding material filling device 12 in the radiation shielding device of this embodiment structured as depicted in FIG. 5 includes a first filling step of supplying the fluid and the shielding materials from the first supply unit 54 to the inside of the shielding vessel 11 and increasing the internal pressure, and a second filling step of pumping only the fluid on the inside from the first discharge unit 56 to the outside by the internal pressure of the shielding vessel 11. A shielding material collecting method by the shielding material collecting device 13 includes a first collecting step of supplying the fluid from the second supply unit 55 to the inside of the shielding vessel 11 and increasing the internal pressure, and a second collecting step of pumping the fluid and the shielding materials on the inside from the second discharge unit 57 to the outside by the internal pressure of the shielding vessel 11.

[0069] The radiation shielding method by the radiation shielding device of this embodiment is hereinafter described.

[0070] First, the shielding vessel 11 of the radiation shielding device is disposed around the body to be shielded P. Next, the shielding material filling device 12 and the shielding material collecting device 13 are attached to the shielding vessel 11. Specifically, in the shielding vessel 11, the first supply unit 54 is connected to the second supply tube 24 and the second supply unit 55 is connected to the third supply tube 26. Moreover, in the shielding vessel 11, the first discharge unit 56 is connected to the first discharge tube 31 and the second discharge unit 57 is connected to the third discharge tube 33.

[0071] In this state, the switch valve 27 is opened and the switch valve 28 is closed, and the switch valve 34 is opened and the switch valve 35 is closed. Then, the pump 23 is operated, whereby the water in the tank unit 21 is supplied from the first supply unit 54 to the inside of the shielding vessel 11 through the first supply tube 22 and

the second supply tube 24, thereby filling the inside of the shielding vessel 11 with the fluid. Subsequently, the opening/closing valve 30 is opened to supply a number of shielding materials from the shielding material supply hopper 25 to the second supply tube 24 through the supply tube 29. Thus, in addition to the fluid, a number of shielding materials are supplied from the first supply unit 54 to the inside of the shielding vessel 11 through the second supply tube 24 and are sequentially deposited on the bottom. On this occasion, since the pressure in the shielding vessel 11 is increased by the supply of the fluid and the shielding materials, the fluid is extruded through the filter of the first discharge unit 56 and then returned to the tank unit 21 through the first discharge tube 31 and the second discharge tube 32; thus, the fluid circulates.

[0072] After the shielding vessel 11 is sufficiently filled with the shielding materials inside, the opening/closing valve 30 is closed, thereby stopping the supply of the shielding materials from the shielding material supply hopper 25 to the second supply tube 24 through the supply tube 29. Subsequently, the operation of the pump 23 is stopped and the switch valve 27 is closed and the switch valve 34 is closed, whereby the supply of the fluid and the shielding materials to the shielding vessel 11 is stopped. As a result, the shielding vessel 11 is filled with just an appropriate amount of the fluid and the shielding materials.

[0073] Since the shielding vessel 11 is filled with a number of shielding materials inside, the outside of the body to be shielded P can be protected from radiation. Thus, an operator can work near the outside of the body to be shielded P where the radiation is blocked by the shielding vessel 11. Upon the completion of the work for the body to be shielded P, the radiation shielding device is removed.

[0074] First, the switch valve 27 is closed and the switch valve 28 is opened, and the switch valve 34 is closed and the switch valve 35 is opened. Then, the pump 23 is operated, whereby the water in the tank unit 21 is supplied from the second supply unit 55 to the inside of the shielding vessel 11 through the first supply tube 22 and the third supply tube 26. Therefore, since the pressure in the shielding vessel 11 is increased by the supply of the fluid, the fluid and the shielding materials are extruded through the collecting nozzle 72 of the second discharge unit 57 and then returned to the tank unit 21 through the third discharge tube 33 and the second discharge tube 32; thus, the shielding materials are collected and the fluid circulates.

[0075] In other words, as depicted in FIG. 1 and FIG. 2, upon the supply of the fluid to the second supply unit 55, the fluid is jet from the jet nozzle 65 to the inside of the vessel main body 51 in the shielding vessel 11. Then, a number of shielding materials filling the inside together with the fluid are dispersed in the vessel main body 51 and at the same time the internal pressure is increased. Then, the fluid and the shielding materials in the vessel

main body 51 are extruded from the collecting nozzle 72.

[0076] On this occasion, the fluid is discharged through the entire regions of the opening 91 in the nozzle main body 81 including the covering portion 82 and the passing portion 83. On the other hand, the shielding materials cannot pass through the covering portion 82 and are discharged through the passing portion 83 only. The amount of shielding materials passing through the opening 91 is restricted by the covering portion 82 and the density of the shielding materials to the fluid becomes the appropriate density, for example, 60%. Therefore, the shielding materials do not clog the third discharge tube 33 and are collected efficiently in a short time through this third discharge tube 33.

