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(71) Applicant: **Nippon Steel & Sumikin Engineering Co., Ltd.**
Tokyo 141-8604 (JP)

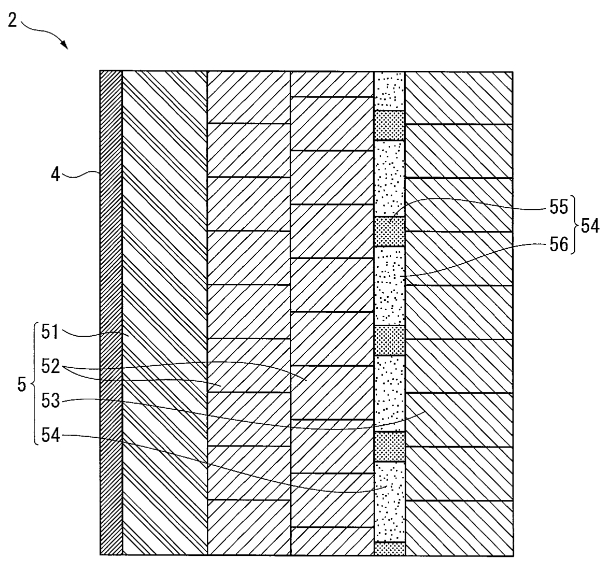
(72) Inventors:
- **SHIINO, Akira**
  Tokyo 141-8604 (JP)
- **KURAYOSHI, Kazumi**
  Tokyo 141-8604 (JP)
- **MAEKAWA, Norimasa**
  Tokyo 141-8604 (JP)

(74) Representative: **Gille Hrabal**
Brucknerstrasse 20
40593 Düsseldorf (DE)

(54) **HOT-BLAST STOVE CONSTRUCTION METHOD**

(57) In a method of constructing a hot-blast stove, the hot-blast stove includes a furnace body including a furnace shell (4) and a lining (5) formed inside the furnace shell (4), in which the lining (5) includes a castable refractory (51) installed inside the furnace shell (4), heat-insulating bricks (52) installed inside the castable refractory (51), and fire bricks (53) installed inside the heat-insulating brick (52). The method of constructing the hot-blast stove includes: installing the heat-insulating bricks (52) and the fire bricks (53) inside the furnace shell (4) at an interval from the furnace shell (4); injecting the castable refractory (51) between the furnace shell (4) and the heat-insulating bricks (52); and solidifying the castable refractory (51).

FIG.1



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Description

TECHNICAL FIELD

[0001] The present invention relates to a method for constructing a hot-blast stove, and more specifically, to a method for constructing a hot-blast stove configured to supply hot air to a blast furnace.

BACKGROUND ART

[0002] A hot-blast stove has been typically used as equipment for supplying hot air to a blast furnace for producing pig iron.

[0003] A plurality (three to five) of hot-blast stoves are installed to a blast furnace. Some of the hot-blast stoves store heat and the rest of the hot-blast stoves supply hot air to the blast furnace, whereby the hot air can be continuously supplied to the blast furnace.

[0004] Each of the hot-blast stoves includes: a combustion chamber equipped with a heating burner; and a heat storage chamber filled with checker bricks (i.e., a heat storage medium). In a heat storage operation, fuel is combusted in the combustion chamber to generate a hot air and the hot air is fed to the heat storage chamber, where heat is stored in the checker bricks stacked in the interior of the heat storage chamber. Further, in an air supply operation, an outside air passes through the heat storage chamber to be heated, and the hot air heated to about 1200 degrees C to 1400 degrees C is supplied to the blast furnace.

[0005] Examples of the hot-blast stove includes: an external combustion type hot-blast stove including the combustion chamber and the heat storage chamber that are constructed as separate furnace bodies; and an internal combustion type hot-blast stove including the combustion chamber and the heat storage chamber that are collectively housed in the same blast furnace body.

[0006] Fig. 24 illustrates an external combustion type hot-blast stove 1 as an example. The hot-blast stove 1 is of an external combustion type and includes the combustion chamber and the heat storage chamber as separate bodies. Specifically, the hot-blast stove 1 includes a combustion-chamber furnace body 2 and a heat-storage-chamber furnace body 3 (i.e., two furnace bodies). It should be noted that the illustrated hot-air stove 1 is one of a plurality of hot-air stoves installed to a single blast furnace.

[0007] A burner 21 is formed on a furnace hearth inside the combustion-chamber furnace body 2. The burner 21 mixes and combusts a fuel gas introduced to a fuel gas introduction unit 22 with an air introduced to an air introduction unit 23, thereby generating a high-temperature combustion gas flowing toward a furnace top of the combustion-chamber furnace body 2.

[0008] A hot-air supply unit 24 extending to the blast furnace is installed on a side surface of the combustion-chamber furnace body 2. The furnace top portion of the combustion-chamber furnace body 2 is connected to a furnace top portion of the heat-storage-chamber furnace body 3 by a connecting pipe 25.

[0009] Checker bricks 31 as a heat storage medium are stacked inside the heat-storage-chamber furnace body 3, The checker bricks 31 are stacked without a gap from a furnace hearth to the vicinity of the furnace top in the heat-storage-chamber furnace body 3. The respective checker bricks 31 are formed with a plurality of ventilation holes and are stacked so that the respective ventilation holes communicate with each other. Thus, in the plurality of stacked checker bricks 31, air can flow from the furnace hearth to the furnace top portion of the heat-storage-chamber furnace body 3.

[0010] In the furnace hearth of the heat-storage-chamber furnace body 3, an intake-exhaust port 32 is opened to the outside.

[0011] In such a hot-blast stove 1, heat storage and air supply are performed in the following manner.

[0012] In a heat storage operation, the burner 21 combusts the fuel gas to generate a combustion gas to go up in the combustion-chamber furnace body 2. The combustion gas is introduced from the connecting pipe 25 into the heat-storage-chamber furnace body 3. The introduced combustion gas is flowed downward through the checker bricks 31. During the flow of the combustion gas, heat of the combustion gas is stored in the checker bricks 31. The combustion gas after passing through the checker bricks 31 is discharged from the intake-exhaust port 32.

[0013] In the air supply operation, the outside air is sucked from the intake-exhaust port 32 into the heat-storage-chamber furnace body 3. The sucked outside air is flowed upward through the checker bricks 31. During the flowing of the outside air, the outside air is heated by the heat stored in the checker bricks 31 to generate a hot air. The hot air is introduced from the connecting pipe 25 into the combustion-chamber furnace body 2 and is supplied from the hot-air supply unit 24 to the blast furnace.

[0014] In such a hot-blast stove 1, each of the combustion-chamber furnace body 2 and the heat-storage-chamber furnace body 3 includes: a cylindrical furnace shell 4 as an outer shell; and a lining 5 formed inside the outer shell and protecting the furnace shell from the high temperature in the furnace.

[0015] Fig. 25 illustrates the lining 5 of the combustion-chamber furnace body 2.

[0016] The lining 5 includes: a castable refractory 51 formed on an inner surface of the furnace shell 4; heat-insulating bricks 52 stacked inside the castable refractory 51; and fire bricks 53 stacked inside the heat-insulating bricks 52. An inner side of the fire bricks brick 53 is formed as a cavity. The cavity serves as an air duct in the combustion-chamber furnace body 2.

[0017] In the lining 5, an expansion clearance 54 is formed, for instance, between a layer of the heat-insulating bricks 52 and a layer of the fire bricks 53.

[0018] When the newly constructed hot-blast stove 1 is fired, there is a possibility that the fire bricks 53 are thermally expanded significantly and are displaced outward in a radial direction of the furnace body to interfere with the heat-insulating bricks 52. In order to cope with such a problem, since the expansion clearance 54 is provided between the layers of the heat-insulating bricks 52 and the layers of the fire bricks 53 in a continuous manner in a circumferential direction of the furnace body, the thermal expansion of the fire bricks 53 is allowed by the expansion clearance 54 (see Patent Literature 1) as illustrated in Fig. 26.

[0019] In the arrangement with the expansion clearance 54, when the expansion clearance 54 is simply provided by a cavity, a leak gas may unfavorably pass through the expansion clearance 54. For this reason, the cavity of the expansion clearance 54 is filled with a flexible and amorphous filling material (filler) such as ceramic fiber and foamed plastics. Alternatively, a foamable filling material is injected to the cavity and is foamed to fill every corner. Subsequently, the foamed filling material is solidified and held in the cavity. Even when the foamable filling material is solidified, the solidified foamable filling material is sufficiently soft and does not restrain the thermal expansion of the fire bricks 53 in the same manner as the flexible amorphous filling material.

[0020] The expansion clearance 54 may be formed between the layer of the heat-insulating bricks 52 and the castable refractory 51, in addition to between the layer of the heat-insulating bricks 52 and the layer of the fire bricks 53.

[0021] Figs. 27 and 28 illustrate different structures of the lining 5 of the combustion-chamber furnace body 2.

[0022] In each drawing, the expansion clearance 54 as illustrated in Fig. 25 is not formed between the layer of the heat-insulating bricks 52 and the layer of the fire bricks 53. However, the expansion clearance 54 is formed in each of gaps formed between the fire bricks 53 arranged in the circumferential direction of the furnace body, in a continuous manner in the radial direction of the furnace body. The expansion clearance 54 allows thermal expansion of the fire bricks 53 and can prevent the fire bricks 53 from being displaced radially outward. Accordingly, when the expansion clearance 54 is employed, the fire bricks 53 and the heat-insulating bricks 52 can be stacked in close contact with each other.

[0023] The lining 5 of the heat-storage-chamber furnace body 3 is configured in the same manner as the lining 5 of the combustion-chamber furnace body 2 described above.

[0024] As illustrated in Fig. 29, in the heat-storage-chamber furnace body 3, for instance, the lining 5 illustrated in Fig. 25 is formed inside the furnace shell 4 and the checker bricks 31 are stacked without a gap inside the innermost side of the fire bricks 53.

[0025] When the above-described lining 5 is installed, a scaffolding is set up inside the combustion-chamber furnace body 2 or the heat-storage-chamber furnace body 3, or alternatively, a gondola is suspended and the castable refractory 51 is sprayed to the interior of the furnace shell 4 at a predetermined height of the furnace body. Subsequently, a stacking operation of the heat-insulating bricks 52 and the fire bricks 53 inside the castable refractory 51 is performed (see Patent Literatures 2 and 3).

[0026] In general, the inner side of each of the combustion-chamber furnace body 2 and the heat-storage-chamber furnace body 3 is divided into levels by a height (about 1.2 m) within which a worker can easily perform the stacking operation of the heat-insulating bricks 52 and the fire bricks 53. The stacking operation is sequentially repeated at each of the levels.

CITATION LIST

PATENT LITERATURE(S)

[0027]

Patent Literature 1: JP-A-8-269514
Patent Literature 2: JP-B-56-24007
Patent Literature 3: JP-A-2009-115444

SUMMARY OF THE INVENTION

PROBLEM(S) TO BE SOLVED BY THE INVENTION

[0028] As described above, in the installation of the typical lining 5, since the scaffolding or the gondola is used when the castable refractory 51 is sprayed to the inside of the furnace shell 4, the scaffolding or the gondola needs to be assembled before the castable refractory 51 is sprayed.

[0029] Moreover, since the scaffolding or the gondola used for spraying the castable refractory 51 interferes with the heat-insulating bricks 52 and the fire bricks 53 to be stacked inside the castable refractory 51, the scaffolding or the gondola needs to be disassembled before the stacking operation.

[0030] In other words, the assembling and disassembling operations of the scaffolding or the gondola are required between the spraying operation of the castable refractory 51 and the stacking operation of the heat-insulating bricks 52 and the fire bricks 53, which entails an increase in a work period and a cost required for the construction of the hot-blast stove 1.

[0031] An object of the present invention is to provide a method for constructing a hot-blast stove including a furnace body to which a lining is easily built in a short period of time.

MEANS FOR SOLVING THE PROBLEM(S)

[0032] According to an aspect of the invention, in a method of constructing a hot-blast stove, the hot-blast stove includes a furnace body including a furnace shell and a lining formed inside the furnace shell, and the lining includes: a castable refractory installed inside the furnace shell; heat-insulating bricks installed inside the castable refractory; and fire bricks installed inside the heat-insulating bricks. The method includes: installing the heat-insulating bricks and the fire bricks inside the furnace shell at an interval from the furnace shell; subsequently injecting the castable refractory between the furnace shell and the heat-insulating bricks; sharing a force of the castable refractory in a radially inward direction of the furnace body, which is caused by a head pressure of the castable refractory, by the heat-insulating bricks and the fire bricks to prevent shifting or breakage of the heat-insulating bricks; and solidifying the castable refractory. In the above aspect of the invention, as a procedure of the furnace construction, the fire bricks may be installed after the heat-insulating bricks are installed from the furnace shell side, or the heat-insulating bricks may be installed after the fire bricks are installed from an inner surface side of the furnace. The order of the installation is not relevant but the castable refractory is injected and solidified after the heat-insulating bricks and the fire bricks are stacked.

[0033] In the above aspect of the invention, since the castable refractory is not provided by a spraying operation, it is not necessary to assemble and disassemble a scaffolding or a gondola inside the furnace shell, and the lining of the furnace body can be easily built in a short period of time.

[0034] Here, when the castable refractory is injected between the furnace shell and the heat-insulating bricks, the heat-insulating bricks receive a load or impact (a force of the castable refractory in a radially inward direction of the furnace body, which is caused by a head pressure of the castable refractory) from the castable refractory. However, the load or impact can be shared by the heat-insulating bricks and the fire bricks. Accordingly, this arrangement can prevent disadvantages (e.g., shifting or breakage) of the stacked heat-insulating bricks, which is brought, for instance, when only the heat-insulating bricks receive the load from the castable refractory.

[0035] In the above arrangement, the lining preferably includes an expansion clearance between the heat-insulating bricks and the fire bricks, between the heat-insulating bricks, or between the fire bricks, and the expansion clearance preferably includes a spacer that is interposed therein, has a predetermined strength at normal temperature, and disappears at an internal temperature of the hot-blast stove at working.

[0036] With this arrangement, the expansion clearance can allow the thermal expansion of the fire bricks when the hot-blast stove is fired. If the expansion clearance is provided by only a freely deformable space or a soft filling material, the load sharing by the heat-insulating bricks and the fire bricks as an essential feature of the invention is not achievable. However, in the above arrangement, since the spacer is interposed in the expansion clearance, the load sharing that is a requisite of the invention is achievable.

[0037] In other words, the spacer has a predetermined strength at normal temperature and the spacer can transmit the load from the heat-insulating bricks to the fire bricks. Accordingly, when the castable refractory is injected between the furnace shell and the heat-insulating bricks, even if the heat-insulating bricks receive the load or impact from the castable refractory, the load or impact can be shared by the heat-insulating bricks and the fire bricks.

[0038] Although it is not included in the above arrangement, the castable refractory may be injected after only the heat-insulating bricks are stacked and no fire brick is stacked. In this case, in order to suppress the displacement of the heat-insulating bricks caused by the castable refractory injection, a method of providing a support (e.g., a bracing plate and a strut) to an inner surface of the heat-insulating bricks near the furnace body or a method of keeping a low height of the stacked heat-insulating bricks at each of the stacking is applicable. However, such a method is inefficient and requires a high cost.

[0039] In contrast, since the spacer is melted or the like with an increase in an internal temperature of the fired hot-blast stove and disappears from the expansion clearance, the expansion clearance can fulfill the desired function and allow the thermal expansion of the fire bricks.

[0040] Accordingly, a predetermined strength of the spacer according to the above aspect only needs to have a strength greater than the load to be shared during the injection of the castable refractory. It is desirable to suitably design the strength of the spacer depending on the hot-blast stove to which the spacer is applied.

[0041] In the above arrangement, the spacer is preferably a thermoplastic resin foam.

[0042] As the thermoplastic resin foam, for instance, styrene foam often usable as a cushioning material, namely, polystyrene resin (PS) foam is available. In addition, foams of other thermoplastic resins may be used. Examples of the other thermoplastic resins include a low-density polyethylene resin (LDPE), a high-density polyethylene resin (HDPE), a polyethylene vinyl alcohol resin (EVA), a polypropylene resin (PP), a polyvinyl chloride resin (PVC), a PE/PS blend resin, an acrylic resin (PMMA), and an acrylonitrile butadiene styrene copolymer resin (ABS).

[0043] With this arrangement, since the spacer is provided by a thermoplastic resin foam, the spacer can obtain the temperature characteristics (i.e., the spacer has strength at normal temperature and is softened and melted with an increase in temperature). In addition, adjustment of the strength and shape-machining of the spacer can be easily made and the spacer can be inexpensively obtained.

[0044] As the spacer, for instance, a spacer obtained by molding the above-described thermoplastic resin foam into a block shape is usable. Moreover, the thermoplastic resin may be molded into a grid structure or a honeycomb structure. Further, a material of the spacer is not limited to a synthetic resin material having thermoplastic properties, but may be paper (e.g., cardboard).

[0045] In the above arrangement, the expansion clearance preferably includes a filler that is soft or amorphous at normal temperature and is interposed therein together with the spacer.

[0046] With this arrangement, after the spacer disappears in the expansion clearance, the expansion clearance is filled with the filler. Further, when the expansion clearance is reduced with an increase in thermal expansion of the fire bricks, the filler can follow the deforming expansion clearance, so that the filler can fill a gap between the fire bricks while allowing thermal expansion of the fire bricks, thereby preventing hot air from entering the expansion clearance.

[0047] As such a filler, a heat-resistant ceramic fiber and the like are preferable. The filler may be packed in the cavity with no spacer in the expansion clearance, may be packed in a cavity or a recess formed in the spacer, or may be melted at the time of molding when the spacer is provided by a synthetic resin molded article.

[0048] In the above arrangement, the method preferably further includes installing a checker brick inside the lining, in which the injecting the castable refractory is performed during or after the installing the checker brick.

[0049] With this arrangement, since the castable refractory is injected during the installation of the checker bricks after the installation of the heat-insulating bricks and the fire bricks, the operations can be conducted simultaneously and an entire work period can be shortened. Alternatively, since the castable refractory is injected after the installation of the checker bricks, the checker bricks can receive load applied when the castable refractory is injected.

[0050] In the above arrangement, the method further includes: dividing the furnace body into a plurality of sections arranged in a height direction; and injecting the castable refractory in each of the sections.

[0051] With this arrangement, for instance, when the heat-insulating bricks and the fire bricks are to be stacked in every 1.2-meter sections, it is only necessary to determine the sections accordingly. When a height of the section for stacking the heat-insulating bricks and the fire bricks is thus equal to a height of a section for injecting the castable refractory, the heat-insulating bricks and the fire bricks may be stacked before the castable refractory is injected, or alternatively, the heat-insulating bricks and the fire bricks may be stacked at the same time when the castable refractory is injected.

[0052] Further, in the arrangement where the height of the section for injecting the castable refractory is determined as about 1.2 m, fluidity of the castable refractory or whether foreign matters (e.g., tools) is mixed in a castable refractory injection unit can be visually checked from above.

[0053] In the above arrangement, the heat-insulating bricks are preferably installed in a plurality of layers in a thickness direction of the lining, and horizontal joints in a circumferential direction of the heat-insulating bricks in the layers are preferably shifted from each other.

[0054] With this arrangement, since the joints of the heat-insulating bricks in one of the layers are shifted from the joints of the heat-insulating bricks in another of the layers, even when the heat-insulating bricks receive a load or an impact from the injected castable refractory, the load is shared between the heat-insulating bricks due to the shifted joints thereof, so that the heat-insulating bricks can be effectively prevented from being shifted or broken.

[0055] In the above arrangement, the castable refractory preferably has a free-flow value in a range from 200 mm to 300 mm.

[0056] With this arrangement, since the free-flow value is 200 mm or more, the fluidity of the castable refractory is secured. Even when the castable refractory is injected into the gap between the furnace shell and the heat-insulating bricks, the castable refractory can certainly fill every corners of the gap. Moreover, since the free-flow value is 300 mm or less, it is possible to prevent a poor quality or hose clogging caused by component separation of the castable refractory when the castable refractory is injected.

[0057] In the above aspect of the invention, since the castable refractory is not provided by a spraying operation, it is not necessary to assemble and disassemble a scaffolding or a gondola inside the furnace shell, and the lining of the furnace body can be easily built in a short period of time.

BRIEF DESCRIPTION OF DRAWING(S)

[0058]

Fig. 1 is a vertical cross-sectional view illustrating a lining of a first exemplary embodiment of the invention.

Fig. 2 is a vertical cross-sectional view illustrating an installation step of a first layer of heat-insulating bricks in the first exemplary embodiment.

Fig. 3 is a vertical cross-sectional view illustrating an installation step of a second layer of the heat-insulating bricks in the first exemplary embodiment.

Fig. 4 is a vertical cross-sectional view illustrating an installation step of an interposed substance in the first exemplary embodiment.