[0077] Note that the shielding materials are attached to the covering portion 82, especially the surface of the second covering portion 103; however, since the opening of the covering portion 82 is sufficiently smaller than the outer diameter of the shielding material, it is possible to avoid that the shielding materials block all the regions of the covering portion 82.

[0078] Moreover, since the collecting nozzle 72 of the second discharge unit 57 is disposed horizontally relative to the jet nozzle 65 of the second supply unit 55, the fluid jet from the jet nozzle 65 of the second supply unit 55 guides the shielding materials toward the collecting nozzle 72 of the second discharge unit 57, thereby enabling the appropriate discharge of the shielding materials out of the vessel main body 51.

[0079] After all the shielding materials inside are discharged and collected from the shielding vessel 11, the operation of the pump 23 is stopped and the switch valve 28 is closed and the switch valve 35 is closed as depicted in FIG. 5. Then, the supply of the fluid into the shielding vessel 11 is stopped and accordingly, the shielding vessel 11 is filled with the fluid only. Thus, in the shielding vessel 11, the second supply tube 24 is disconnected from the first supply unit 54 and the third supply tube 26 is disconnected from the second supply unit 55. Moreover, in the shielding vessel 11, the first discharge tube 31 is disconnected from the first discharge unit 56 and the third discharge tube 33 is disconnected from the second discharge unit 57. In this manner, the shielding material filling device 12 and the shielding material collecting device 13 are disconnected from the shielding vessel 11. Then, by removing the shielding vessel 11 from around the body to be shielded P, the radiation shielding device is removed and all the works are completed.

[0080] Thus, the shielding material collecting nozzle 72 of this embodiment includes: the nozzle main body 81 having the opening 91; the covering portion 82 which is provided covering a part of the opening 91 and through which the fluid can pass and the shielding materials cannot pass; and the passing portion 83 which is provided outside the region to be covered with the covering portion 82 in the opening 91 and through which the fluid and the shielding materials can pass.

[0081] Thus, the fluid is discharged through the entire

regions of the opening 91 including the covering portion 82 and the passing portion 83, while the shielding materials cannot pass through the covering portion 82 and are discharged through the passing portion 83 only. As a result, the amount of shielding materials passing through the opening 91 can be restricted to make the density of the shielding materials relative to the fluid the appropriate density. Thus, it is possible to prevent the shielding materials from blocking the opening 91 and to collect the shielding materials efficiently in a short time. By merely providing the covering portion 82 so as to cover a part of the opening 91 of the nozzle main body 81, the passing portion 83 can be secured and the structure can be simplified and reduced in weight and moreover the shielding function can be improved.

[0082] In the shielding material collecting nozzle 72 of this embodiment, the area of the covering portion 82 is set to be larger than that of the passing portion 83. Moreover, in the opening 91, the region of the covering portion 82 is set to be larger than that of the passing portion 83. Therefore, it is possible to prevent the shielding materials from blocking the covering portion 82 and to efficiently collect the shielding materials in a short time by securing enough area for the covering portion 82.

[0083] In the shielding material collecting nozzle 72 of this embodiment, the covering portion 82 is formed of a mesh material. This can simplify the structure and reduce the cost of the structure.

[0084] In the shielding material collecting nozzle 72 of this embodiment, the covering portion 82 is extended toward the entrance of the nozzle main body 81. Therefore, the amount of projecting toward the exit can be reduced and the enlargement of the device can be suppressed.

[0085] In the shielding material collecting nozzle 72 of this embodiment, the passing portion 83 is disposed below the covering portion 82 and the protection plate 101 is provided above the covering portion 82. Therefore, if the shielding material drops from above, the dropped material collides with the protection plate 101, thereby suppressing the contact with the covering portion 82 and preventing the damage of the covering portion 82. Moreover, the dropped shielding material can be efficiently discharged from the passing portion 83 located below.

[0086] In the shielding material collecting nozzle 72 of this embodiment, the opening 91 is circular, the protection plate 101 has an arc-like shape along the upper edge of the opening 91, and the first covering portion 102 is provided below the protection plate 101 as the covering portion 82. Therefore, since the protection plate 101 has the arc-like shape along the upper edge of the opening 91, it is possible to suppress that the shielding materials dropped from above are deposited on the protection plate 101; thus, the shielding materials can be collected as appropriate.

[0087] In the shielding material collecting nozzle 72 of this embodiment, the second covering portion 103 is provided at the end of the protection plate 101 and the first covering portion 102 as the covering portion 82. There-

fore, enough area can be secured for the covering portion 82.