Fig. 5 is a vertical cross-sectional view illustrating an installation step of fire bricks in the first exemplary embodiment.

Fig. 6 is a vertical cross-sectional view illustrating an injection step of a castable refractory in the first exemplary embodiment.

Fig. 7 is a vertical cross-sectional view illustrating a working state of the lining in the first exemplary embodiment.

Fig. 8 is a vertical cross-sectional view illustrating a

work sequence for injecting the castable refractory in each of levels in the first exemplary embodiment.
Fig. 9 is a vertical cross-sectional view illustrating a work sequence for simultaneously injecting the castable refractory in plural ones of levels in the first exemplary embodiment.
Fig. 10 is a vertical cross-sectional view illustrating a lining of a second exemplary embodiment of the invention.
Fig. 11 is a vertical cross-sectional view illustrating a lining of a third exemplary embodiment of the invention.
Fig. 12 is a cross-sectional plan view illustrating the lining of the third exemplary embodiment.
Fig. 13 is a vertical cross-sectional view illustrating a lining of a fourth exemplary embodiment of the invention.
Fig. 14 is a vertical cross-sectional view illustrating a lining of a fifth exemplary embodiment of the invention.
Fig. 15 is a vertical cross-sectional view illustrating a lining of a sixth exemplary embodiment of the invention.
Fig. 16 is a cross-sectional plan view illustrating the lining of the sixth exemplary embodiment.
Fig. 17 is a perspective view illustrating an example of a spacer usable in the invention.
Fig. 18 is a perspective view illustrating an example of another spacer usable in the invention.
Fig. 19 is a perspective view illustrating an example of still another spacer usable in the invention.
Fig. 20 is a perspective view illustrating an example of a further spacer usable in the invention.
Fig. 21 is a perspective view illustrating an example of a still further spacer usable in the invention.
Fig. 22 is a perspective view illustrating an example of a still further spacer usable in the invention.
Fig. 23 is a perspective view illustrating an example of a still further spacer usable in the invention.
Fig. 24 is a vertical cross-sectional view illustrating a conventional external-combustion type hot-blast stove.
Fig. 25 is a vertical cross-sectional view illustrating a lining of a typical combustion chamber.
Fig. 26 is a vertical cross-sectional view illustrating a working state of the lining of the typical combustion chamber.
Fig. 27 is a vertical cross-sectional view illustrating a different form of the lining of the typical combustion chamber.
Fig. 28 is a plan cross-sectional view illustrating a different form of the lining of the typical combustion chamber.
Fig. 29 is a vertical cross-sectional view illustrating a lining of a typical heat storage chamber.
Fig. 30 is a cross-sectional plan view of a lining of a seventh exemplary embodiment of the invention.
Fig. 31 is a graph illustrating a selection of a styrene foam usable as a spacer in the invention.
Fig. 32 is a vertical cross-sectional view illustrating operations in Example 1 of the invention.

DESCRIPTION OF EMBODIMENT(S)

[0059] Embodiments of the invention will be described below with reference to the drawings.

First Exemplary Embodiment

[0060] In the first exemplary embodiment, a combustion-chamber furnace body 2 (see Fig. 25) of the above-described hot-blast stove 1 (see Fig. 24) is built.

[0061] In the first exemplary embodiment, a unique structure and a construction procedure according to the invention are employed particularly for a lining 5 to be installed in the furnace body (i.e., combustion-chamber furnace body 2).

[0062] In Fig. 1, the lining 5 includes: a castable refractory 51 formed on an inner surface of a furnace shell 4; double-layered heat-insulating bricks 52 stacked inside the castable refractory 51; and single-layered fire bricks 53 stacked inside the heat-insulating bricks 52. Further, the lining 5 includes an expansion clearance 54 between a layer of the heat-insulating bricks 52 and a layer of the fire bricks 53.

[0063] The castable refractory 51, the heat-insulating bricks 52, the fire brick 53 and the expansion clearance 54 have the same structure as the above-described structure of the lining 5 shown in Fig. 24.

[0064] However, in the exemplary embodiment, an injection procedure of the castable refractory 51 and the structure of the expansion clearance 54 are unique.

[0065] The castable refractory 51 in the first exemplary embodiment is solidified after being injected into a gap between the heat-insulating bricks 52 and the furnace shell 4 installed in advance. In other words, there is no need to repeat the installation of the scaffolding and the spraying operation at a plurality of heights as required for building an existing castable refractory 51.

[0066] Basic components of the castable refractory 51 in the exemplary embodiment are similar to those of the existing castable refractory. However, in order to reliably and completely inject the castable refractory between the heat-insulating bricks 52 and the furnace shell 4 without using a vibrator, a free-flow value representing the fluidity is adjusted to 200 mm to 300 mm.

[0067] While the castable refractory 51 is built, moisture of the castable refractory 51 is absorbed by the heat-insulating bricks built inside the castable refractory 51, so that the fluidity the castable refractory 51 is reduced. In order to prevent the heat-insulating bricks from absorbing the moisture, a contact surface of the heat-insulating bricks may be subjected to a water-repellent treatment in advance. However, such a treatment increases the cost. In order that the castable refractory 51 can be built without such a pre-treatment, it is effective to adjust the free-flow value to 200 mm to 300 mm.

[0068] Here, even when the free-flow value is 200 mm or less, the castable refractory can be built by using a vibrator. However, since the use of the vibrator causes joint breakage and position shift of the heat-insulating bricks due to vibration, it is desirable not to use the vibrator.

[0069] In the exemplary embodiment, since the castable refractory is directly built on a surface of the heat-insulating bricks without applying the water-repellent treatment on the surface of the heat-insulating bricks as described above, the castable refractory firmly adheres to the heat-insulating bricks to form no gap therebetween, thereby preventing channeling of hot air in a hot-blast stove enters between the furnace shell and the castable refractory.

[0070] In addition, in order to inject the castable refractory 51 as described above, the expansion clearance 54 includes a spacer 55 and a filler 56 that are interposed in the gap between the heat-insulating bricks 52 and the fire bricks 53 and a load of a head pressure caused by the injection of the castable refractory 51 can be transmitted from the heat-insulating bricks 52 to the fire bricks 53.

[0071] The spacer 55 is an elongated block that continuously and horizontally extends in the gap between the heat-insulating bricks 52 and the fire bricks 53.

[0072] The spacer 55 has a rectangular cross-sectional shape. A surface of the spacer 55 near an outer surface of the furnace body is in close contact with an inner surface of the heat-insulating bricks 52 and a surface of the spacer 55 near an inner surface of the furnace body is in close contact with an outer surface of the fire bricks 53. A size of the spacer 55 in a radial direction of the furnace body is set to be equal to a gap dimension between the heat-insulating bricks 52 and the fire bricks 53 in order to ensure the close contact between the heat-insulating bricks 52 and the fire bricks 53.

[0073] The spacer 55 is exemplified by a block molded by a styrene foam resin. In order to allow the transmission of a load from the heat-insulating bricks 52 to the fire bricks 53, the spacer 55 has hardness, in other words, rigidity at a certain degree or more, among blocks made of a styrene foam resin.

[0074] When selecting the rigidity (compressive elasticity modulus) of the styrene foam, the following procedure is employed.

[0075] Fig. 31 illustrates a relationship between a compressive elasticity modulus and a spacer insertion ratio.

[0076] The insertion ratio of the styrene foam is defined as 100% when the expansion clearance is completely filled with styrene foam as illustrated in Fig. 12. The insertion ratio is defined as 10% when a 46-mm styrene foam is placed at every 460 mm in a height direction as illustrated in Fig. 1.

[0077] Specifically, as illustrated by a curve P1 in Fig. 31, when the castable refractory is provided at every 2 m in the height direction and the 46-mm styrene foam is placed at every 460-mm height, the required compressive elasticity modulus is 80 kg/cm^2 (785 N/cm^2) or more. Moreover, as illustrated by a curve P2, when the castable refractory is built at every 1 m in the height direction and the 46-mm styrene foam is placed at every 460-mm height, the required compressive elasticity modulus is 50 kg/cm^2 (490 N/cm^2) or more.

[0078] Thus, it is necessary to select the material of the styrene foam resin spacer 55 according to the insertion ratio and the castable refractory injection height so that the spacer itself is not crushed.

[0079] When the furnace body has a cylindrical shape, the gap between the heat-insulating bricks 52 and the fire bricks 53, in which the spacer 55 is disposed, is curved in a circular arc shape in the horizontal direction. As described above, since the spacer 55 is long and hard, the spacer 55 in an original state may be difficult to treat (for instance, the spacer is temporarily fixed to the inner surface of the heat-insulating bricks 52). Accordingly, in the exemplary embodiment, it is preferable to perform, for instance, the following treatment in order to cope with the circular arc shape.

[0080] As illustrated in Fig. 17, a spacer obtained by laminating a plurality of thin plates 55A molded from a styrene foam resin is used. The thin plates 55A curved in advance are laminated into a single body. The single body can provide the spacer 55 curved in a circular arc shape in advance.

[0081] As illustrated in Fig. 18, a styrene foam resin is molded into a linearly extending base material 55B having a rectangular cross-sectional shape. A plurality of notches 55C having a predetermined width is formed on a surface of the base material 55B. When the base material 55B is used as the spacer 55, the base material 55B is curved with the notches 55C facing inward, so that the base material 55B is easily bendable by a cut amount of the cut notches 55C. It should be noted that the base material 55B is bendable with the notches 55C facing outward.

[0082] As illustrated in Fig. 19, a plurality of small pieces 55D having a planar shape of an isosceles trapezoid are formed by molding the same base material 55B as shown in Fig. 18 and cutting the base material 55B in a cutting plane inclined to a longitudinal direction. A circular arc-shaped spacer 55 as a whole can be obtained by arranging the small pieces 55D so that a lower base of the isosceles trapezoid is on the outer side and an upper base thereof is on the inner side.

[0083] In the expansion clearance 54, the above-described spacers 55 are intermittently arranged at a plurality of heights. In the gap between the heat-insulating brick 52 and the fire brick 53, a cavity remains between the vertically adjacent spacers 55. The cavity between the spacers 55 is filled with the filler 56.

[0084] The filler 56 is a heat-resistant ceramic fiber or the like. A shape and a thickness of the filler 56 are optionally deformable by an external force.

[0085] The filler 56 may be set in an amount enough to fill a gap to be left between the heat-insulating bricks 52 and the fire bricks 53 after the hot-blast stove is operated and the fire bricks 53 are thermally expanded.

[0086] Further, in the expansion clearance 54, a ratio of an area where the spacer 55 is in close contact with the surface of the heat-insulating bricks 52 or the fire bricks 53 (a ratio of the close-contact area of the spacer 55 to the sum of the close-contact area and an area of the expansion clearance 54 facing the cavity in which the filler 56 is housed) is, for instance, 10% to 50%.

[0087] The required amount of the spacer 55 is reducible and the material cost is reducible by decreasing the ratio. However, since the load transmitted from the heat-insulating bricks 52 to the fire bricks 53 is concentrated on a narrow area, it is necessary to increase the rigidity of the material of the spacer 55.

[0088] When the ratio is increased, since the load from the heat-insulating bricks 52 to the fire bricks 53 can be transmitted in a wide area, the rigidity level of the material of the spacer 55 can be lowered.

[0089] Further, in regard to the ratio of the spacer 55, the expansion clearance 54 is completely filled with the spacer 55, so that the ratio may be 100% (see a fourth exemplary embodiment described later) or 50% to 99% in an intermediate between the above-described ratios.

Construction Procedure in First Exemplary Embodiment

[0090] A building procedure of the lining 5 in the first exemplary embodiment is as follows.

[0091] Firstly, as illustrated in Fig. 2, the heat-insulating bricks 52 in a first layer are built at a predetermined interval inside the furnace shell 4 of the combustion-chamber furnace body 2.

[0092] Next, as illustrated in Fig. 3, the heat-insulating bricks 52 in a second layer are built inside the heat-insulating bricks 52 in the first layer in close contact with each other. At this time, joints of the heat-insulating bricks 52 in the second layer are shifted in the height direction with respect to the horizontal joints of heat-insulating bricks 52 in the first layer.

[0093] Moreover, a bonding mortar or the like is applied between the heat-insulating bricks 52 in each of the first and second layers and between the heat-insulating bricks 52 in the first layer and the heat-insulating bricks 52 in the second layer, so that the heat-insulating bricks 52 are fixed to each other.

[0094] Subsequently, as illustrated in Fig. 4, the spacer 55 extending in the horizontal direction is installed at a predetermined height position of the inner surface of the heat-insulating bricks 52 in the second layer. When installed, the spacer 55 is temporarily fixed to the inner surface of the heat-insulating bricks 52, using a double-sided adhesive tape or the like.

[0095] Further, the filler 56 fills a gap between the vertically adjacent spacers 55. The filler 56 packed in a bag or the like may be installed. It is desirable to temporarily fix the filler 56 to the upper spacer 55 or the inner surface of the heat-insulating brick 52 with a double-sided adhesive tape or the like.

[0096] Next, as illustrated in Fig. 5, the fire bricks 53 are built inside the spacer 55 in close contact with each other. At this time, the spacer 55 is interposed between the heat-insulating bricks 52 and the fire bricks 53 so that the spacer 55 is brought into close contact with the heat-insulating brick 52 and the fire brick 53 when a compressive force is applied.

[0097] Subsequently, as illustrated in Fig. 6, the castable refractory 51 is injected to the gap between the inner surface of the furnace shell 4 and the outer surface of the heat-insulating bricks 52 in the first layer, and the castable refractory is solidified.

[0098] The castable refractory 51 may be injected in a manner to flow down the castable refractory 51 from above. Alternatively, as illustrated in Fig. 6, the castable refractory may be gradually injected from the bottom using an injection pipe 41 penetrating the furnace shell 4.

[0099] By the above-described procedure, the lining 5 including the castable refractory 51, the heat-insulating bricks 52, the fire bricks 53 and the expansion clearance 54 is formed.

[0100] When the hot-blast stove is in a working state, as illustrated in Fig. 7, the spacer 55 is melted by an internal heat of the furnace and disappears from the expansion clearance 54, and the filler 56 fills the expansion clearance 54 narrowed by the expansion of the fire bricks.

Advantages of First Exemplary Embodiment

[0101] According to the exemplary embodiment, the following advantages are obtainable.

[0102] In the exemplary embodiment, since the castable refractory is not provided by a spraying operation, it is possible to omit a complicated work in which a scaffolding or a gondola is installed inside the furnace shell 4 to spray the castable refractory 51 and is disassembled before the installation of the heat-insulating bricks 52. Thus, the lining 5 of the furnace body can be easily built in a short period of time.

[0103] In the exemplary embodiment, in the heat-insulating bricks 52 in the first and second layers, since the horizontal joints of the heat-insulating bricks 52 in the first layer and the horizontal joints of the heat-insulating bricks 52 in the second layer are shifted from each other, even when the heat-insulating bricks 52 in the first layer are about to displace toward the inner side of the furnace by the load (a force of the castable refractory in a radially inward direction of the furnace body, which is caused by a head pressure of the castable refractory 51) caused by the injection of the castable refractory 51, an intermediate portion of each of the heat-insulating bricks 52 in the second layer suppresses displacement of the heat-insulating bricks 52 in the first layer.

[0104] In addition, since a bonding mortar or the like is applied between the heat-insulating bricks 52 in each of the first and second layers and between the heat-insulating bricks 52 in the first layer and the heat-insulating bricks 52 in the second layer, so that the heat-insulating bricks 52 are fixed to each other, the load due to the injection of the castable refractory 51 is dispersible.

[0105] Accordingly, even the heat-insulating brick 52 itself can enhance the strength against the load or impact due to the injection of the castable refractory 51.

[0106] In the exemplary embodiment, the lining 5 includes the expansion clearance 54 between the heat-insulating bricks 52 and the fire bricks 53. In the expansion clearance 54, the spacers 55 having a predetermined strength at normal temperature and disappears at the internal furnace temperature in the working hot-blast stove are interposed.

[0107] During the construction of the furnace body (i.e., before the furnace body works as the hot-blast stove), the spacer 55 is interposed between the heat-insulating bricks 52 and the fire bricks 53 and can transmit the load (the force of the castable refractory in a radially inward direction of the furnace body, which is caused by a head pressure of the castable refractory 51) applied to the heat-insulating bricks 52 at the time of injection of the castable refractory 51 to the fire bricks 53.

[0108] Specifically, when the castable refractory 51 is injected between the furnace shell 4 and the heat-insulating bricks 52, the heat-insulating bricks 52 receive the load or impact (the force in the radially inward direction of the furnace body) caused by the head pressure from the castable refractory 51. However, the load or impact can be transmitted from the heat-insulating bricks 52 to the fire bricks 53 via the spacer 55 installed in the expansion clearance 54. Accordingly, a sufficiently large mass of from the heat-insulating bricks 52 to the fire bricks 53 can reliably share the load.

[0109] For this reason, for instance, in an arrangement without the spacer 55 and the fire bricks 53, in other words, when the load from the castable refractory 51 is received only by the heat-insulating bricks 52, disadvantages (e.g., shifting or breakage) of the stacked heat-insulating bricks 52, which is brought, for instance, when only the heat-insulating bricks 52 receive the load from the castable refractory 51 can be prevented.

[0110] Since the spacer 55, for instance, is made of a styrene foam resin, when the hot-blast stove is fired to work, the spacer 55 disappears by the internal heat of the furnace and can allow the thermal expansion (the radially outward displacement of the furnace body) of the fire bricks 53.

[0111] Specifically, after the firing of the hot-air stove, the spacer 55 is melted with an increase in the furnace temperature and disappears from the expansion clearance 54. Accordingly, the expansion clearance 54 can fulfill the intended function and can allow the thermal expansion of the fire bricks 53.

[0112] In the exemplary embodiment, since the spacer 55 is provided by a polystyrene resin foam (e.g., styrene foam), the spacer 55 can obtain the temperature characteristics (i.e., the spacer 55 has strength at normal temperature and is softened and melted with an increase in temperature). In addition, adjustment of the strength and shape-machining of the spacer 55 can be easily made and the spacer 55 can be inexpensively obtained.

[0113] In the exemplary embodiment, along with the spacer 55, the filler 56 that is soft or amorphous at normal temperature is interposed in the expansion clearance 54. Accordingly, after the spacer 55 disappears from the expansion clearance 54, the filler 56 fills the expansion clearance 54. Further, when the expansion clearance 54 is reduced with an increase in thermal expansion of the fire bricks 53, the filler 56 can follow the deforming expansion clearance 54, so that the filler 56 can fill a gap between the fire bricks 53 while allowing thermal expansion of the fire bricks 53, thereby preventing hot air from entering the expansion clearance 54.

[0114] In the exemplary embodiment, since a heat-resistant ceramic fiber is used as the filler 56, the filler 56 can reliably follow the thermal expansion of the fire bricks 53 and a deterioration of the filler 56 due to heat generated in the working furnace can be minimized.

Modification of Castable Refractory Injection Procedure in First Exemplary Embodiment

[0115] In the above-described first exemplary embodiment, the castable refractory 51 is injected after the heat-insulating bricks 52, the spacer 55 and the filler 56 of the expansion clearance 54, and the fire bricks 53 are installed. However, in order to inject the castable refractory 51, the castable refractory 51 may be injected in each of levels with a predetermined height or may be simultaneously injected in plural ones of levels with the predetermined height.

[0116] Here, the level with the predetermined height is a height of about 1.2 m that is suitable for a worker to build the heat-insulating bricks 52, the spacer 55 and the filler 56 of the expansion clearance 54, and the fire bricks 53.

[0117] Fig. 8 illustrates the procedure for injecting the castable refractory 51 in each of levels.

[0118] As shown in Fig. 8, a plurality of levels (including levels C1 to C3) are set in the combustion-chamber furnace body 2. In the levels C1 to C3, the lining 5 is built inside the furnace shell 4 in the order denoted by reference numerals 1 to 15.

[0119] Firstly, in the level C1, the heat-insulating bricks 52 are installed in two layers (reference numeral 1 and reference numeral 2) inside the furnace shell 4 at a predetermined interval, the expansion clearance 54 (the spacer 55 and the filler 56) is installed inside the heat-insulating bricks 52 (reference numeral 3), and the fire bricks 53 are installed inside the expansion clearance 54 (reference numeral 4). The castable refractory 51 is injected between the furnace shell 4 and the heat-insulating bricks 52 (reference numeral 5). Subsequently, a 1.2-m framework scaffolding (a single pipe assembly or a 1.2-m activity scaffold) is temporarily installed.

[0120] Subsequently, in the level C2, similarly, the heat-insulating bricks 52 (reference numeral 6 and reference numeral 7), the expansion clearance 54 (reference numeral 8) and the fire bricks 53 (reference numeral 9) are installed, and the castable refractory 51 is injected (reference numeral 10). After that, the same framework scaffolding is temporarily installed.

[0121] Further, in the level C3, similarly, the heat-insulating bricks 52 (reference numeral 11 and reference numeral 12), the expansion clearance 54 (reference numeral 13) and the fire bricks 53 (reference numeral 14) are installed, and the castable refractory 51 is injected (reference numeral 15).

[0122] In each of the levels C1 to C3, the castable refractory 51 may be injected from above by a working standing on an upper surface of the heat-insulating bricks 52 at each of the levels, or alternatively, may be injected through the injection pipe 41 penetrating the furnace shell 4 provided at a lower portion of each of the levels C1 to C3.

[0123] Since the height of the section for injecting the castable refractory 51 can be reduced with such an injection in each of the level, the fluidity of the castable refractory or whether foreign matters (e.g., tools) is mixed in the castable refractory injection unit can be visually checked by the worker, so that the castable refractory 51 can be reliably fed.

[0124] Fig. 9 illustrates the procedure for simultaneously injecting the castable refractory 51 in plural ones of levels.

[0125] In Fig. 9, a plurality of levels (including the levels C1 to C4) are set in the combustion-chamber furnace body 2. In the levels C1 to C4, the lining 5 is built inside the furnace shell 4 in the order illustrated by the reference numerals 1 to 17.

[0126] Firstly, in the level C1, the heat-insulating bricks 52 are installed in two layers (reference numeral 1 and reference numeral 2) inside the furnace shell 4 at a predetermined interval, the expansion clearance 54 (the spacer 55 and the filler 56) is installed inside the heat-insulating bricks 52(reference numeral 3), and the fire bricks 53 are installed inside expansion clearance 54 (reference numeral 4). After that, a framework scaffolding (a 1.2-m single tube assembly or a 1.2-m activity scaffold) is temporarily installed.

[0127] Next, in the level C2, similarly, the heat-insulating bricks 52 (reference numeral 5 and reference numeral 6), the expansion clearance 54 (reference numeral 7) and the fire bricks 53 (reference numeral 8) are installed.

[0128] In this state, the castable refractory 51 is simultaneously injected to the two levels of the level C1 and the level C2 between the furnace shell 4 and the heat-insulating bricks 52 (reference numeral 9). After that, the framework scaffolding is similarly temporarily installed.

[0129] Subsequently, in the level C3, similarly, the heat-insulating bricks 52 (reference numeral 10 and reference numeral 11), the expansion clearance 54 (reference numeral 12) and the fire bricks 53 (reference numeral 13) are installed. After that, the framework scaffolding is similarly temporarily installed.

[0130] Further, in the level C4, similarly, the heat-insulating bricks 52 (reference numeral 14 and reference numeral 15), the expansion clearance 54 (reference numeral 16) and the fire bricks 53 (reference numeral 17) are installed.

[0131] In this state, the castable refractory 51 is simultaneously injected to the two levels of the level C3 and the level C4 between the furnace shell 4 and the heat-insulating bricks 52 (reference numeral 18).

[0132] Further, the castable refractory 51 may be injected to the levels C1, C2 and the levels C3 and C4 from above by the worker standing on the upper surface of the heat-insulating bricks 52 in each of the upper level C2 and C4, or alternatively, may be injected through the injection pipe 41 penetrating the furnace shell 4 provided at the lower portion of the lower levels C1 and C3.

[0133] Since the castable refractory 51 can be simultaneously injected to the plurality of levels with the above injection for the levels, the number of the injection operations of the castable refractory 51 can be reduce to improve a working efficiency.

Modification of Spacer 55 of First Exemplary Embodiment

[0134] In the above-described first exemplary embodiment, the spacers 55 are intermittently installed at each predetermined height in the expansion clearance 54 and the filler 56 fills a space between spacers 55. However, a volume of the spacer 55 may be expanded and a recess or the like is formed on a surface the spacer 55 to house the filler 56 therein.

[0135] In Fig. 20, the spacer 55 has a rectangular parallelepiped main body including recesses 55E formed on a surface thereof and the filler 56 filling the recesses 55E. When using such a spacer 55, since the installation of the filler 56 is simultaneously performed in the installation operation of the spacer 55, the working steps can be simplified to improve the efficiency.

[0136] In Fig. 21, the spacer 55 has a main body having an E-shaped cross-section and continuously extending in a longitudinal direction. The filler 56 fills a recessed groove 55F continuously formed on a surface. Even by using such a spacer 55, since the installation of the filler 56 is simultaneously performed in the installation operation of the spacer 55, the working steps can be simplified to improve the efficiency.

[0137] As the spacer 55 configured to house the fillers 56, the spacer 55 is not limited to the spacer 55 including the recess 55E or the recessed groove 55F formed on the block-shaped main body, but the spacer 55 may include the main body formed in a shape other than the block.

[0138] As shown in Fig. 22, the main body of the spacer 55 is shaped in a grid in which shaft materials 55G made of a thermoplastic resin having a predetermined rigidity are mutually crossed, and the fillers 56 are held in an internal space of the grid.

[0139] As shown in Fig. 23, the main body of the spacer 55 is shaped in a honeycomb structural body 55H made of a thermoplastic resin having a predetermined rigidity, and the fillers 56 are held in an internal space of the honeycomb structural body 55H.

[0140] In the spacer 55 of Fig. 22 or 23, since the shaft material 55G or the honeycomb structural body 55H maintains a predetermined rigidity before the hot-blast stove is fired, the function of transmitting the load of the heat-insulating bricks 52 to the fire bricks 53 as illustrated in Fig. 1 can be secured.

[0141] However, after the hot-blast stove is fired, the shaft material 55G or the honeycomb structural body 55H is softened or melted by the internal heat of the furnace, thereby allowing the thermal expansion of the fire bricks 53.

[0142] The filler 56 held in the grid of the shaft material 55G or the honeycomb structural body 55H remains as the expansion clearance 54, so that the same advantages as those by the expansion clearance 54 (the intermittently disposed spacer 55 and filler 56) of the first exemplary embodiment can be obtained.

Second Exemplary Embodiment

[0143] In the second exemplary embodiment, the heat-storage-chamber furnace body 3 (see Fig. 10) that constitutes the above-described hot-blast stove 1 (see Fig. 24) is constructed.

[0144] As shown in Fig. 10, the heat-storage-chamber furnace body 3 has the same structure as that of the combustion-chamber furnace body 2 (see Fig. 1) described in the first exemplary embodiment and includes the checker bricks 31 stacked inside the heat-storage-chamber furnace body 3. Accordingly, the description on the same structure as that of the combustion-chamber furnace body 2 described above will be omitted.

[0145] In a furnace construction procedure in the second exemplary embodiment, installation of the checker bricks 31 inside the fire brick 53 is added after the procedure described in the first exemplary embodiment (see Figs. 2 to 7). Accordingly, the same procedure as that for the combustion-chamber furnace body 2 described above will be omitted.

[0146] According to the second exemplary embodiment, the same advantages as the above-described advantages in the first exemplary embodiment can be also obtained in the heat-storage-chamber furnace body 3.

Third Exemplary Embodiment

[0147] In the third exemplary embodiment, a differently structured combustion-chamber furnace body 2 (see Figs. 11 and 12) that constitutes the above-described hot-blast stove 1 (see Fig. 24) is constructed.

[0148] In the third exemplary embodiment, a unique structure and a construction procedure according to the invention are employed particularly for the lining 5 to be installed in the furnace body (i.e., the combustion-chamber furnace body 2).

[0149] In Figs. 11 and 12, the lining 5 includes: the castable refractory 51 formed on the inner surface of a furnace shell 4; the heat-insulating bricks 52 stacked inside the castable refractory 51; and the fire bricks 53 stacked inside the heat-insulating bricks 52. Further, the lining 5 includes the expansion clearance 54 continuously extending in the radial direction and provided between the fire bricks 53 arranged in the circumferential direction of the furnace body.

[0150] The castable refractory 51, the heat-insulating bricks 52, the fire bricks 53 and the expansion clearance 54 have the same structure as the above-described structure of the lining 5 shown in Figs. 27 and 28.

[0151] However, in the third exemplary embodiment, the injection procedure of the castable refractory 51 and the structure of the expansion clearance 54 are unique.

[0152] In the third exemplary embodiment, the castable refractory 51 is solidified after being injected into the gap between the heat-insulating bricks 52 and the furnace shell 4 installed in advance, in the same manner as in the first exemplary embodiment. For this reason, the free-flow value of the castable refractory 51 is adjusted to 200 mm to 300 mm.

[0153] In addition, in order to allow the injection of the castable refractory 51 as described above, the expansion clearance 54 includes the spacer 55 and the filler 56 interposed in the gap between the heat-insulating bricks 52 and the fire bricks 53. With this arrangement, when the load from the heat-insulating bricks 52 is received by the fire brick 53, the expansion clearance 54 is not narrowed, so that the heat-insulating bricks 52 can be reliably supported.

[0154] The spacer 55 is a rod-shaped block having a rectangular cross-section that is molded from the same hard styrene foam as in the first exemplary embodiment. The spacer 55 is installed in the gap between the fire bricks 53 along the horizontal and radial directions.

[0155] The spacer 55 is installed while being pressed by the fire bricks 53 on both sides of the spacer 55. Accordingly, both the sides of the spacer 55 are respectively in close contact with surfaces of the fire bricks 53.

[0156] In the expansion clearance 54, the above-described spacers 55 are intermittently arranged at a plurality of heights. In the gap between the fire bricks 53, a cavity remains between the vertically adjacent spacers 55. The cavity between the spacers 55 is filled with the filler 56.

[0157] The filler 56 is a heat-resistant ceramic fiber or the like. A shape and a thickness of the filler 56 are optionally deformable by an external force.

[0158] The filler 56 may be set in an amount enough to fill a gap to be left between the heat-insulating bricks 52 and the fire bricks 53 after the hot-blast stove is operated and the fire bricks 53 are thermally expanded.

[0159] The building procedure of the lining 5 in the third exemplary embodiment is as follows.

[0160] Firstly, the heat-insulating bricks 52 in two layers are built inside the furnace shell 4 at a predetermined interval from the furnace shell 4 and the fire bricks 53 are installed inside the heat-insulating bricks 52. In stacking the fire bricks 53, after one fire brick 53 is stacked, the expansion clearance 54 (the spacer 55 and the filler 56) is installed on a side surface of the fire brick 53 and another fire brick 53 is stacked adjacently on the expansion clearance 54 such that the fire bricks 53 interpose the expansion clearance 54.

[0161] When the heat-insulating bricks 52, the fire bricks 53 and the expansion clearance 54 are installed by repeating these operations, the castable refractory 51 is injected in the gap between the furnace shell 4 and the heat-insulating bricks 52. The castable refractory 51 is injected in the same manner as in the first exemplary embodiment.

[0162] Also in the third exemplary embodiment, the same advantages as the above-described advantages in the first exemplary embodiment can be obtained.

[0163] It can be selected in the same manner as in the first exemplary embodiment whether the castable refractory 51 is injected in each of the levels or simultaneously injected in plural ones of the levels.

Fourth Exemplary Embodiment

[0164] In the fourth exemplary embodiment, a combustion-chamber furnace body has substantially the same structure as that in the first exemplary embodiment, but includes the expansion clearance 54 having a different structure.

[0165] As shown in Fig. 13, as in the same manner as in the first exemplary embodiment, the combustion-chamber furnace body 2 in the fourth exemplary embodiment includes the lining 5 provided inside the furnace shell 4, in which the lining 5 includes the castable refractory 51, the heat-insulating bricks 52, the fire bricks 53 and the expansion clearance 54.

[0166] Since the details of the components other than the expansion clearance 54 in the lining 5 and the installation procedure of the lining 5 in the fourth exemplary embodiment are the same as those of the first exemplary embodiment, the duplicate description will be omitted, and differences on the expansion clearance 54 will be described below.

[0167] The expansion clearance 54 of the first exemplary embodiment includes the spacers 55 arranged at predetermined intervals and the filler 56 fed therebetween as illustrated in Fig. 1. However, in the fourth exemplary embodiment, a spacer 57 is provided in an entirety of the expansion clearance 54 as illustrated in Fig. 13. In other words, a ratio of the spacer 55 in the expansion clearance 54 is defined as 100%.

[0168] For the spacer 57 of the fourth exemplary embodiment, a material obtained by mixing the same hard styrene foam resin as that for the spacer 55 in the first exemplary embodiment with the ceramic fiber used as the filler 56 in the first exemplary embodiment is usable. However, the spacer 57 may be formed using exactly the same material (not including the ceramic fiber) as that for the spacer 55 of the first exemplary embodiment.

[0169] Also in the fourth exemplary embodiment, the same advantages as the above-described advantages in the first exemplary embodiment can be obtained.

[0170] Specifically, since the castable refractory 51 is provided by the injection, a scaffolding can be omitted. Moreover, the spacer 57 can transmit the load from the heat-insulating bricks 52 to the fire bricks 53 and reliably receive the load or impact due to a head pressure associated with the injection of the castable refractory 51.

[0171] The spacer 57 disappears by being melted or the like due to the internal heat of the furnace after the hot-air stove is fired. However, the ceramic fiber mixed in the spacer 57 remains as the expansion clearance 54 between the heat-insulating bricks 52 and the fire bricks 53 and can replace the functions of the filler 56 (see Fig. 1) of the first exemplary embodiment, and the expansion clearance 54 is more easily installed than that in the first exemplary embodiment.

Fifth Exemplary Embodiment

[0172] In the fifth exemplary embodiment, the heat-storage-chamber furnace body 3 (see Fig. 14) that constitutes the above-described hot-blast stove 1 (see Fig. 24) is constructed.

[0173] As shown in Fig. 14, the heat-storage-chamber furnace body 3 has the same structure as that of the combustion-chamber furnace body 2 (see Fig. 1) described in the first exemplary embodiment and includes the checker bricks 31 stacked inside the heat-storage-chamber furnace body 3, in the same manner as in the second exemplary embodiment. Accordingly, the duplicate description on the same structure and construction procedure as those in the second exemplary embodiment will be omitted.

[0174] In the second exemplary embodiment, the spacers 55 intermittently disposed and the filler 56 fed therebetween are used as the expansion clearance 54 in the same manner as in the first exemplary embodiment.

[0175] However, in the fifth exemplary embodiment, the spacer 57 in which the ceramic fiber is mixed is installed to fill the expansion clearance 54 at the ratio of 100% in the same manner as in the fourth exemplary embodiment.

[0176] According to the fifth exemplary embodiment, the same advantages as the above-described advantages in the first exemplary embodiment can be also obtained in the heat-storage-chamber furnace body 3.

Sixth Exemplary Embodiment

[0177] In the sixth exemplary embodiment, a differently structured combustion-chamber furnace body 2 (see Figs. 15 and 16) that constitutes the above-described hot-blast stove 1 (see Fig. 24) is constructed.

[0178] As shown in Figs. 15 and 16, the lining 5 includes the expansion clearance 54 continuously extending in the radial direction and provided between the fire bricks 53 arranged in the circumferential direction of the furnace body, in the same manner as in the third exemplary embodiment.

[0179] In the third exemplary embodiment, the spacers 55 intermittently disposed and the filler 56 fed therebetween are used as the expansion clearance 54 in the same manner as in the first exemplary embodiment.

[0180] However, in the sixth exemplary embodiment, the spacer 57 in which the ceramic fiber is mixed is installed to fill the expansion clearance 54 at the ratio of 100% in the same manner as in the fourth exemplary embodiment.

[0181] According to the sixth exemplary embodiment, the same advantages as the above-described advantages in the first exemplary embodiment can be also obtained in the lining 5 including the expansion clearance 54 continuously extending in the radial direction.

Seventh Exemplary Embodiment

[0182] In the seventh exemplary embodiment, a differently structured combustion-chamber furnace body 2 (see Fig. 30) that constitutes the above-described hot-blast stove 1 (see Fig. 24) is constructed.

[0183] In the fourth exemplary embodiment (see Fig. 13), the expansion clearance 54 is formed between the heat-insulating bricks 52 and the fire bricks 53. However, in the seventh exemplary embodiment, the expansion clearance 54 is disposed between the two layers of the heat-insulating bricks 52. The spacer 57 is provided in the entirety of the expansion clearance 54 in the same manner as in the fourth exemplary embodiment. In other words, the ratio of the spacer 55 in the expansion clearance 54 is defined as 100%.

[0184] In a furnace construction procedure in the seventh exemplary embodiment, two fire bricks 53 (reference numerals 1 and 2) are initially stacked, one heat-insulating brick 52 (reference numeral 3) is stacked in a manner to press the two fire bricks 53, subsequently, the spacer 57 (reference numeral 4) as the expansion clearance 54 is installed, and another heat-insulating brick 52 (reference numeral 5) are stacked in a manner to press the spacer 57. Subsequently, in the same manner, two fire bricks 53 (reference numerals 6 and 7) are stacked, one heat-insulating brick 52 (reference numeral 8) is stacked in a manner to press the two fire bricks 53, subsequently, the spacer 57 (reference numeral 9) is installed, and another heat-insulating brick 52 (reference numeral 10) is installed in a manner to press the spacer 57. Subsequently, the castable refractory (reference numeral 11) is injected.

[0185] In the seventh exemplary embodiment, since the fire bricks 53 are installed from the inside of the furnace body, the heat-insulating bricks 52 are built while being pressed against the fire bricks 53 or the spacer 57. Accordingly, an advantage of an improved work efficiency for stacking the heat-insulating bricks 52 is obtained.

Modification(s)

[0186] The invention is not limited to the above-described exemplary embodiments but includes modifications and the like as long as the modifications and the like are compatible with the invention.

[0187] The invention is applicable not only to the combustion-chamber furnace body 2 and the heat-storage-chamber furnace body 3 of the hot-blast stove 1 (see Fig. 24) but also hot-blast stoves in other types.

[0188] For instance, in an internal combustion type hot-blast stove, the invention is applicable to a furnace wall of a combustion chamber section and a furnace wall of a heat storage chamber section in a single furnace body.

[0189] In each of the exemplary embodiments, in the lining 5, the double-layered heat-insulating bricks 52 may be replaced by single-layered heat-insulating bricks 52 or triple-layered or multilayered heat-insulating bricks 52. The single-layered fire bricks 53 may be replaced by double-layered or multilayered fire bricks 53.

[0190] As the heat-insulating bricks 52 and the fire bricks 53, existing heat-insulating bricks and fire bricks are appropriately usable.

[0191] The free-flow value of the castable refractory 51, which represents the fluidity, is required to be 200 mm to 300 mm in considering of injecting the castable refractory 51. Adjustment in mixing is only necessary for achieving the free-flow value. Existing mixing components of the castable refractory 51 may be appropriately used for prepare the castable refractory 51.

[0192] The spacers 55 in various forms as described above are usable. It is desirable to adjust characteristics of the material depending on a form in use and conditions, size, arrangement and the like of the spacers 55 in the form. In particular, it is necessary to adjust the rigidity of the material as the spacer 55 to a predetermined value (rigidity sufficient to transfer the load applied when the castable refractory 51 is injected).

[0193] The material of the spacer 55 is not limited to the synthetic resin material such as the thermoplastic resin (e.g., the above-described hard styrene foam resin), but may be paper (e.g., cardboard) and the like.

[0194] The expansion clearance 54 including the spacer 55 may be located between the heat-insulating bricks 52 and the fire bricks 53 (e.g., the arrangement in the first exemplary embodiment) or between the fire bricks 53 (e.g., the arrangement in the third exemplary embodiment). In addition, the expansion clearance 54 including the spacer 55 may be located between two layers of the heat-insulating bricks 52.

[0195] In short, it is only necessary that the expansion clearance 54 can allow the thermal expansion of the fire bricks 53, and the spacer 55 is installed so as to prevent a thermal expansion allowance function of the expansion clearance 54 before the hot-blast stove is fired.

Example 1

[0196] In a new construction of an external combustion type hot-blast stove in an ironworks, a straight body portion of a heat storage chamber was constructed in the same manner as in the second exemplary embodiment (in which the checker bricks 31 were further added inside the heat storage chamber of the first exemplary embodiment).

[0197] Details of each of components and a construction procedure in Example 1 are as follows.

[0198] In Fig. 32, after the furnace shell 4 of the combustion-chamber furnace body 2 is initially disposed, the heat-insulating bricks in two layers were installed at a gap of 50 mm from the furnace shell 4.

[0199] Next, a 30-mm cubic spacer 55 made of styrene foam (thickness and height each are 30 mm) and a ceramic fiber filler 56 were installed as the expansion clearance 54, in which the spacer 55 was installed at every 460-mm pitch in a height direction and the filler 56 filled a gap between the spacers 55.

[0200] Further, the fire bricks 53 were built inside the expansion clearance 54, the checker bricks 31 were further built inside the fire bricks 53, and subsequently, the castable refractory 51 was injected between the furnace shell 4 and the heat-insulating bricks 52.