[0088] The shielding vessel 11 of this embodiment includes: the vessel main body 51 having a hollow shape; the supply unit 52 that can supply the fluid and the shielding materials to the inside of the vessel main body 51; and the discharge unit 53 that can discharge the fluid and the shielding materials out of the vessel main body 51. The discharge unit 53 has the collecting nozzle 72 attached thereto.

[0089] Therefore, by the supply of the fluid from the supply unit 52 to the inside of the vessel main body 51, the pressure in the vessel main body 51 increases, whereby the fluid and the shielding materials in the vessel main body 51 are extruded from the discharge unit 53. On this occasion, the fluid is discharged through the entire regions of the opening 91 including the covering portion 82 and the passing portion 83 and the shielding materials cannot pass through the covering portion 82 and are discharged through the passing portion 83 only. Therefore, the amount of the shielding materials passing through the opening 91 can be restricted to make the density of the shielding materials to the fluid the appropriate density. Thus, it is possible to prevent the shielding materials from blocking the opening 91 and to efficiently collect the shielding materials in a short time. By merely providing the covering portion 82 so as to cover a part of the opening 91 of the nozzle main body 81, the passing portion 83 can be secured and the structure can be simplified and reduced in weight and moreover the shielding function can be improved.

[0090] In the shielding vessel 11 of this embodiment, the covering portion 82 extends toward the inside of the vessel main body 51 as compared with the inner wall surface of the vessel main body 51. Therefore, the covering portion 82 can be disposed at the discharge port 71 of the vertical wall 63 of the vessel main body 51, the amount of projecting toward the inside of the vessel main body 51 can be reduced, and the enlargement of the device can be suppressed.

[0091] In the shielding vessel 11 of this embodiment, the first supply unit 54 that is provided at the upper part of the vessel main body 51 and that can supply the fluid and the shielding materials and the second supply unit 55 that is provided at the lower part of the vessel main body 51 and that can supply only the fluid serve as the supply unit 52, and the first discharge unit 56 that is provided at the upper part of the vessel main body 51 and that can discharge only the fluid and the second discharge unit 57 that is provided at the lower part of the vessel main body 51 and that can discharge the fluid and the shielding materials serve as the discharge unit 53. Thus, by providing the first supply unit 54 and the first discharge unit 56 for filling the vessel main body 51 with the shielding materials and providing the second supply unit 55 and the second discharge unit 57 for collecting the shielding materials in the vessel main body 51, the filling and collecting of the shielding materials for the ves-

sel main body 51 can be conducted efficiently.

[0092] In the shielding vessel 11 of this embodiment, the second supply unit 55 and the second discharge unit 57 are disposed to face each other horizontally. Therefore, the fluid supplied from the second supply unit 55 to the vessel main body 51 is jet toward the second discharge unit 57 and by guiding the shielding materials in the vessel main body 51 toward the second discharge unit 57, the shielding materials can be collected efficiently.

[0093] The shielding material collecting device 13 of this embodiment includes: the supply tubes 22 and 26 that can supply the fluid to the shielding vessel 11; the pump 23 provided for the first supply tube 22; the discharge tubes 32 and 33 that can discharge the fluid and the shielding materials out of the shielding vessel 11; and the collecting nozzle 72 provided for the second discharge unit 57 of the shielding vessel 11 and connected to the third discharge tube 33.

[0094] The shielding material collecting method of this embodiment includes a first collecting step of supplying the fluid from the second supply unit 55 to the shielding vessel 11 and increasing the internal pressure, and a second collecting step of pumping the fluid and the shielding materials on the inside from the second discharge unit 57 to the outside by the internal pressure of the shielding vessel 11 by the use of the shielding material collecting nozzle 72.

[0095] In the shielding material collecting method by the shielding material collecting device 13, the pressure in the shielding vessel 11 is increased by operating the pump to supply the fluid from the second supply unit 55 to the inside of the shielding vessel 11 through the supply tubes 22 and 26; therefore, the fluid and the shielding materials in the shielding vessel 11 are extruded from the second discharge unit 57 to the third discharge tube 33. Therefore, the amount of shielding materials passing through the opening 91 is restricted to make the density of the shielding materials to the fluid the appropriate density. Thus, it is possible to prevent the shielding materials from blocking the opening 91 and to efficiently collect the shielding materials in a short time. By merely providing the covering portion 82 so as to cover a part of the opening 91 of the nozzle main body 81, the passing portion 83 can be secured and the structure can be simplified and reduced in weight and moreover the shielding function can be improved.