[0201] The construction according to the procedure was repeated at every 1.2-m height.

[0202] At this time, in building the heat-insulating bricks 52, as illustrated in Fig. 32, L-shaped rulers 4A were set at 16 positions on the furnace shell 4 in the circumferential direction. A position of an inner surface of the heat-insulating bricks 52 from the core 58 was marked on the L-type ruler 4A. A leveling string 4B was connected between the position and an inner surface of the heat-insulating bricks 52 of the lower stage stacked in advance. The heat-insulating bricks 52 were installed along the leveling string 4B. Between the adjacent L-shaped rulers 4A, the heat-insulating bricks 52 were installed while checking the curvature using an R-shaped ruler having the same curvature as that of the inner surface of the furnace shell 4 of the combustion-chamber furnace body 2.

[0203] Next, the 30-mm cubic spacer 55 made of styrene foam (thickness and height each are 30 mm) and the ceramic fiber filler 56 were installed as the expansion clearance 54, in which the spacer 55 was installed at every 460-mm pitch in a height corresponding to a height of a single heat-insulating brick 52. After the fire bricks 53 and the checker bricks 31 were installed inside the expansion clearance 54, the castable refractory 51 was injected between the heat-insulating bricks 52 and the furnace shell 4.

[0204] A method of injecting the castable refractory includes: injecting about 100 kg to a first section (in the height of 250 mm); injecting another 100 kg to a second section positioned at 45 degrees shifted from the first section; repeating injecting in the same manner at total eight sections in one circumference of the heat-insulating bricks 52; and repeating injecting in the same manner in total five circumferences of the heat-insulating bricks 52 (in the height of 1250 mm).

[0205] As a result, the castable refractory 51 was favorably fed. In an observation of the behavior of the heat-insulating bricks 52 at the uppermost end, no displacement of the heat-insulating bricks 52 caused by the load of the castable refractory 51 was observed and the heat-insulating bricks 52 were favorably built.

[0206] Further, in Example 1, a construction period of the hot-blast stove was seven months as compared to eight months in a conventional method, so that the construction period was shortened by one month.

INDUSTRIAL APPLICABILITY

[0207] The invention relates to a method for constructing a hot-blast stove, and more specifically, to a method for constructing a hot-blast stove configured to supply hot air to a blast furnace.

EXPLANATION OF CODE(S)

[0208]

1	Hot-blast stove
2	Combustion-chamber furnace body
21	Burner
22	Fuel gas introduction unit
23	Air introduction unit
24	Hot-air supply unit
25	Connecting pipe
3	Heat-storage-chamber furnace body
31	Checker brick
32	Intake-exhaust port
4	Furnace shell
41	Injection pipe
4A	L-shaped ruler
4B	Leveling string
5	Lining
51	Castable refractory
52	Heat-insulating brick
53	Fire brick
54	Expansion clearance
55	Spacer
55A	Thin plate
55B	Base material
55D	Small pieces
55E	Recess
55F	Recessed groove

55G	Shaft material
55H	Honeycomb structural body
56	Filler
57	Spacer
58	Core
C1 to C4	Levels

Claims

1. A method of constructing a hot-blast stove, the hot-blast stove comprising: a furnace body comprising a furnace shell and a lining formed inside the furnace shell, the lining comprising: a castable refractory installed inside the furnace shell; heat-insulating bricks installed inside the castable refractory; and fire bricks installed inside the heat-insulating bricks, the method comprising:

   installing the heat-insulating bricks and the fire bricks inside the furnace shell at an interval from the furnace shell;
   subsequently injecting the castable refractory between the furnace shell and the heat-insulating bricks;
   sharing a force of the castable refractory in a radially inward direction of the furnace body, which is caused by a head pressure of the castable refractory, by the heat-insulating bricks and the fire bricks to prevent shifting or breakage of the heat-insulating bricks; and
   solidifying the castable refractory.

2. The method of constructing a hot-blast stove according to claim 1, wherein the lining comprises an expansion clearance between the heat-insulating bricks and the fire bricks, between the heat-insulating bricks, or between the fire bricks, and the expansion clearance comprises a spacer that is interposed therein, has a predetermined strength at normal temperature, and disappears at an internal temperature of the hot-blast stove at working.

3. The method of constructing a hot-blast stove according to claim 2, wherein the spacer is a thermoplastic resin foam.

4. The method of constructing a hot-blast stove according to claim 2 or 3, wherein the expansion clearance comprises a filler that is soft or amorphous at normal temperature and is interposed therein together with the spacer.

5. The method of constructing a hot-blast stove according to any one of claims 1 to 4, further comprising:

   installing a checker brick inside the lining, wherein
   the injecting the castable refractory is performed during or after the installing the checker brick.

6. The method of constructing a hot-blast stove according to any one of claims 1 to 5, further comprising:

   dividing the furnace body into a plurality of sections arranged in a height direction; and
   injecting the castable refractory in each of the sections.

7. The method of constructing a hot-blast stove according to any one of claims 1 to 6, wherein the heat-insulating bricks are installed in a plurality of layers in a thickness direction of the lining, and horizontal joints in a circumferential direction of the heat-insulating bricks in the layers are shifted from each other.

8. The method of constructing a hot-blast stove according to any one of claims 1 to 7, wherein the castable refractory has a free-flow value in a range from 200 mm to 300 mm.