[0096] Note that in the aforementioned embodiment, the covering portion 82 is extended toward the entrance as compared with the passing portion 83 of the collecting nozzle 72; however, the covering portion 82 may be provided as the plane and disposed at the same position as the passing portion 83. Further, although the covering portion 82 is provided in the upper part of the collecting nozzle 72 and the passing portion 83 is provided in the lower part of the collecting nozzle 72, the present invention is not limited to this structure. For example, the passing portion 83 may be provided in the upper part of the

collecting nozzle 72 or the covering portion 82 may be provided in the lower part the collecting nozzle 72, or the passing portion 83 may be provided at the center of the covering portion 82.

[0097] In the aforementioned embodiment, the covering portion 82 is composed of the first covering portion 102 and the second covering portion 103; however, the second covering portion 103 may be the passing portion or a blocking portion. In addition, although the protection plate 101 has the arc-like shape in the above embodiment, the protection plate 101 may alternatively has a triangular or quadrangular shape.

[0098] Furthermore, in the aforementioned embodiment, the first supply unit 54 in the upper part of the vessel main body 51 and the second supply unit 55 in the lower part of the vessel main body 51 are provided as the supply unit 52 and the first discharge unit 56 in the upper part of the vessel main body 51 and the second discharge unit 57 in the lower part of the vessel main body 51 are provided as the discharge unit 53; however, the present invention is not limited thereto. For example, any one of the first supply unit 54 and the second supply unit 55 may be provided as the supply unit 52 or the first supply unit 54 and the second supply unit 55 may be provided at another position or the functions of the first supply unit 54 and the second supply unit 55 may be fulfilled by one supply unit.

[0099] Although the shielding vessel has the ring-like shape in the aforementioned embodiment, the shape can be changed as appropriate in accordance with the shape of the body to be shielded.

[0100] The above embodiment has described the case in which the present invention is applied to the work of maintenance, inspection, or repair in the atomic power plant; however, the present invention is not limited to this place.

Reference Signs List

[0101]

11	SHIELDING VESSEL
12	SHIELDING MATERIAL FILLING DEVICE
13	SHIELDING MATERIAL COLLECTING DEVICE
21	TANK UNIT
22	FIRST SUPPLY TUBE
23	PUMP
24	SECOND SUPPLY TUBE
25	SHIELDING MATERIAL SUPPLY HOPPER
26	THIRD SUPPLY TUBE
31	FIRST DISCHARGE TUBE
32	SECOND DISCHARGE TUBE
33	THIRD DISCHARGE TUBE
51	VESSEL MAIN BODY
52	SUPPLY UNIT
53	DISCHARGE UNIT
54	FIRST SUPPLY UNIT
55	SECOND SUPPLY UNIT

56	FIRST DISCHARGE UNIT
57	SECOND DISCHARGE UNIT
71	DISCHARGE PORT
72	COLLECTING NOZZLE (SHIELDING MATERIAL COLLECTING NOZZLE)
81	NOZZLE MAIN BODY
82	COVERING PORTION
83	PASSING PORTION
91	OPENING
101	PROTECTION PLATE (PROTECTION PORTION)
102	FIRST COVERING PORTION
103	SECOND COVERING PORTION
P	BODY TO BE SHIELDED

Claims

1. A shielding material collecting nozzle (72) comprising:
 - a nozzle main body (81) having an opening (91);
 - a covering portion (82) which is provided so as to cover a part of the opening (91) and through which a fluid can pass and a shielding material cannot pass; and
 - a passing portion (83) which is provided outside a region covered with the covering portion (82) in the opening (91) and through which the fluid and the shielding material can pass.
2. The shielding material collecting nozzle (72) according to claim 1, wherein an area of the covering portion (82) is larger than an area of the passing portion (83).
3. The shielding material collecting nozzle (72) according to claim 1 or 2, wherein a region of the covering portion (82) in the opening (91) is larger than a region of the passing portion (83).
4. The shielding material collecting nozzle (72) according to any one of claims 1 to 3, wherein the covering portion (82) is formed of a mesh material.
5. The shielding material collecting nozzle (72) according to any one of claims 1 to 4, wherein the covering portion (82) of the nozzle main body (81) extends toward an entrance.
6. The shielding material collecting nozzle (72) according to claim 5, wherein a protection portion (101) is provided above the covering portion (82).
7. The shielding material collecting nozzle (72) according to claim 6, wherein
 - the opening (91) is circular,
 - the protection portion (101) has an arc-like shape along an upper edge of the opening (91), and

the covering portion (82) has at least a first covering portion (102) provided below the protection portion (101).

8. The shielding material collecting nozzle (72) according to claim 7, wherein the covering portion (82) has a second covering portion (103) provided at an end of the protection portion (101) and the first covering portion (102).