FIG.1

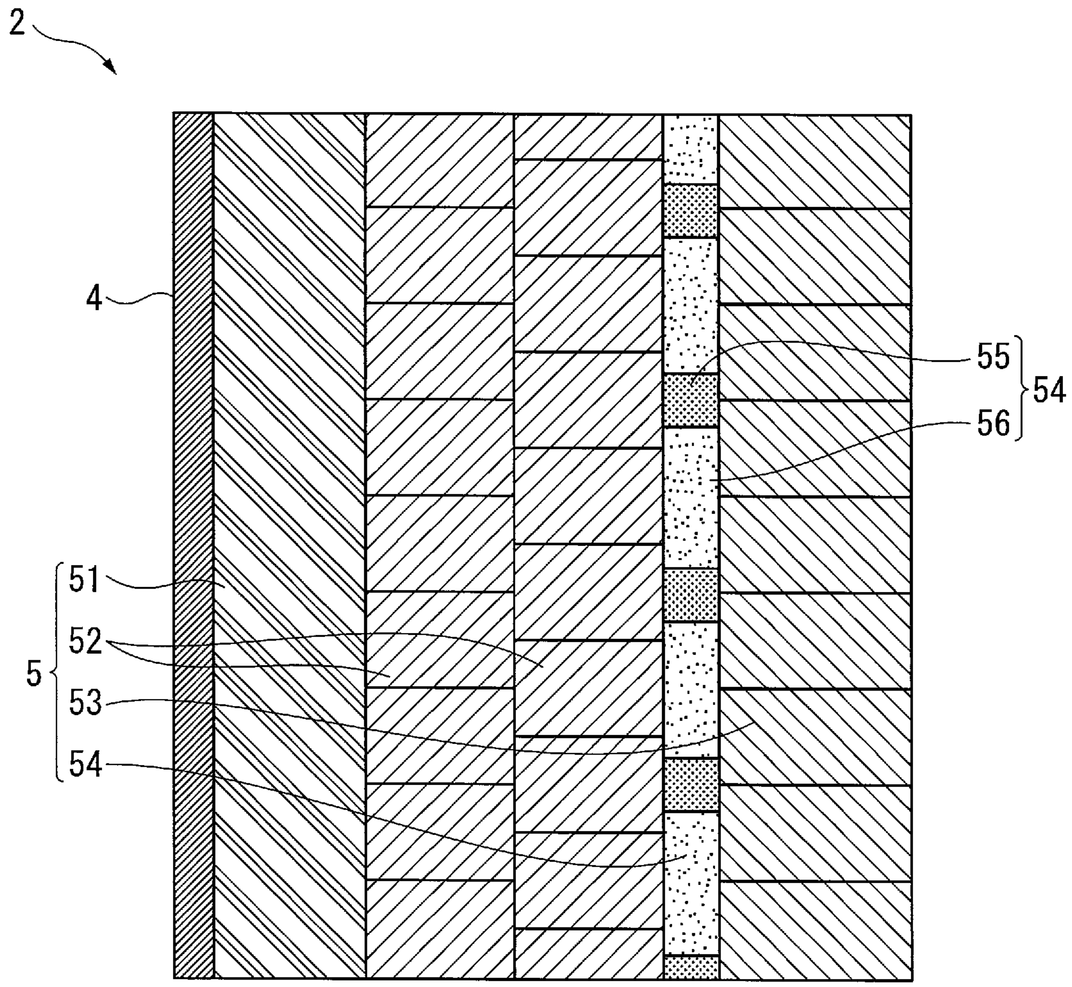


FIG. 2

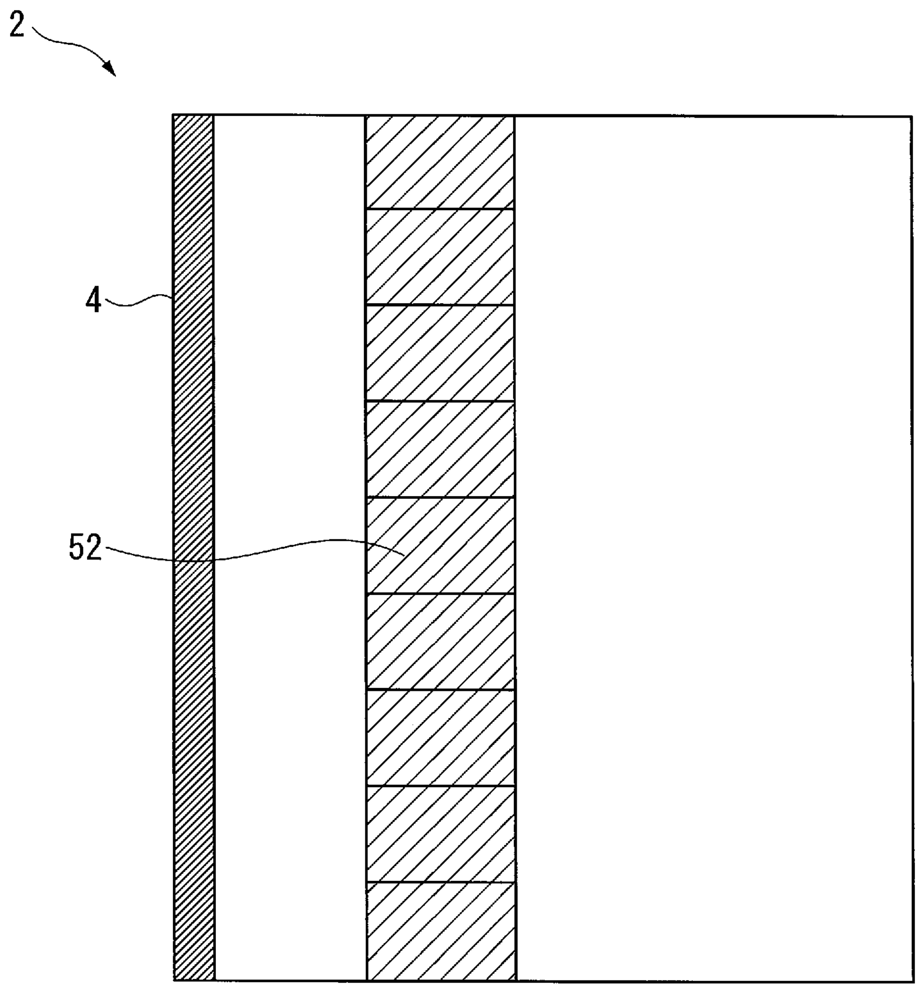


FIG.3

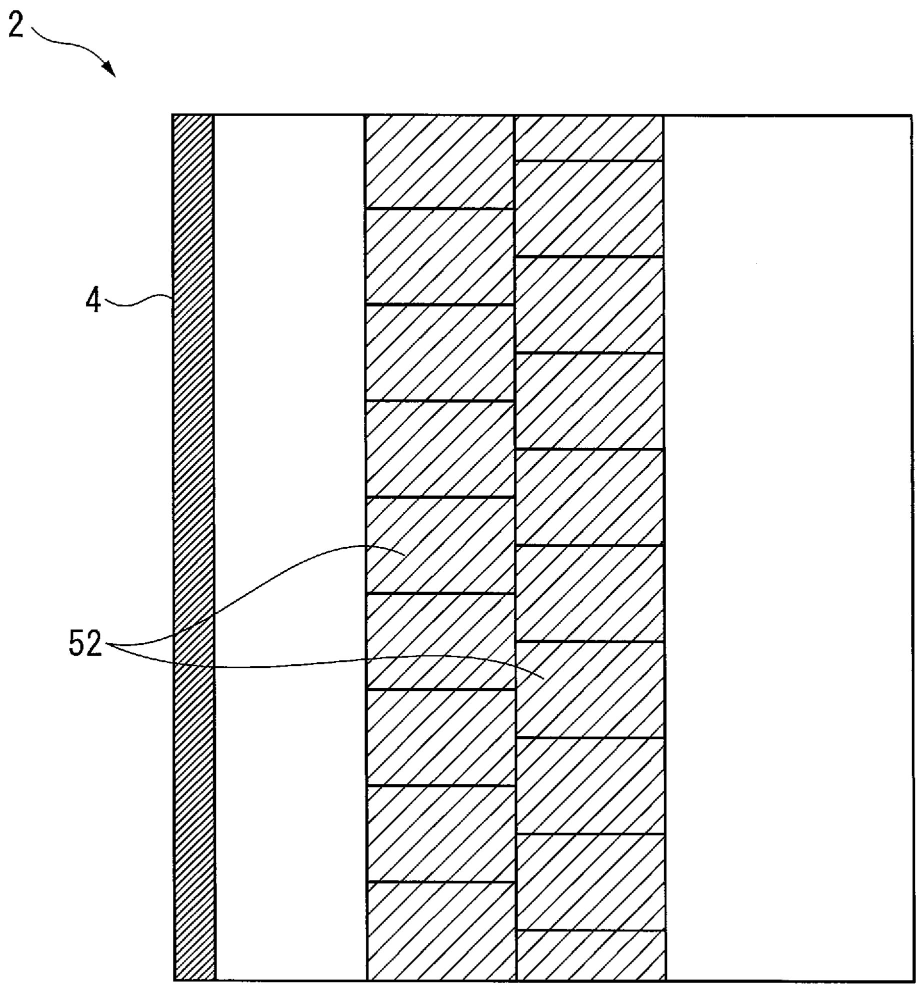


FIG.4

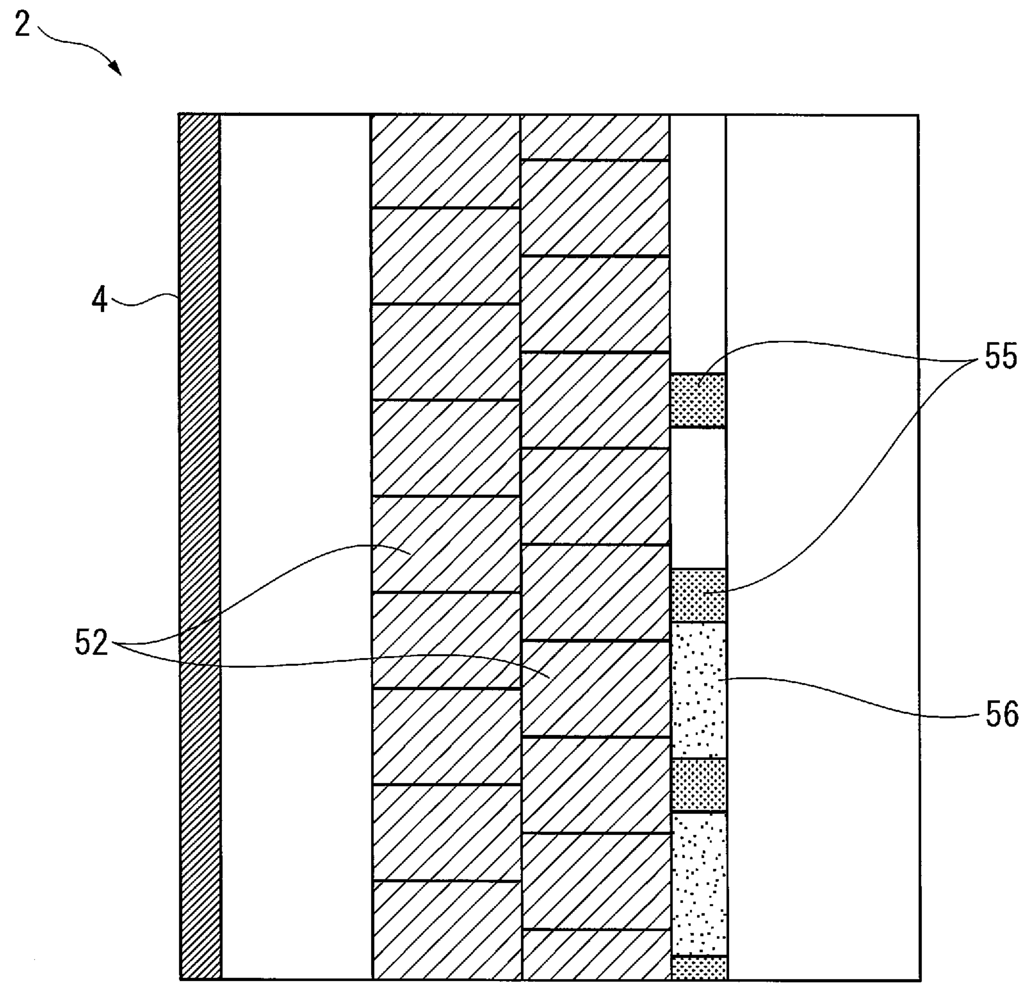


FIG.5

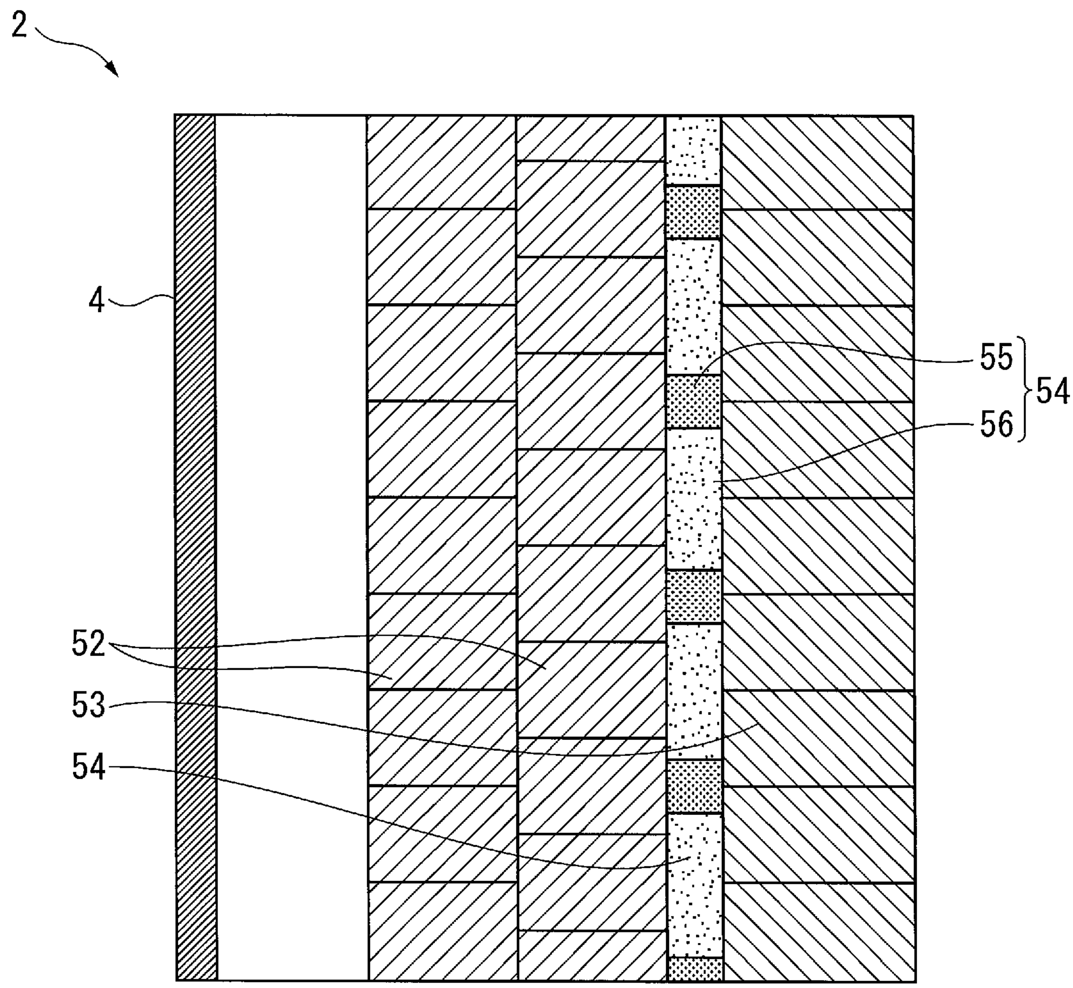


FIG.6

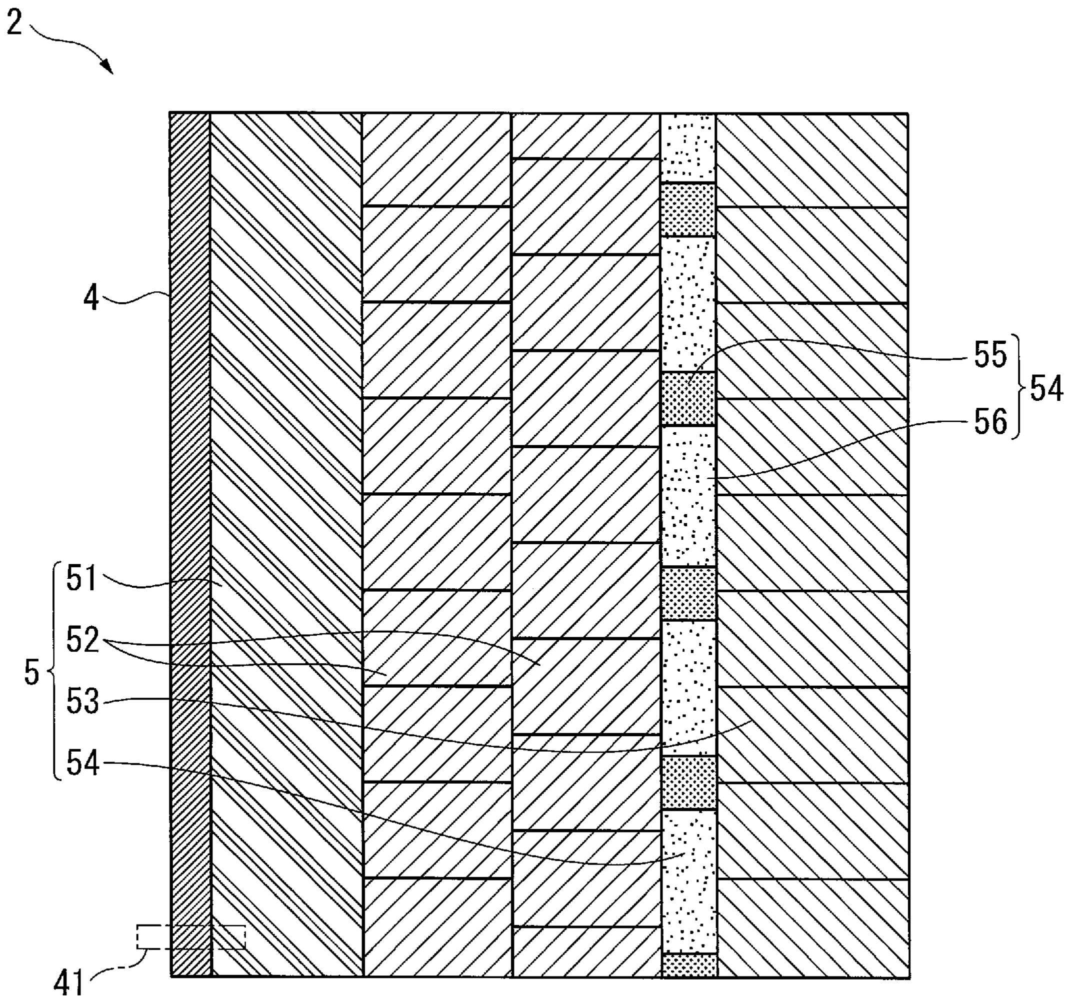


FIG.7

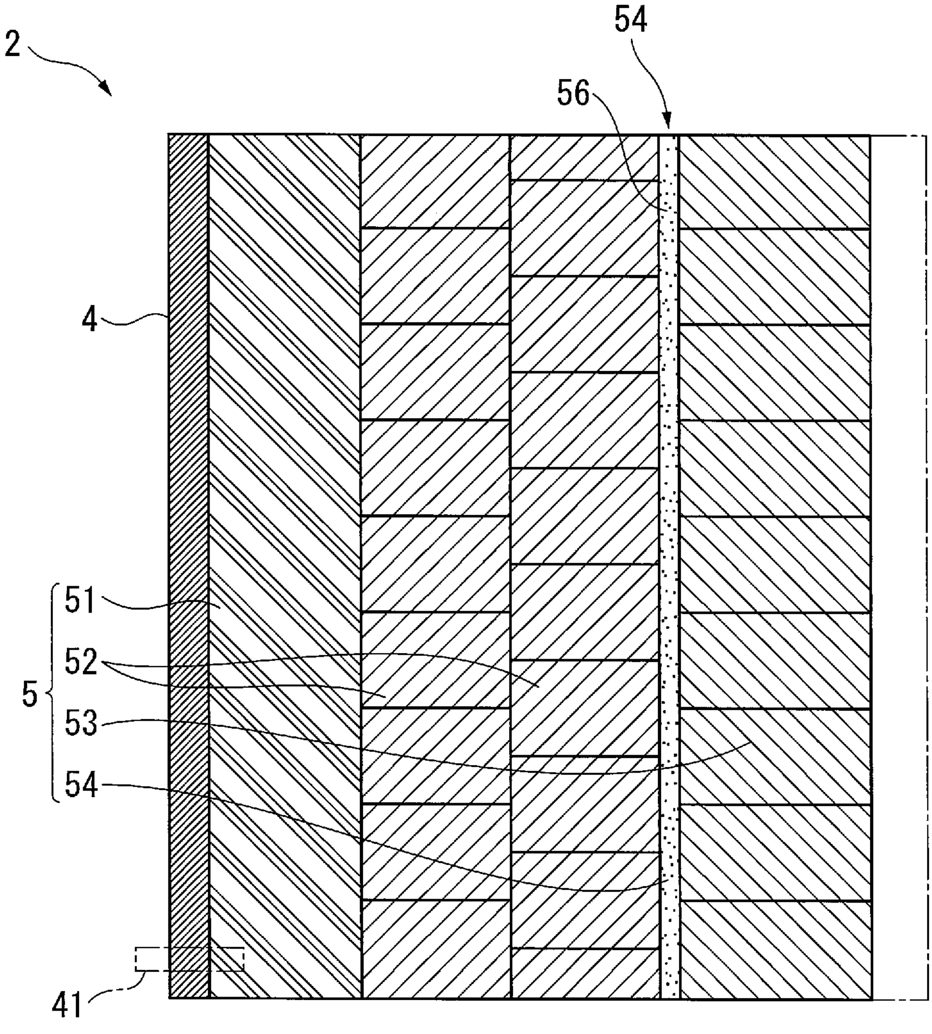


FIG.8

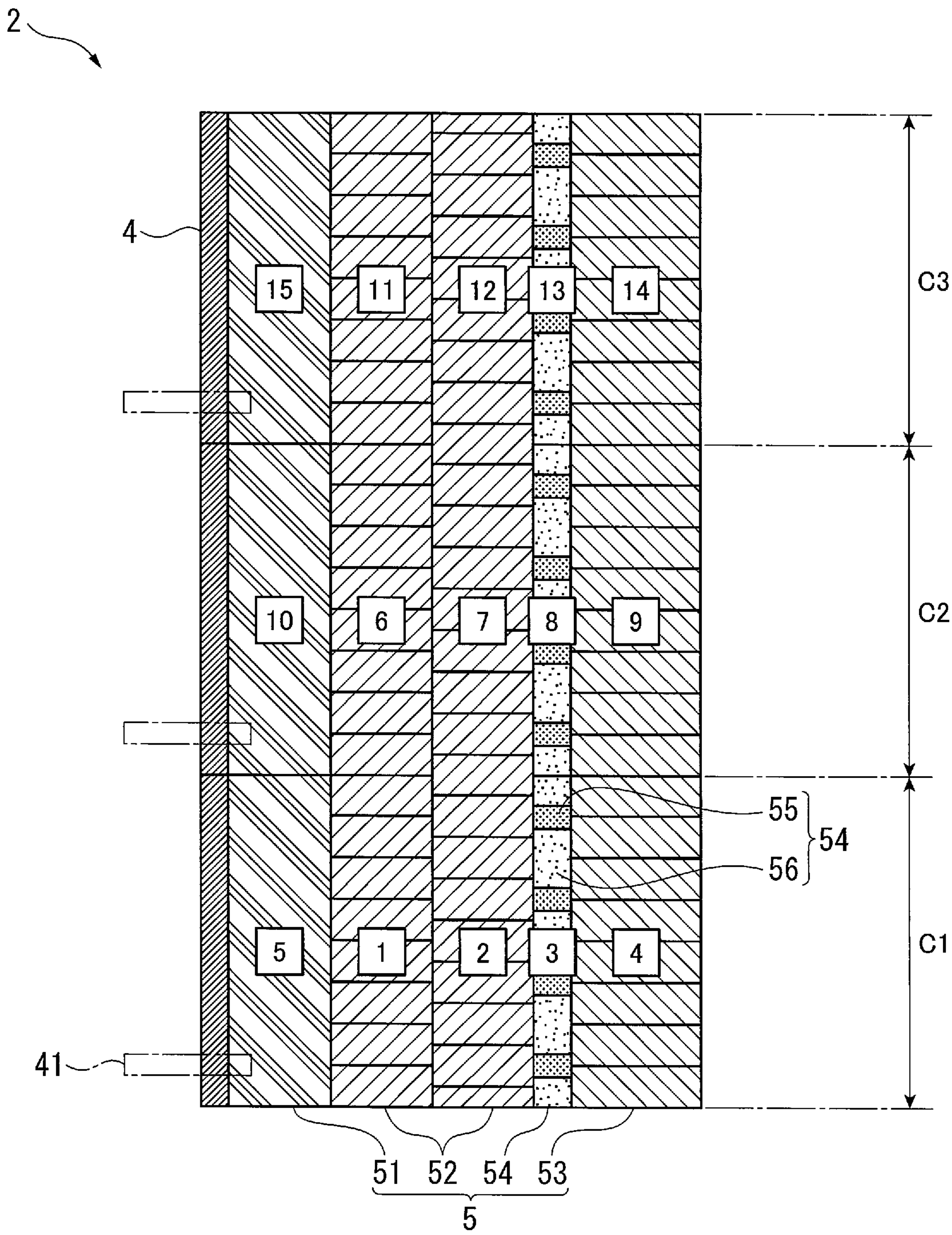


FIG. 9

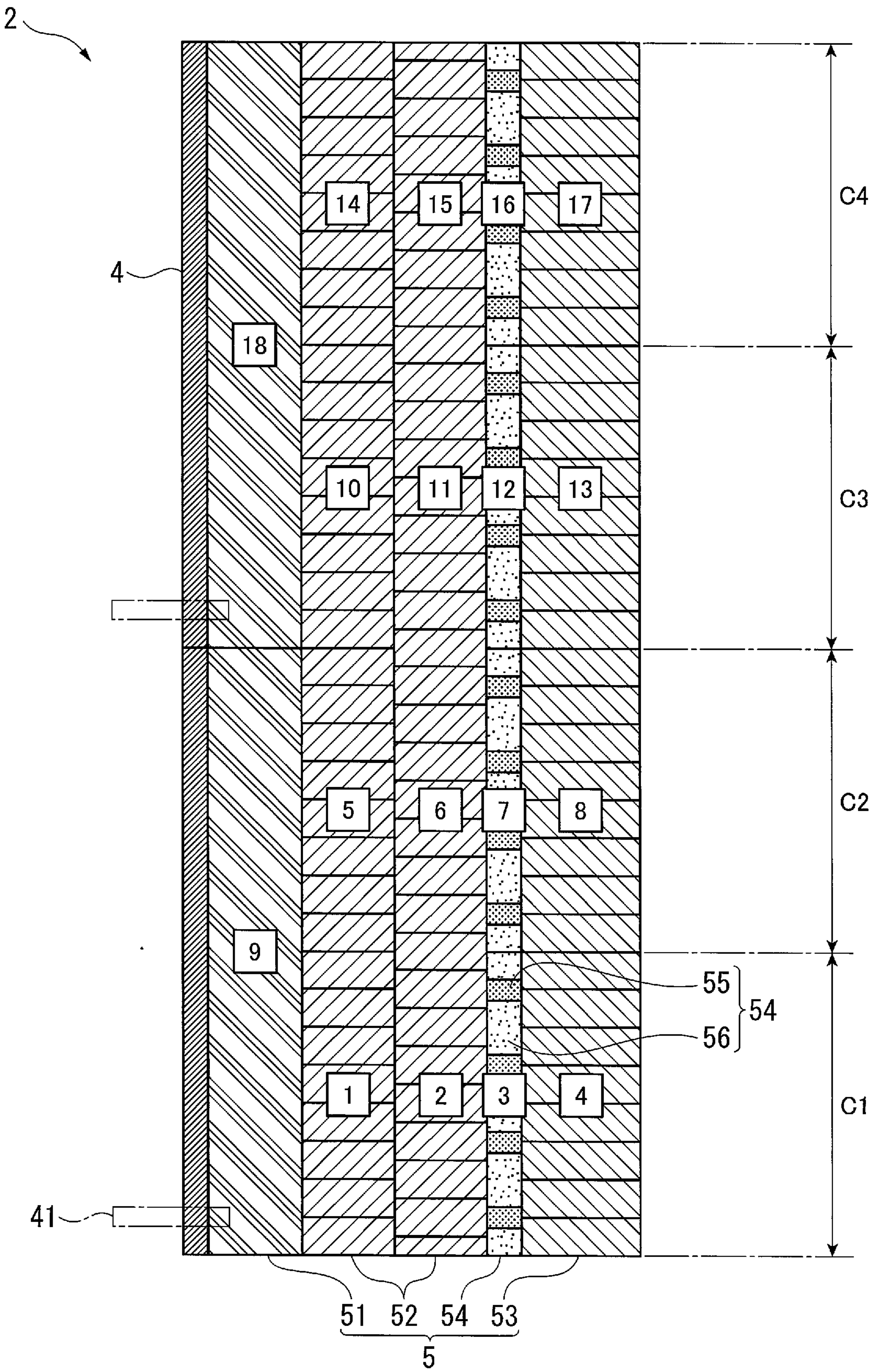

2
4
18
9
41
14
15
16
17
10
11
12
13
5
6
7
8
1
2
3
4
C4
C3
C2
C1
55
54
56
51
52
54
53
5

FIG.10

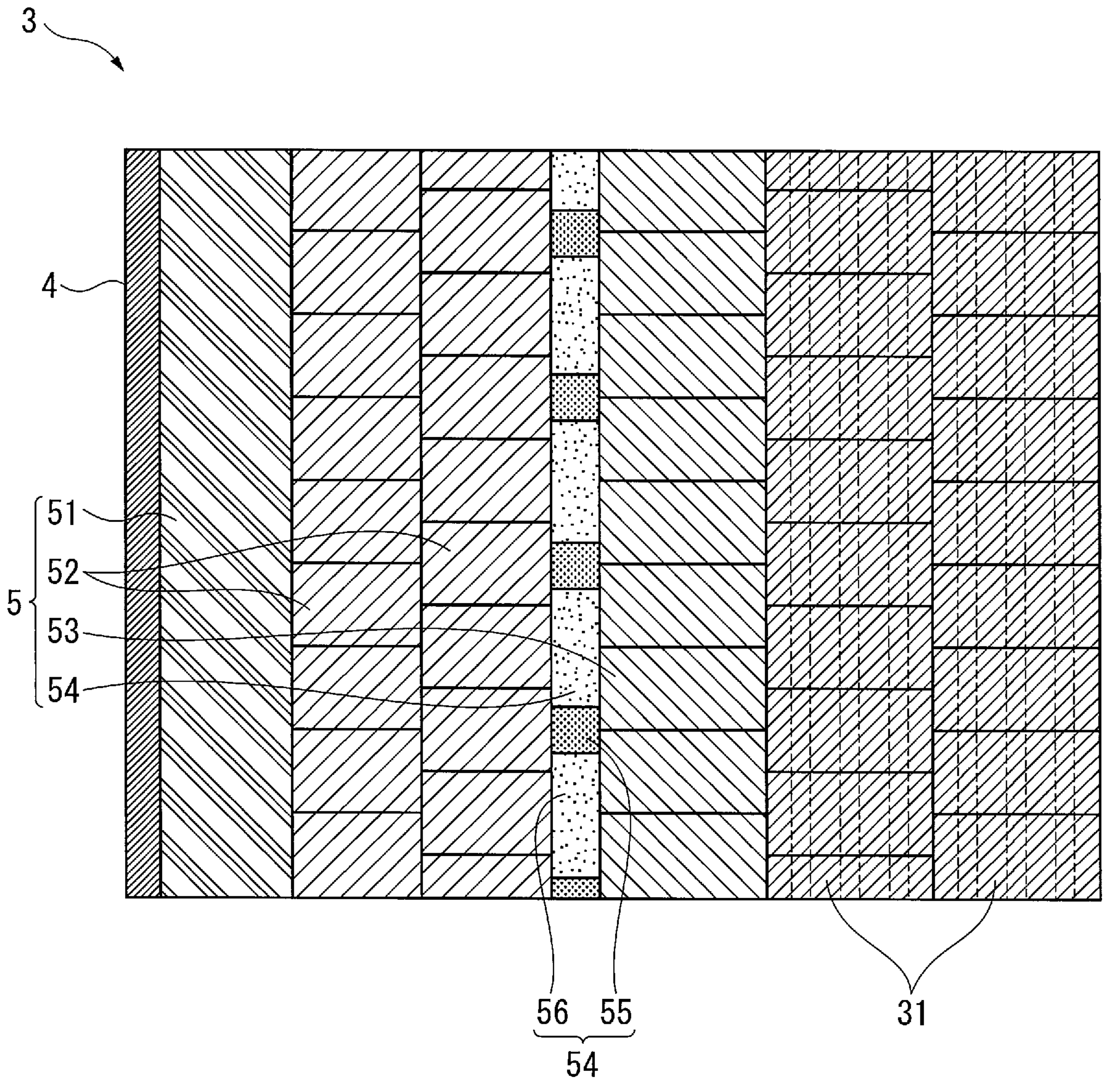


FIG.11

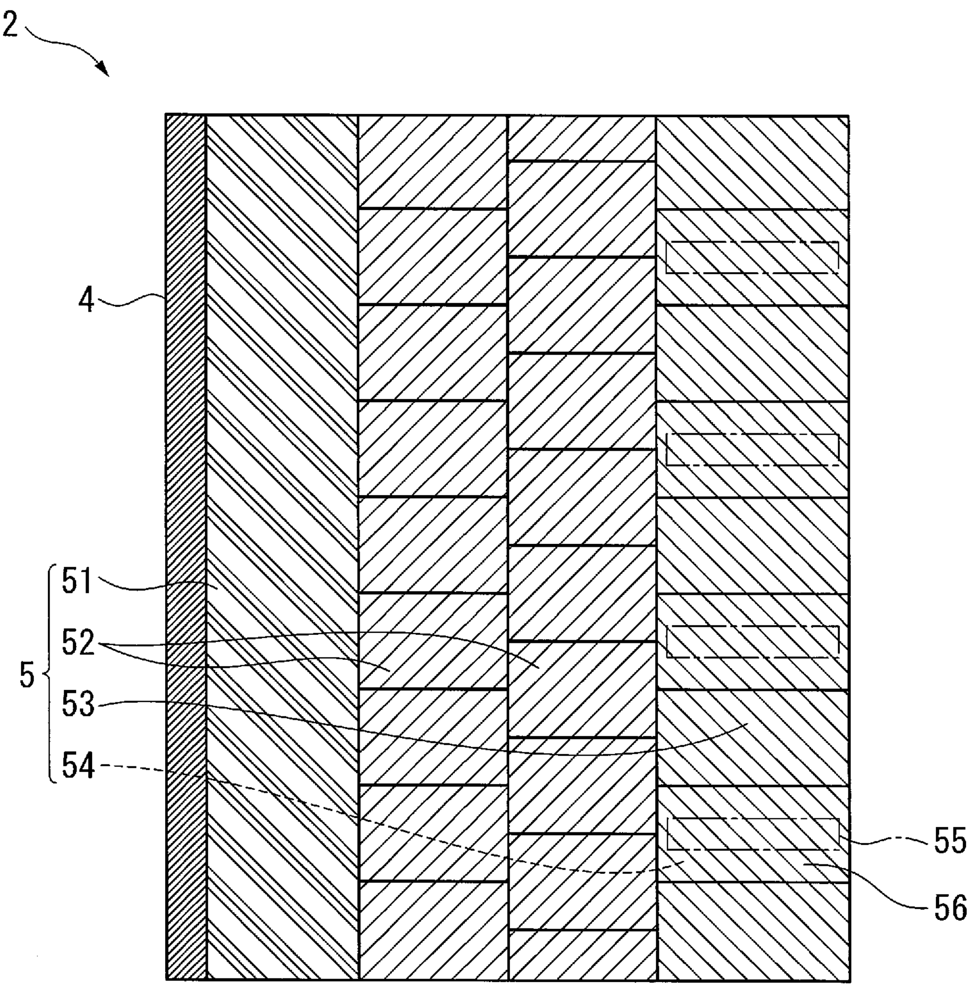


FIG.12

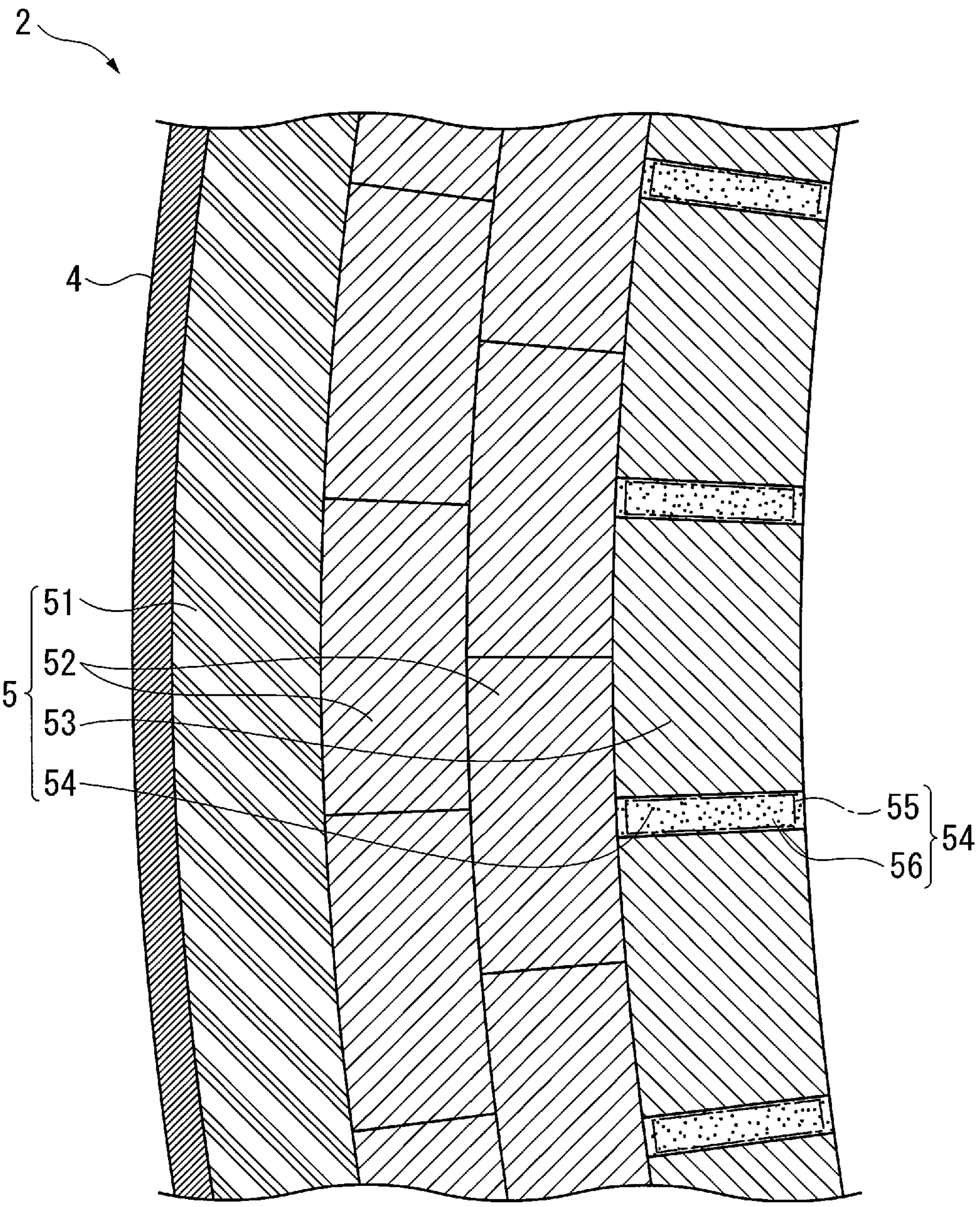


FIG.13

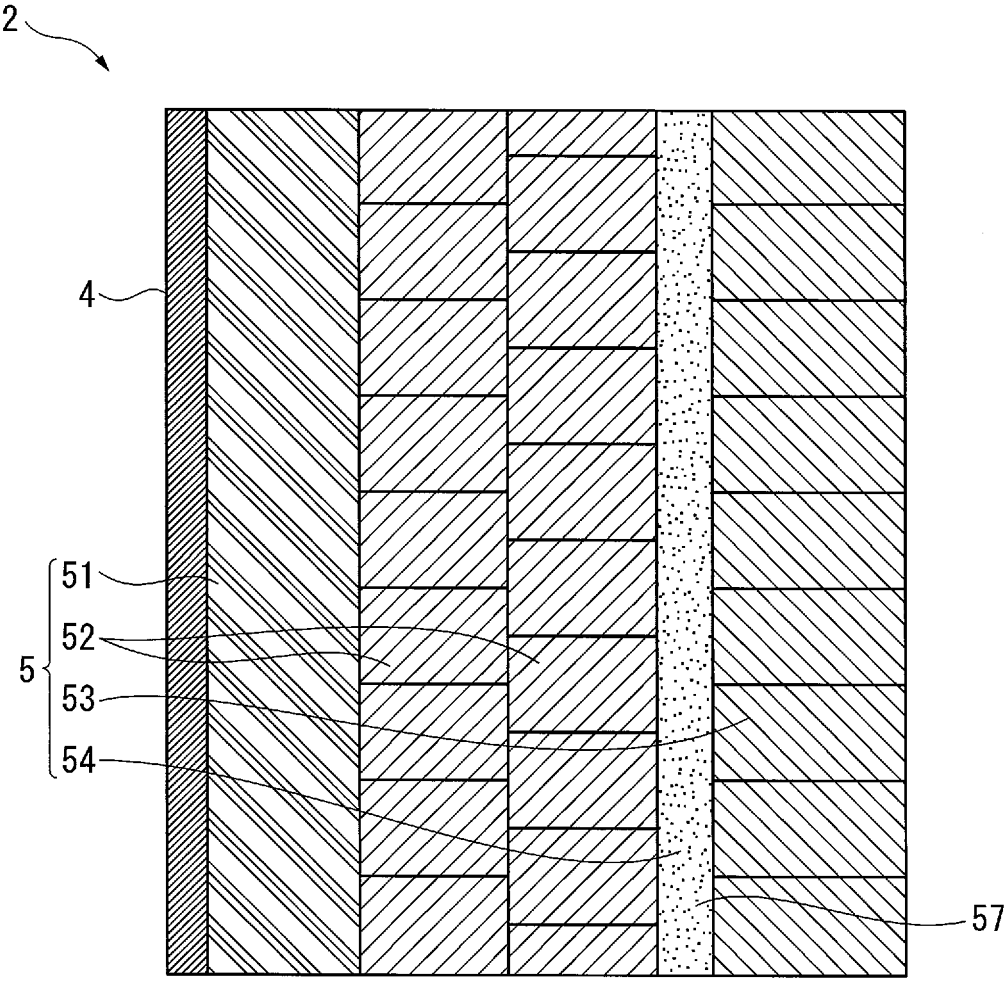