9. A shielding vessel (11) comprising:

a vessel main body (51) having a hollow shape;
a supply unit (52) that can supply a fluid and a shielding material to the inside of the vessel main body (51); and
a discharge unit (53) that can discharge the fluid and the shielding material out of the vessel main body (51), wherein the shielding material collecting nozzle (72) according to any one of claims 1 to 8 is attached to the discharge unit (53).

10. The shielding vessel (11) according to claim 9, wherein the covering portion (82) extends toward the inside of the vessel main body (51) as compared with an inner wall surface of the vessel main body (51).

11. The shielding vessel (11) according to claim 9 or 10, wherein

the supply unit (52) includes a first supply unit (54) that is provided at an upper part of the vessel main body (51) and that can supply the fluid and the shielding material and a second supply unit (55) that is provided at a lower part of the vessel main body (51) and that can supply only the fluid, and
the discharge unit (53) includes a first discharge unit (56) that is provided at the upper part of the vessel main body (51) and that can discharge only the fluid and a second discharge unit (57) that is provided at the lower part of the vessel main body (51) and that can discharge the fluid and the shielding material.

12. The shielding vessel (11) according to claim 11, wherein the second supply unit (55) and the second discharge unit (57) are disposed to face each other horizontally.

13. A shielding material collecting device comprising:

a supply line (22, 24, 26) that can supply a fluid to a shielding vessel (11);
a pump (23) provided for the supply line;
a discharge line (31, 32, 33) that can discharge the fluid and a shielding material out of the shielding vessel (11); and
the shielding material collecting nozzle (72) according to any one of claims 1 to 8 that is pro-

vided for a discharge unit (53) of the shielding vessel (11) and connected to the discharge line (31, 32, 33).

14. A shielding material collecting method comprising:

a first step of supplying a fluid from a supply unit (52) to the inside of a shielding vessel (11) and increasing an internal pressure; and
a second step of pumping the fluid and a shielding material in the shielding vessel (11) through a discharge unit (53) to the outside by the internal pressure of the shielding vessel (11) by the use of the shielding material collecting nozzle (72) according to any one of claims 1 to 8.