FIG.14

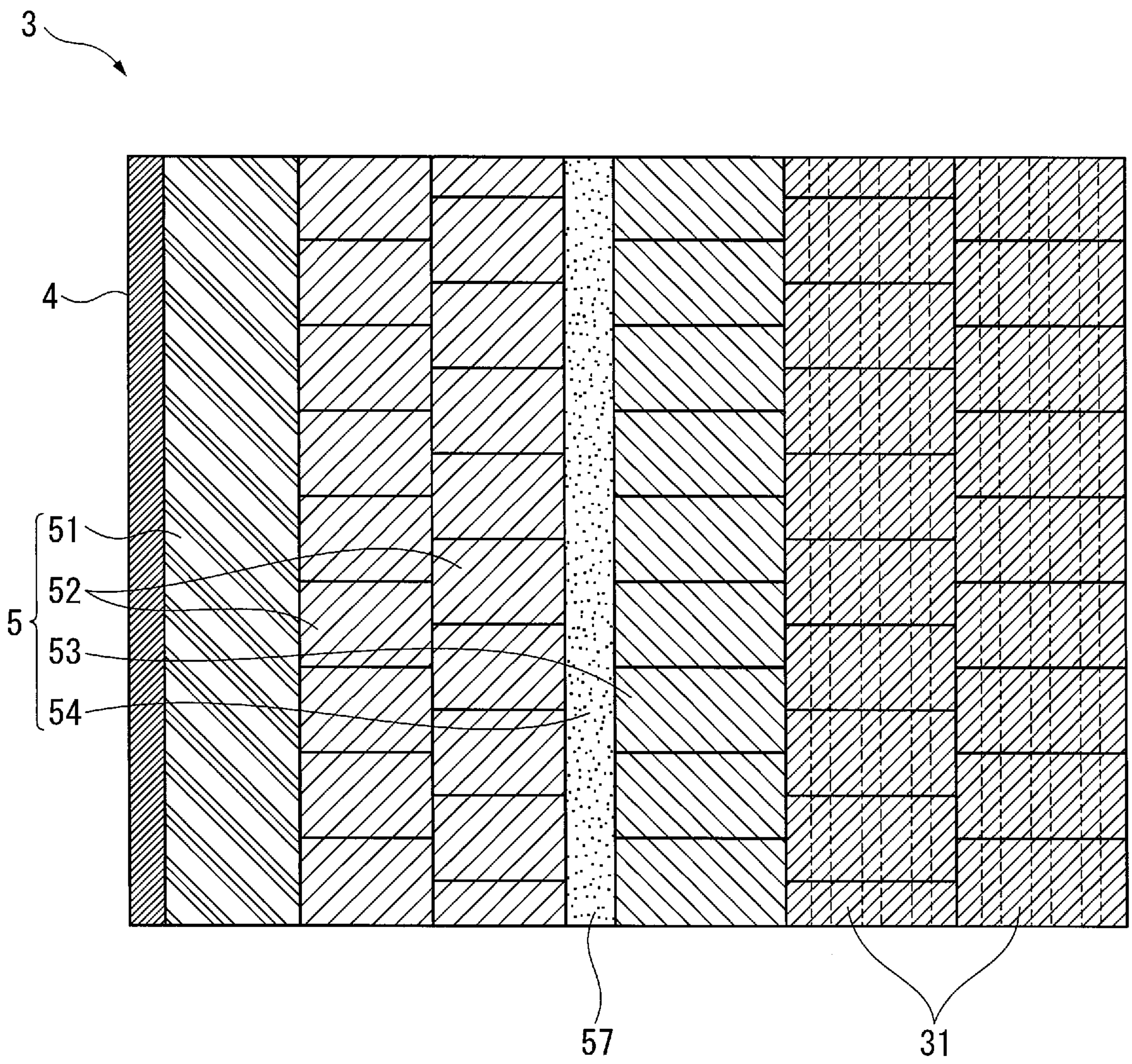


FIG.15

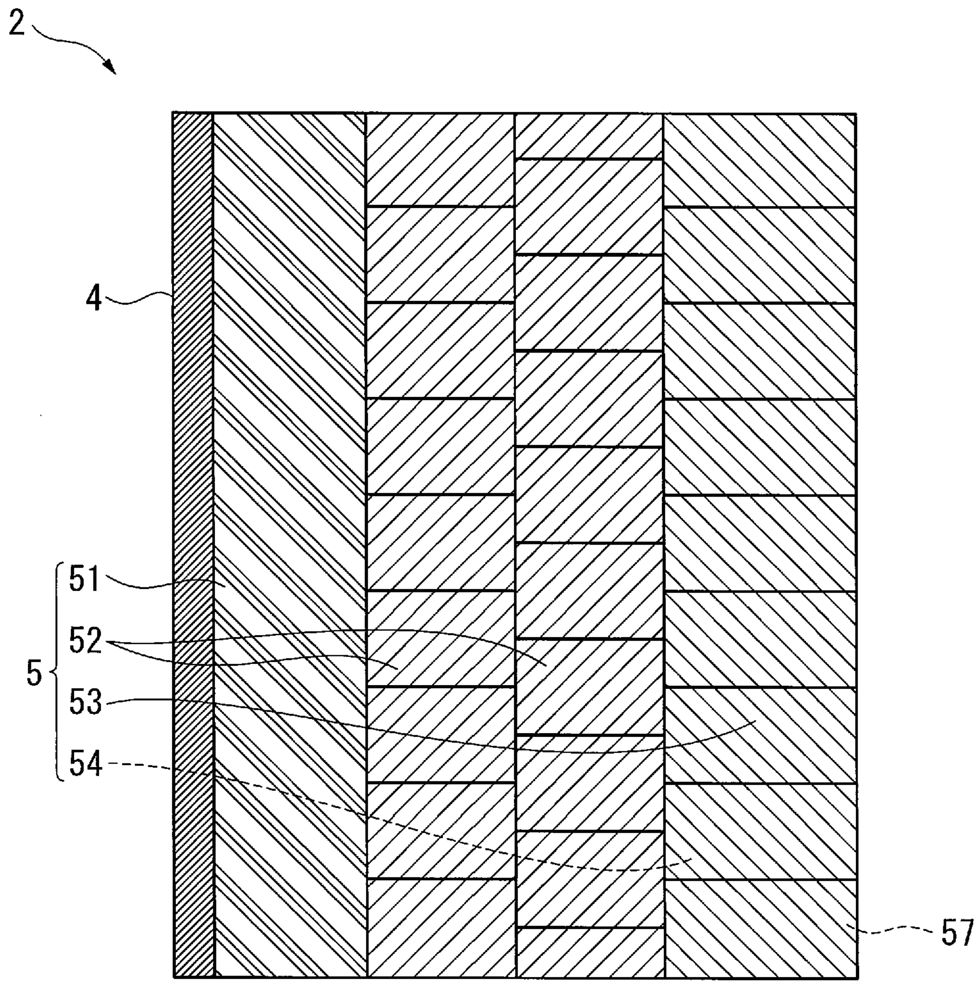


FIG.16

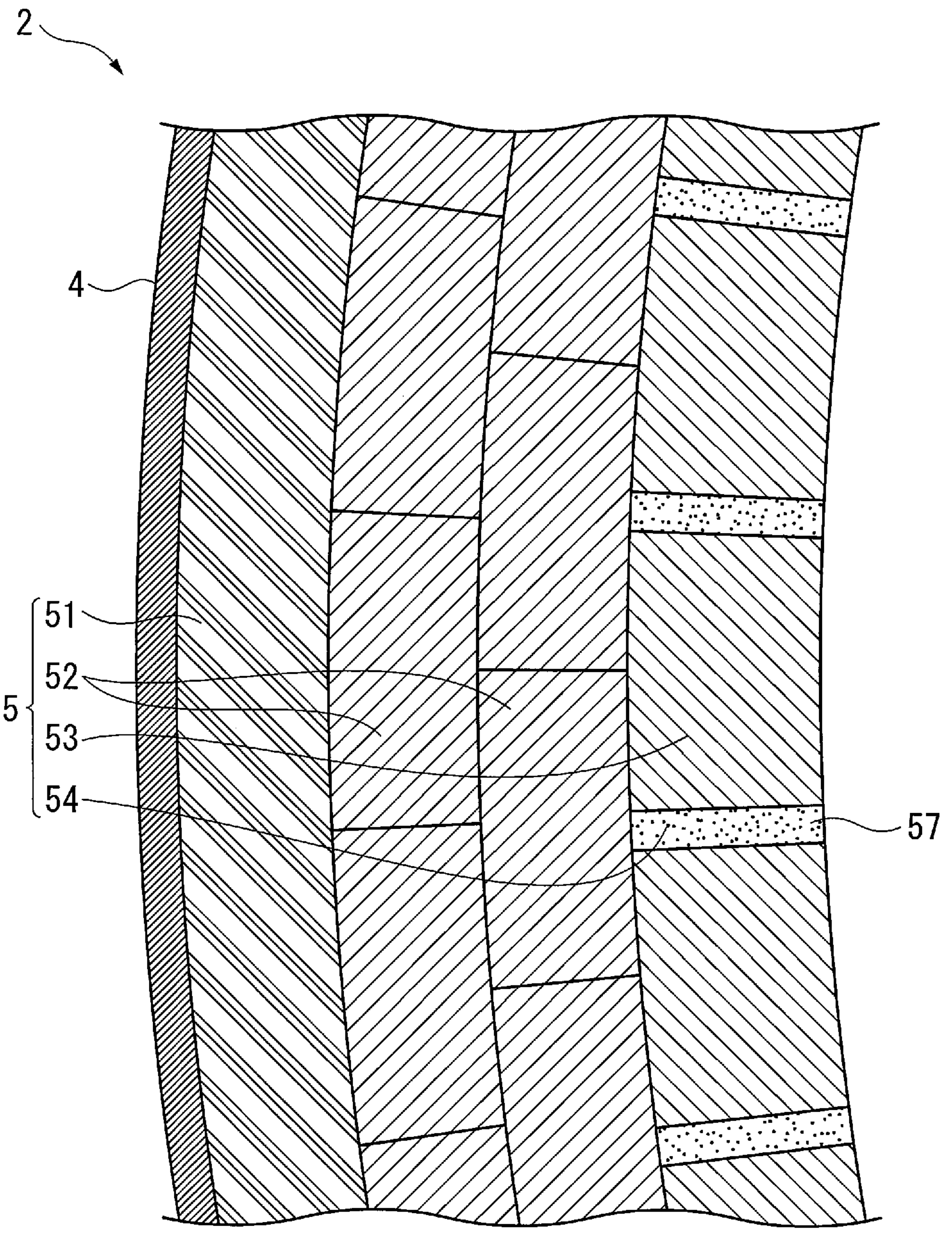


FIG.17

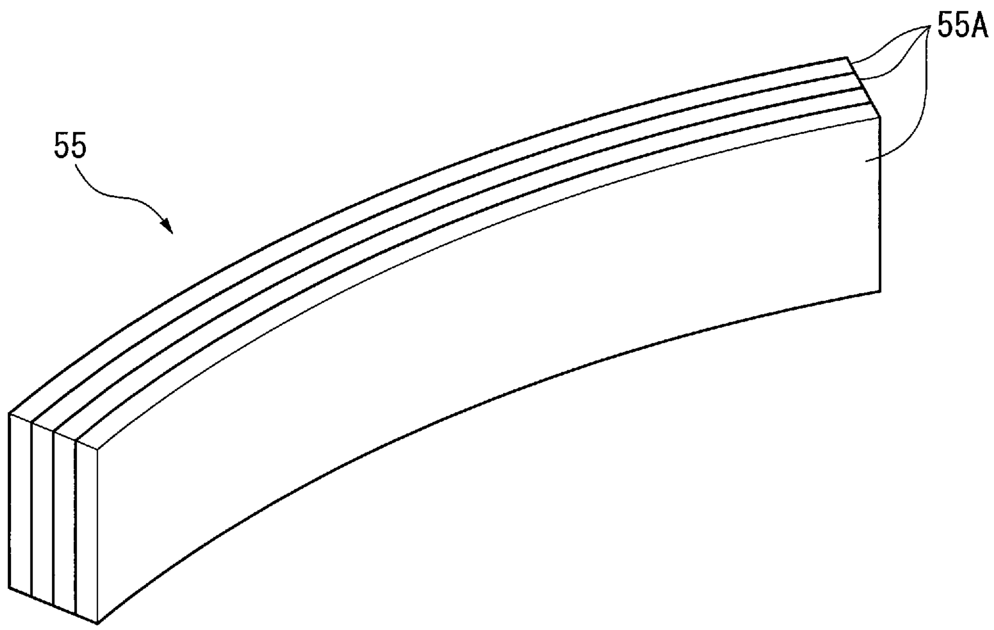


FIG.18

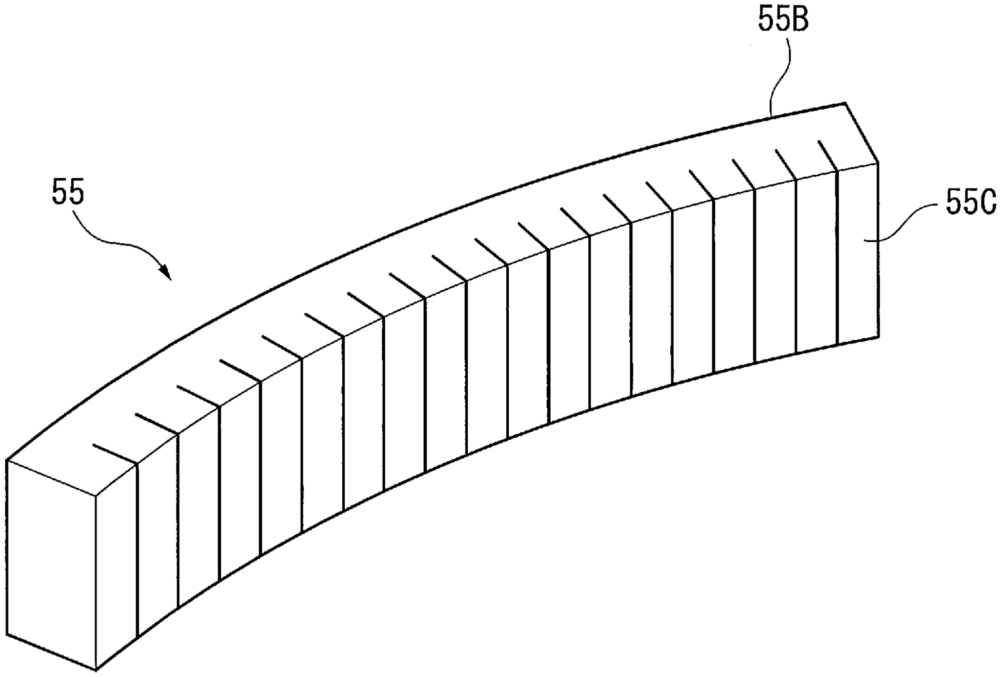


FIG.19

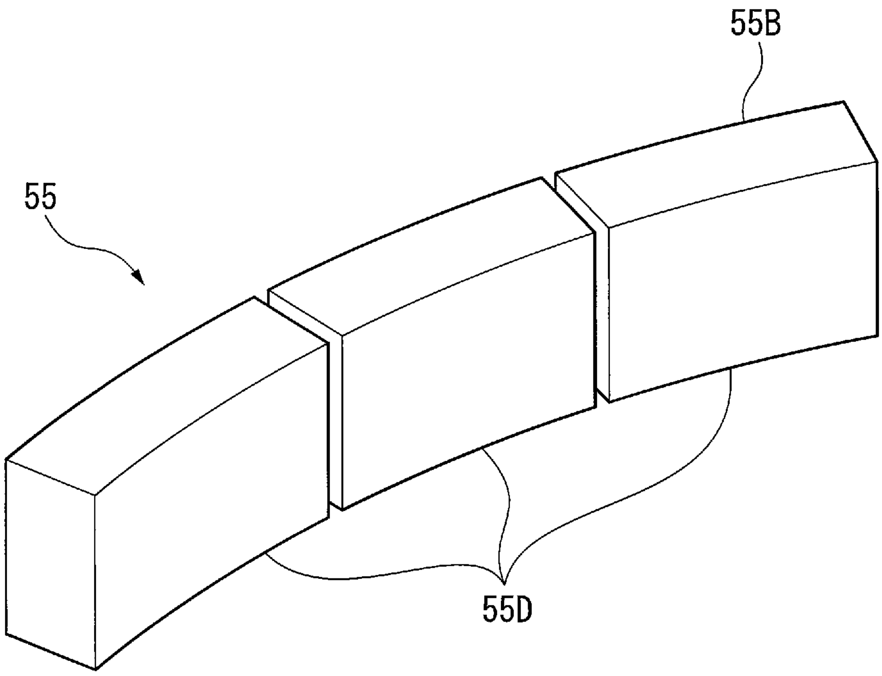


FIG.20

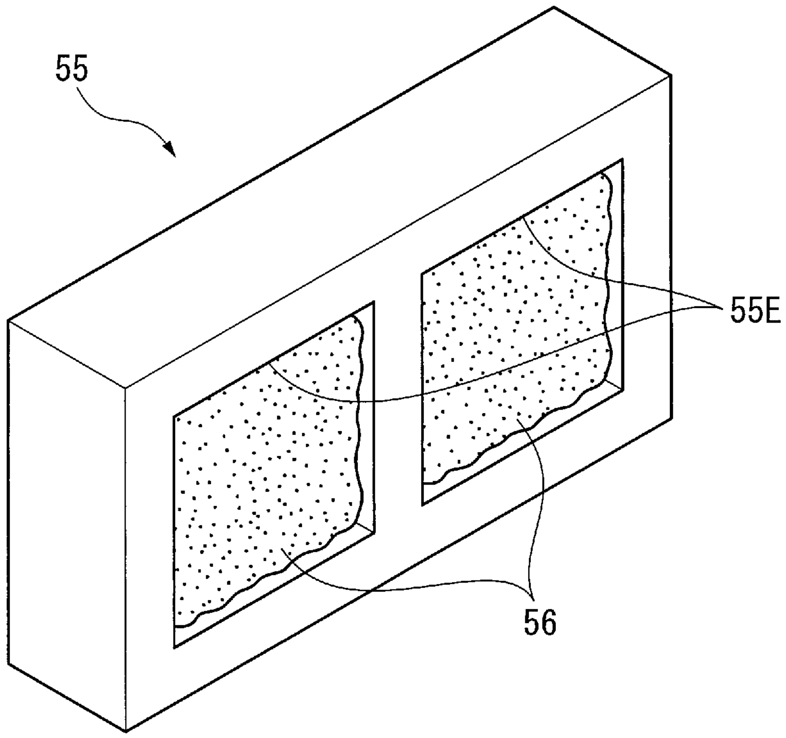


FIG.21

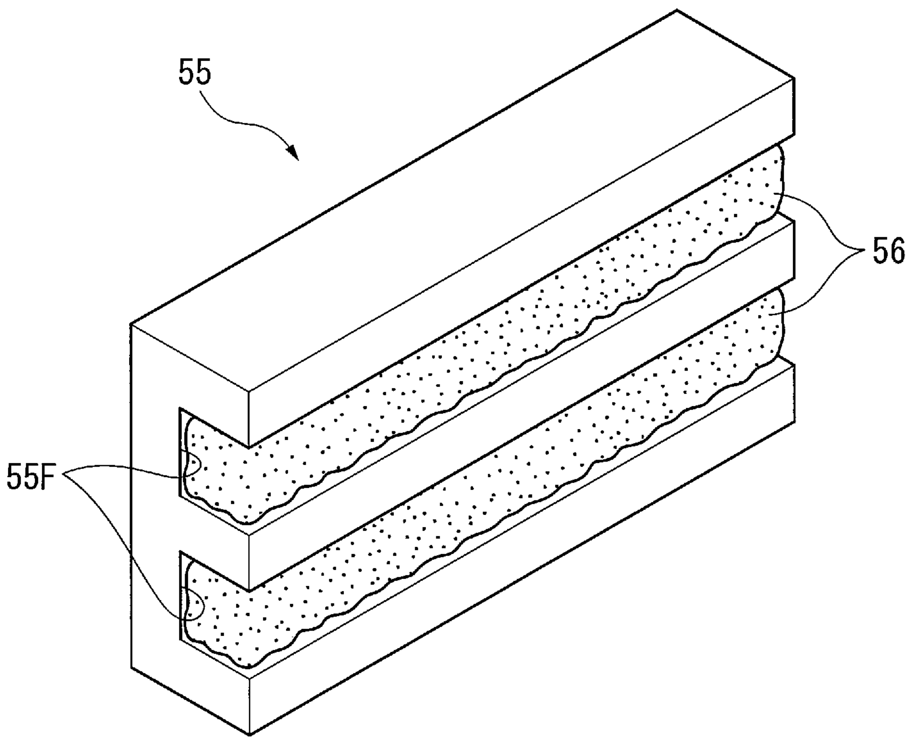


FIG.22

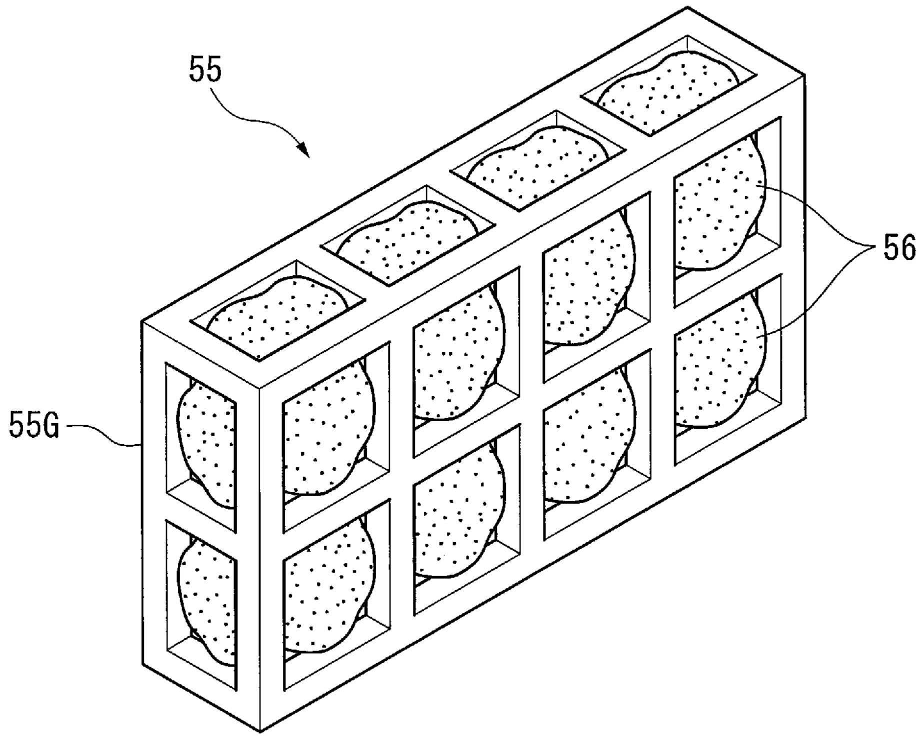


FIG.23

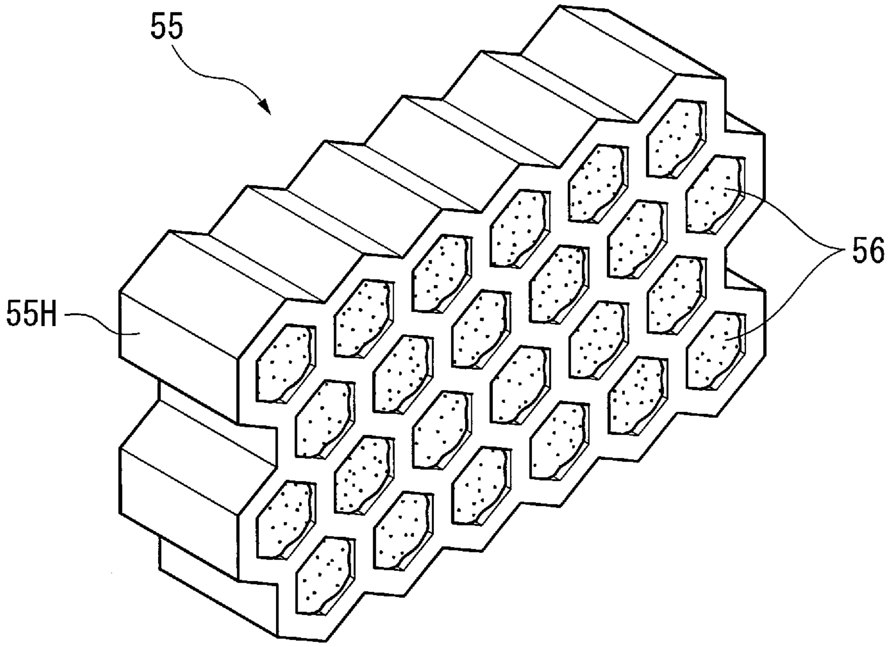


FIG.24

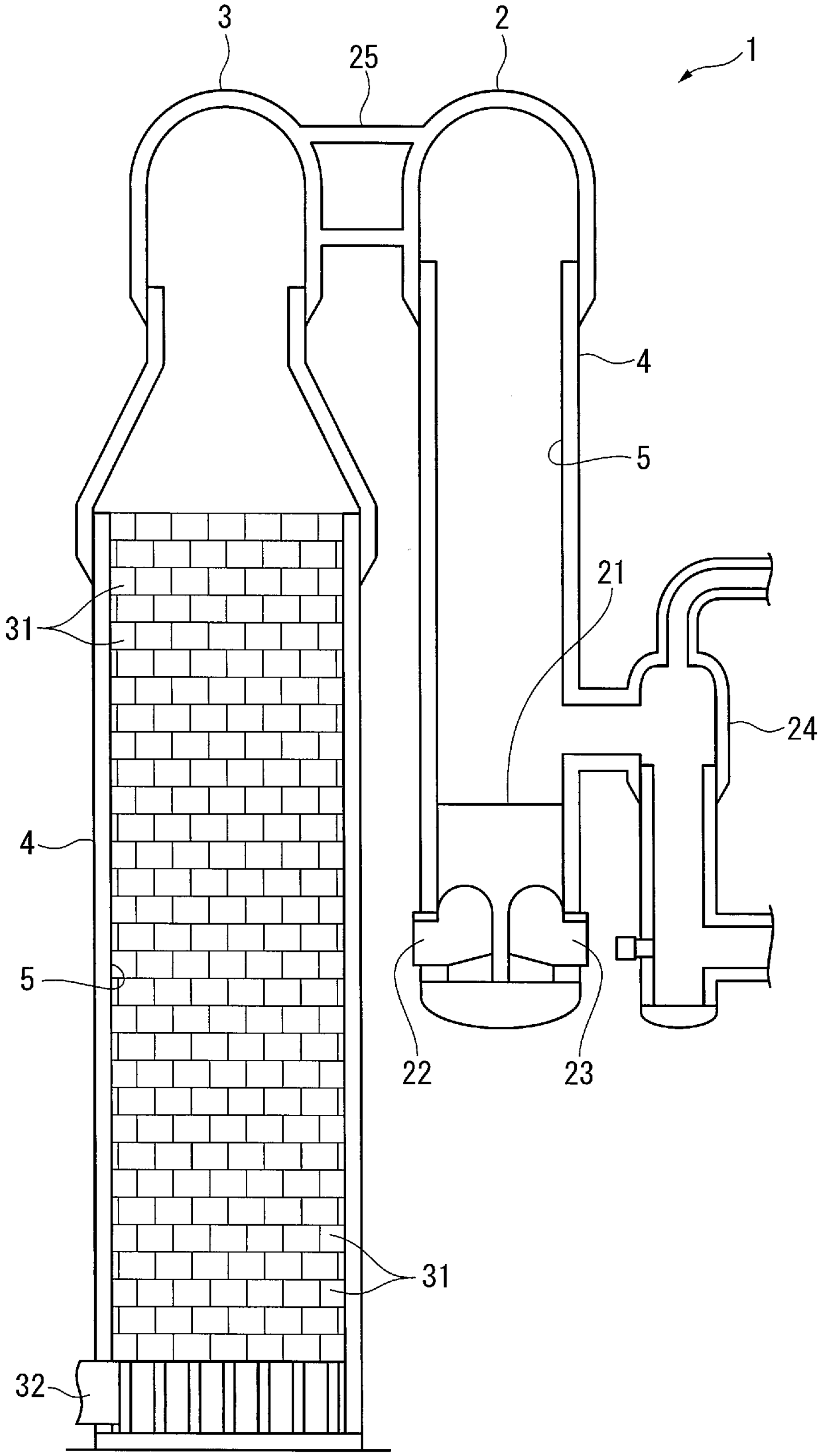


FIG.25

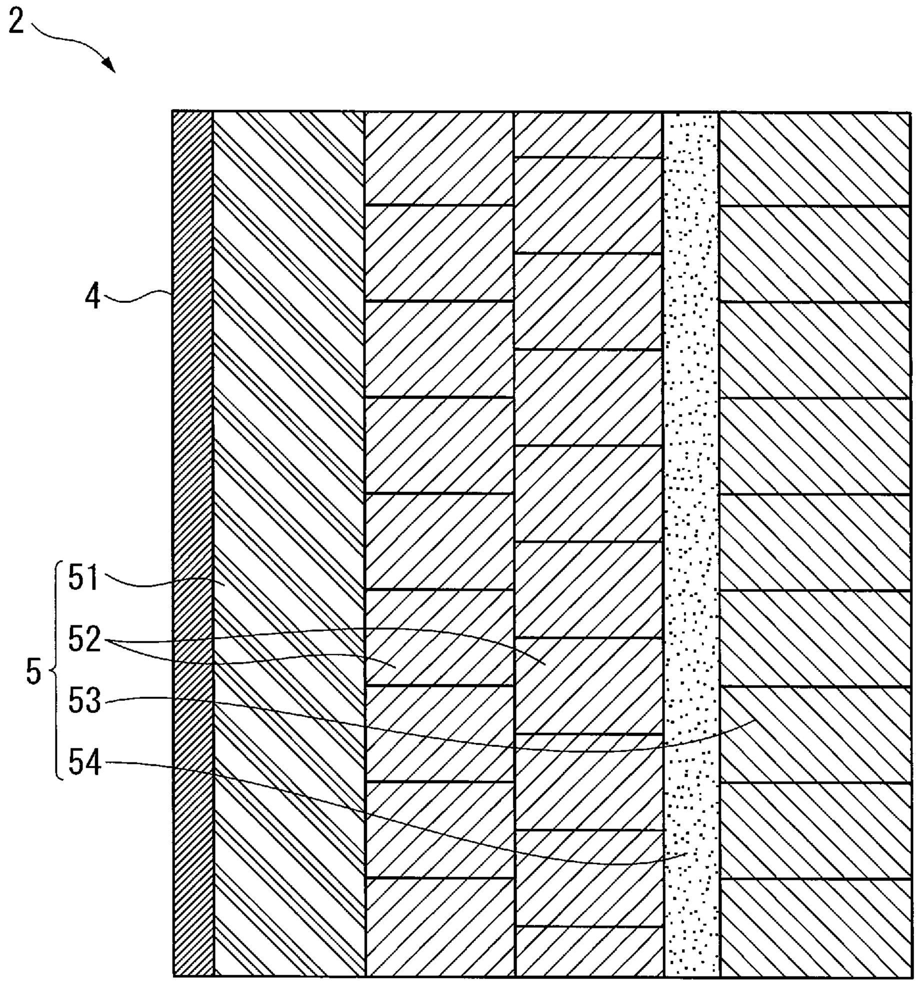


FIG.26

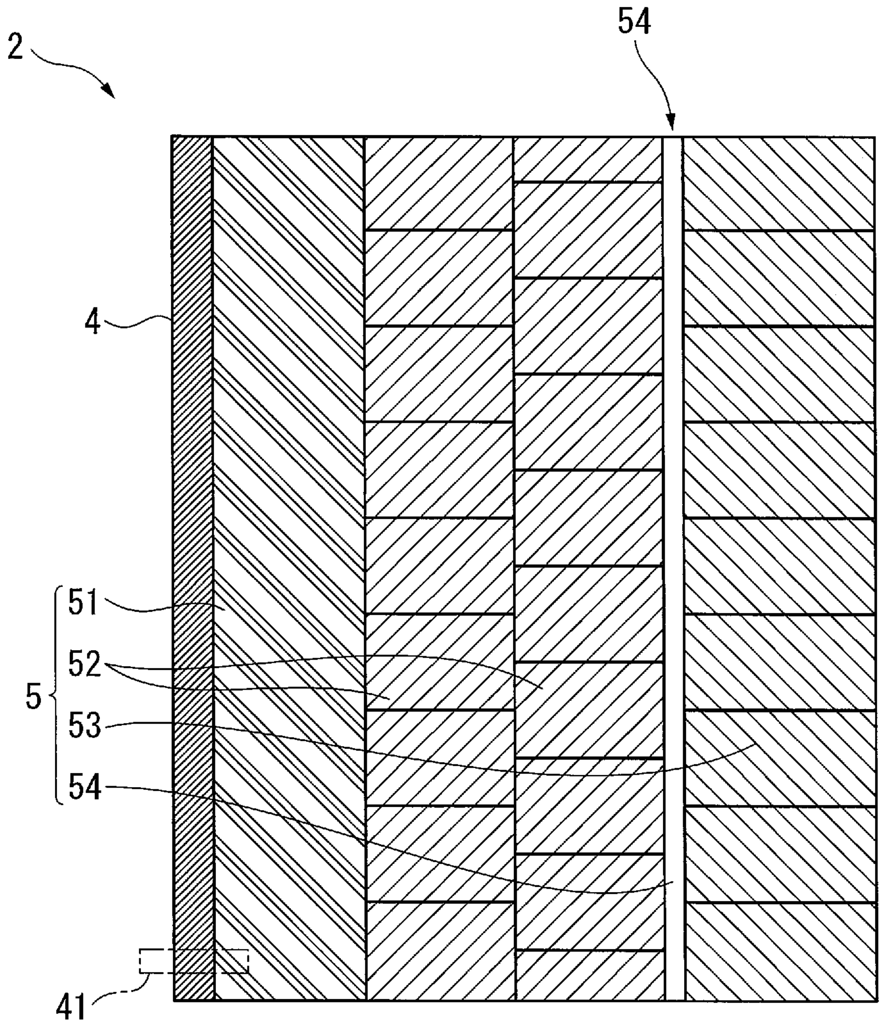


FIG.27

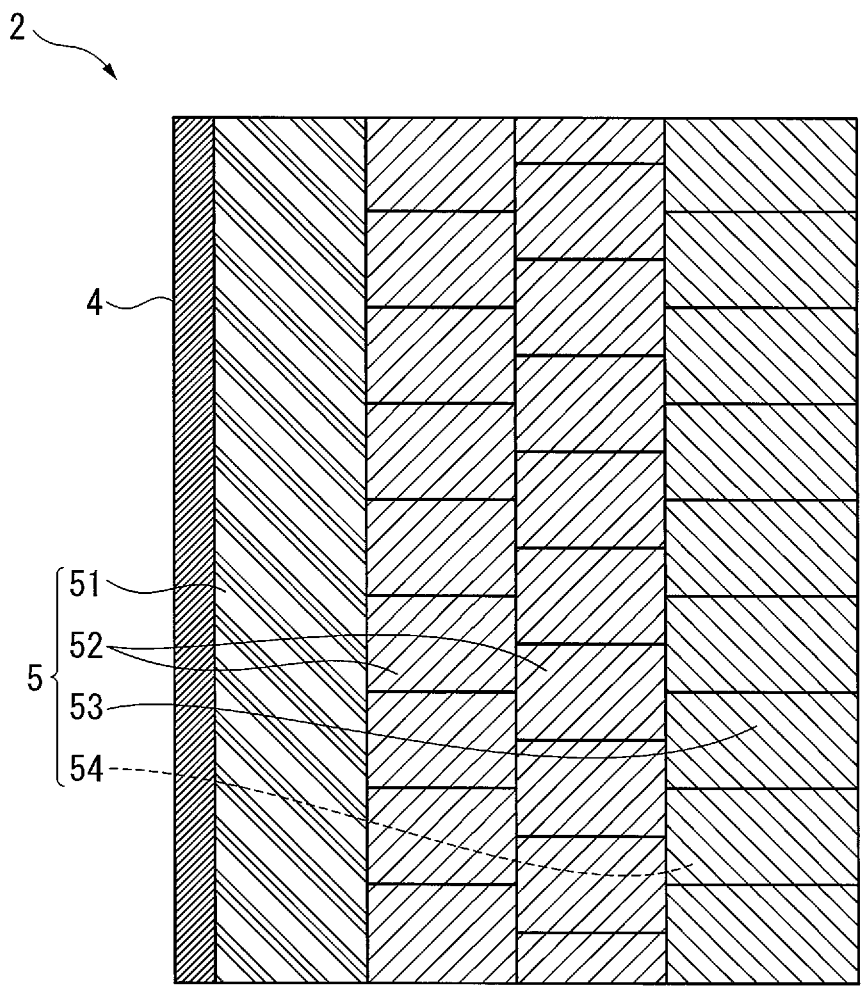


FIG.28

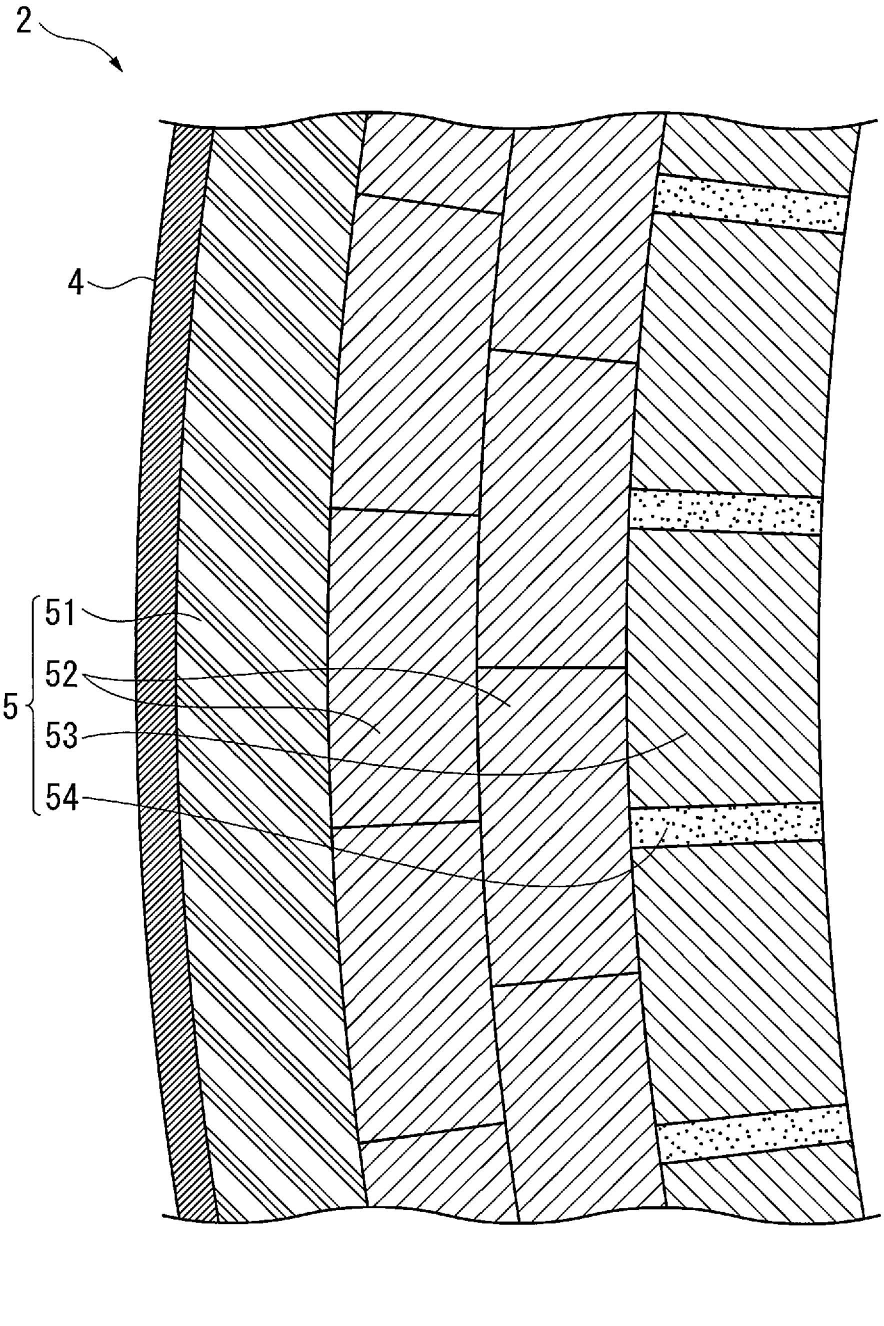


FIG.29

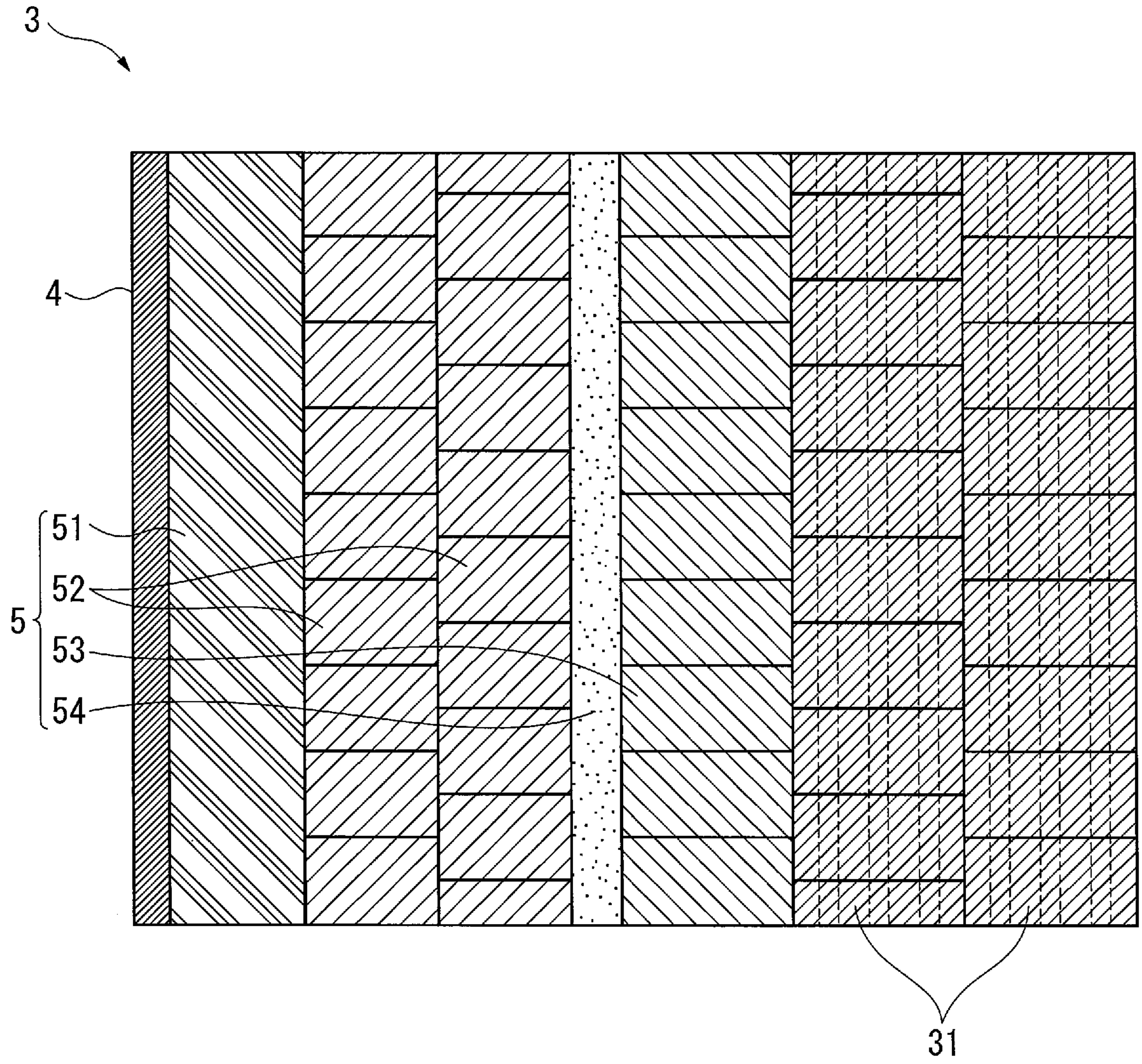


FIG.30

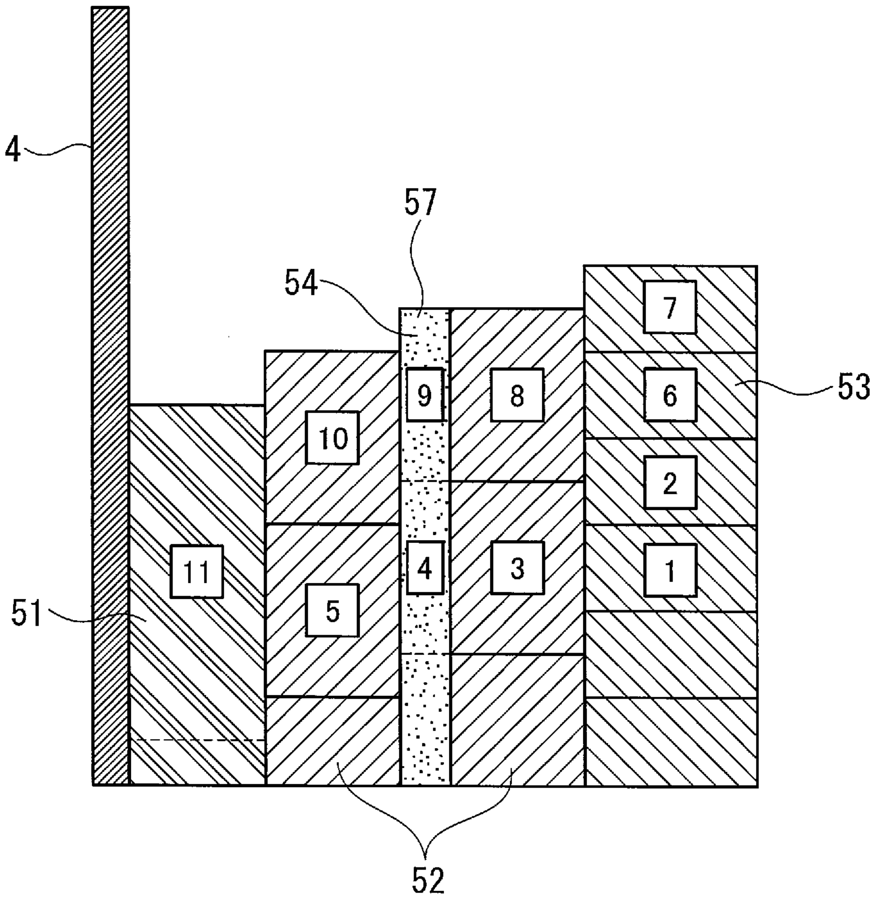


FIG.31

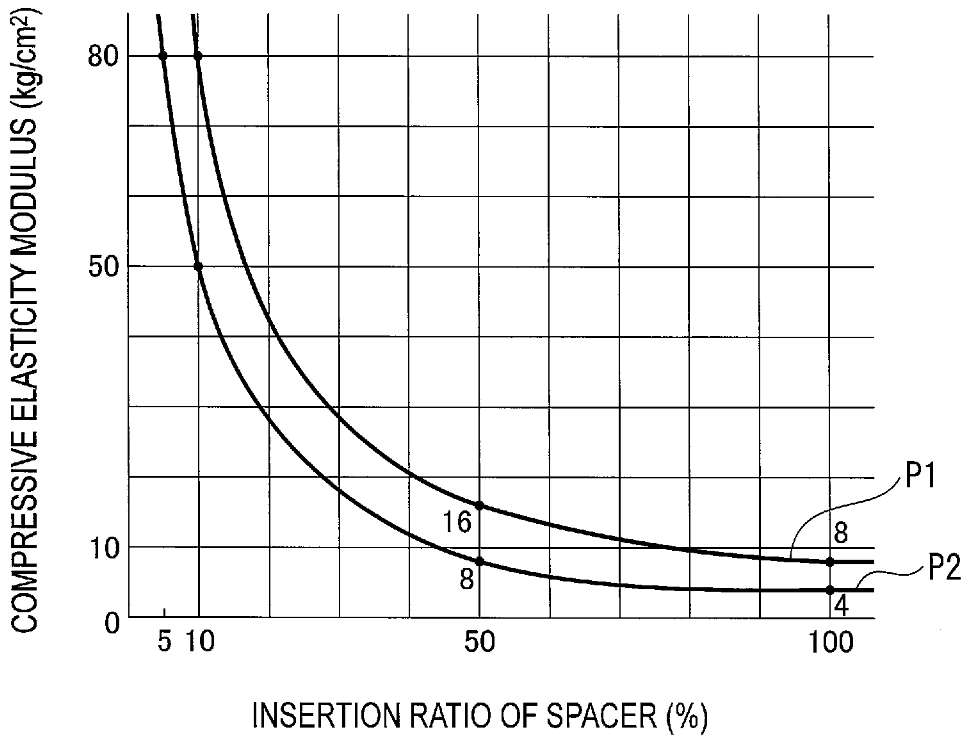
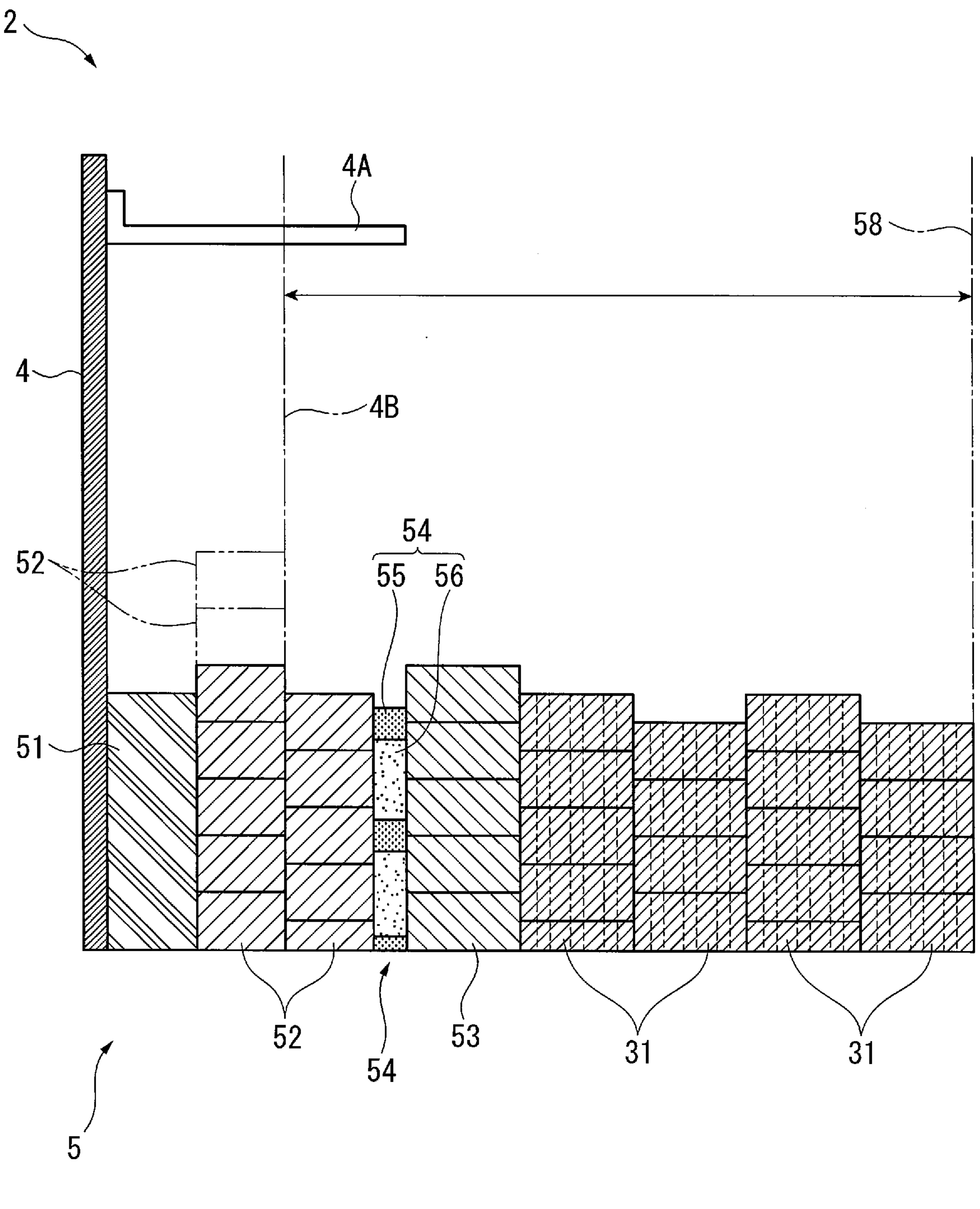

COMPRESSIVE ELASTICITY MODULUS (kg/cm²)
80
50
10
0
5 10
50
100
16
8
8
4
P1
P2
INSERTION RATIO OF SPACER (%)

FIG.32



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2014/065563

A. CLASSIFICATION OF SUBJECT MATTER
C21B9/06(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)
C21B9/06, F27D1/16

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2014
Kokai Jitsuyo Shinan Koho	1971-2014	Toroku Jitsuyo Shinan Koho	1994-2014

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 51-96707 A (Nippon Steel Corp.), 25 August 1976 (25.08.1976), page 2, upper right column, line 5 to page 3, upper left column, line 1; fig. 4 to 5 (Family: none)	1-8
A	JP 56-139608 A (NKK Corp.), 31 October 1981 (31.10.1981), page 1, lower left column, line 16 to lower right column, line 3; fig. 2 (Family: none)	1-8
A	JP 54-115602 A (Nippon Steel Corp.), 08 September 1979 (08.09.1979), page 2, upper left column, lines 2 to 14; fig. 1 (Family: none)	1-8

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

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 July, 2014 (14.07.14)	29 July, 2014 (29.07.14)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 8269514 A **[0027]**
- JP 56024007 B **[0027]**
- JP 2009115444 A **[0027]**