FIG. 1

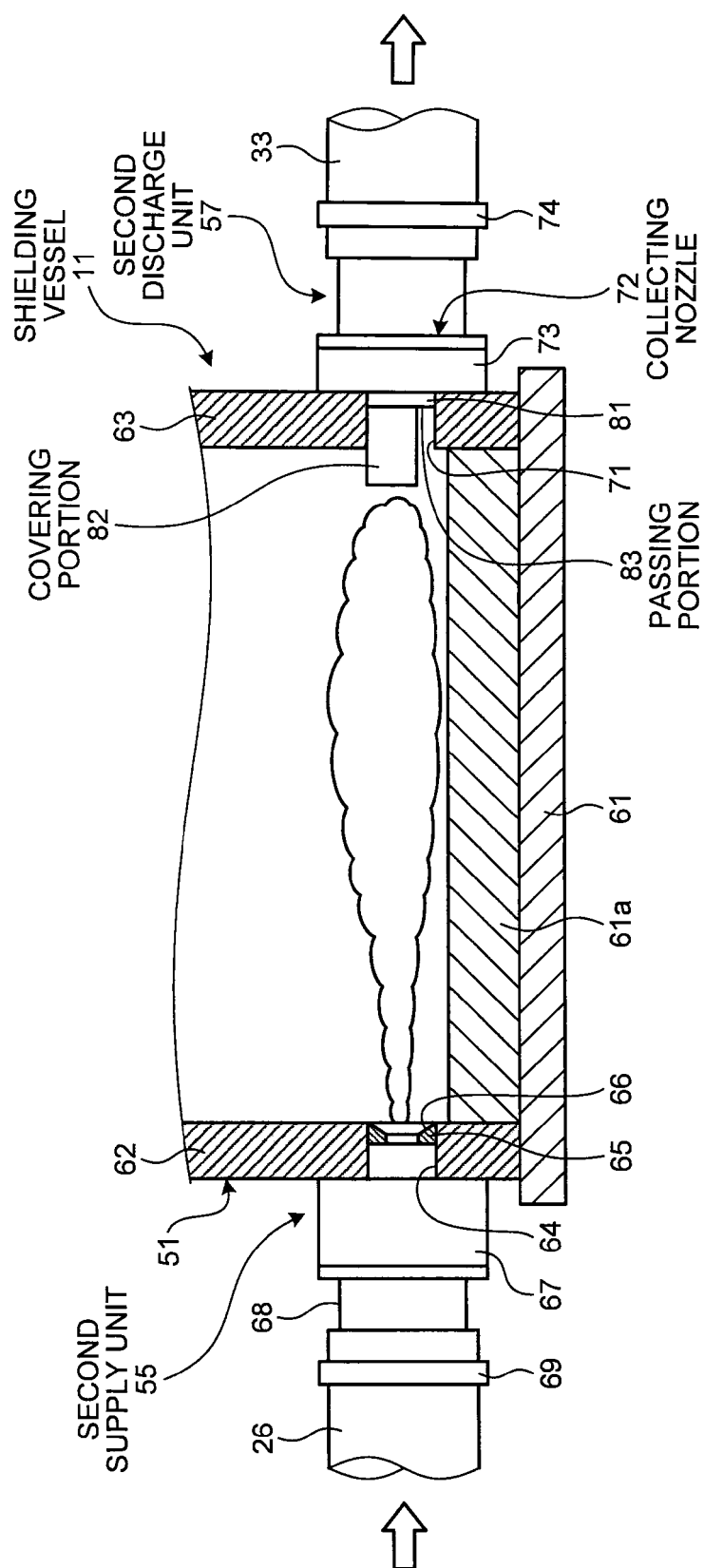


FIG.2

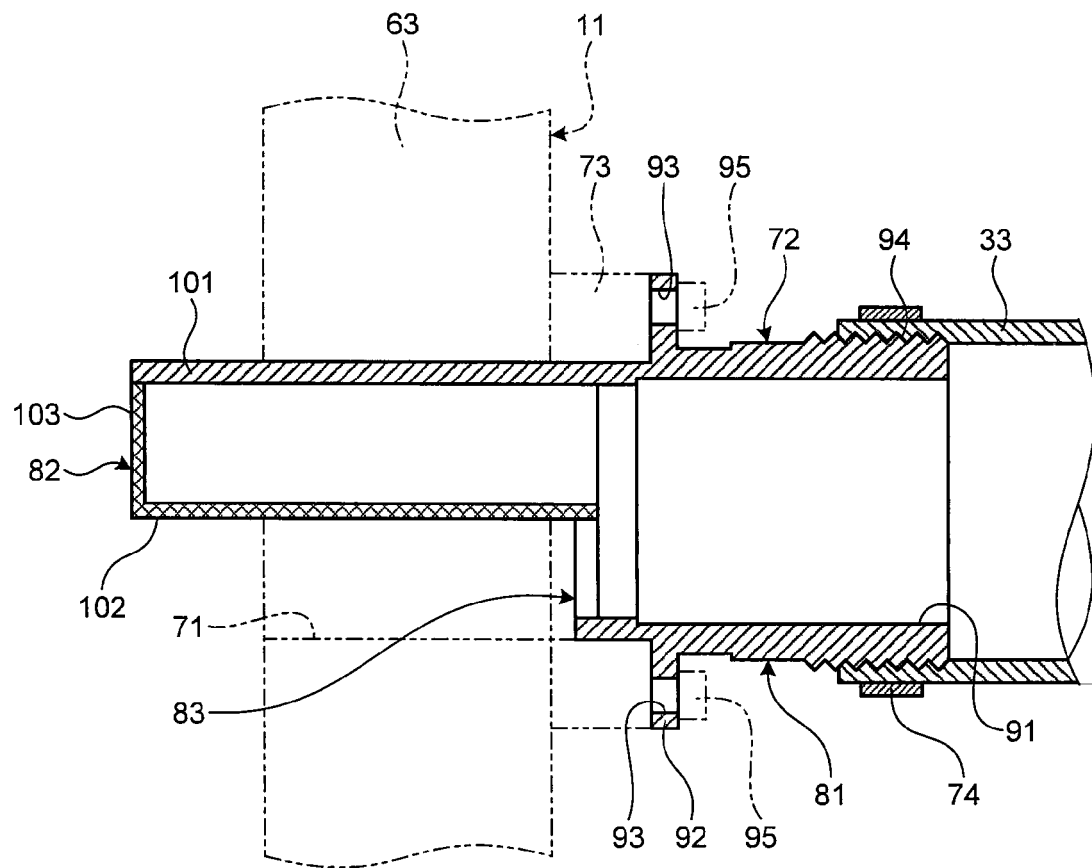


FIG.3

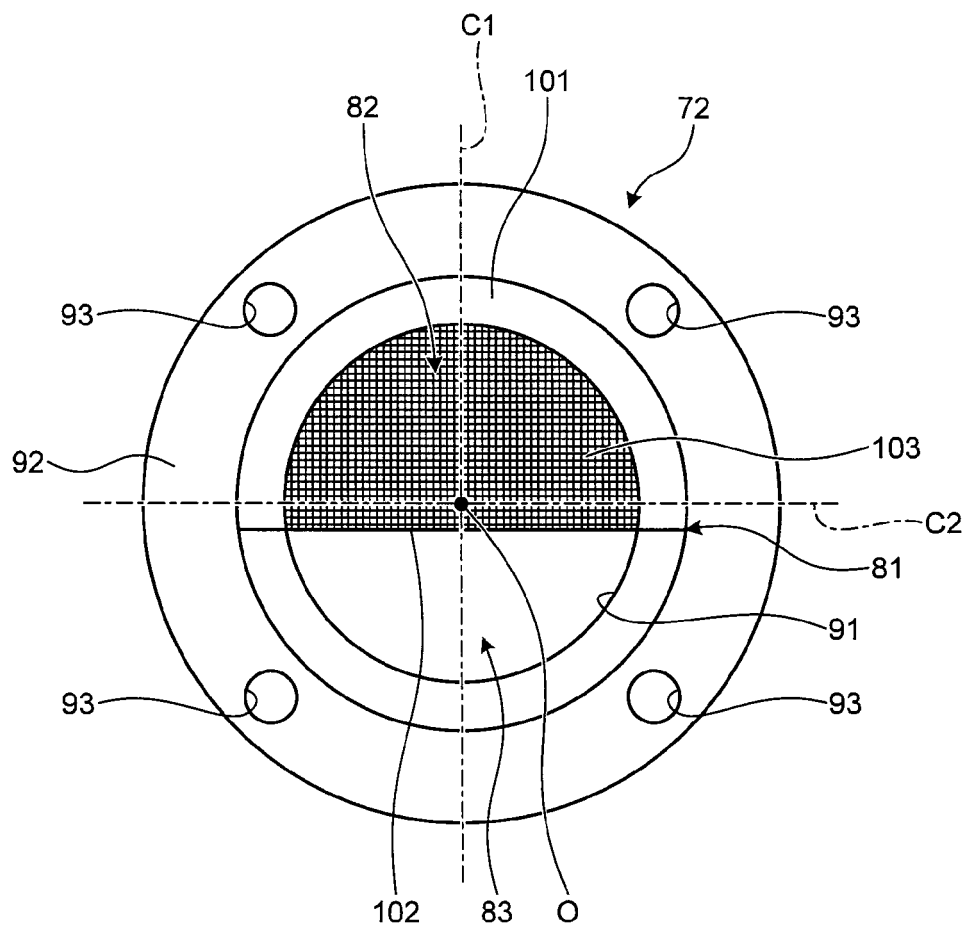


FIG.4

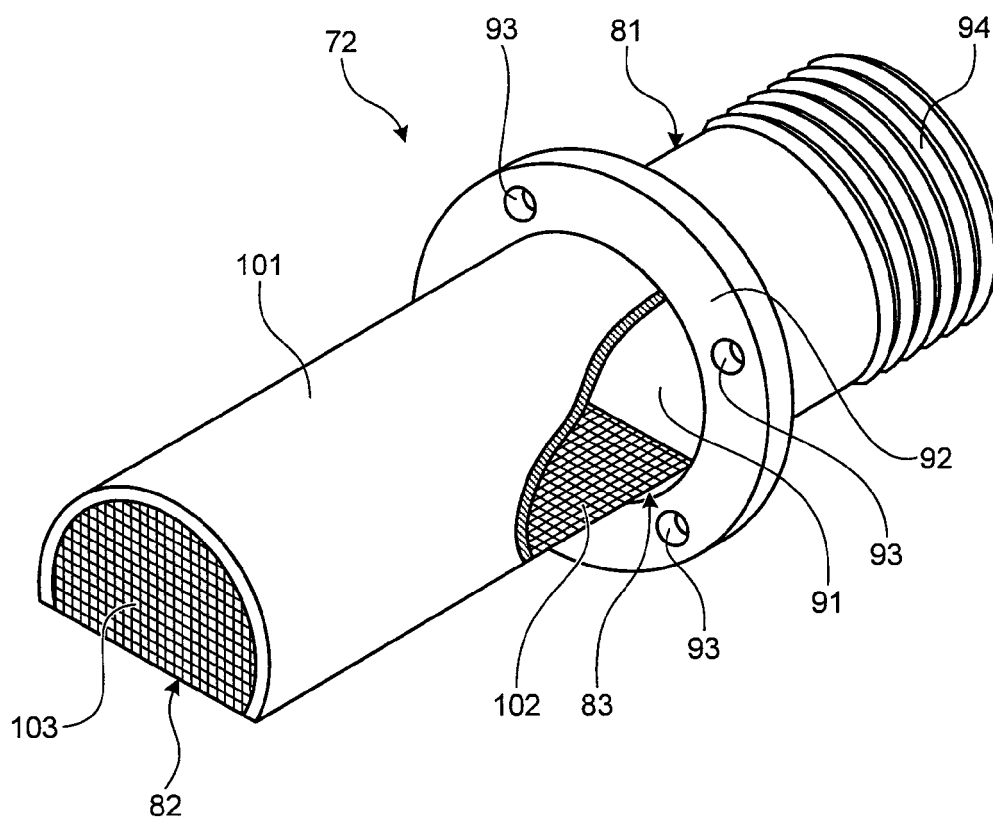
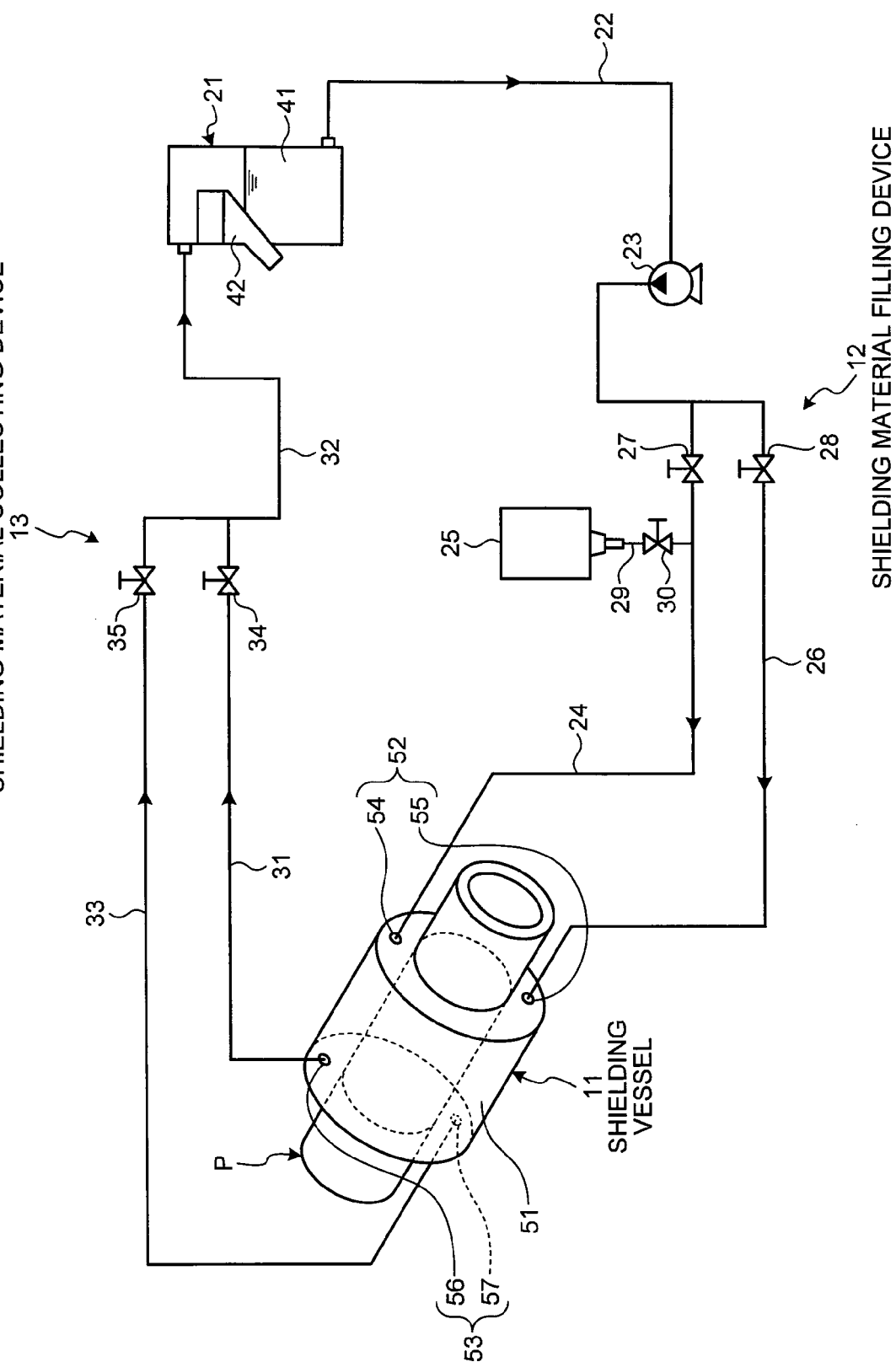


FIG.5

SHIELDING MATERIAL COLLECTING DEVICE



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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