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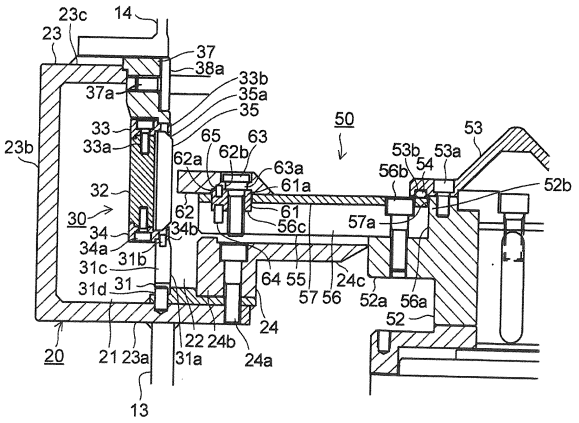
(54) AIR FLOW DRYING DEVICE

(57) An air flow drying device (1) equipped with a vertical cylindrical housing (10), a raw material supply portion (12) that supplies a raw material containing moisture into the housing (10), a disk-shaped rotator (55) that is disposed below the raw material supply portion (12) and rotates on a vertical rotating axis, a pulverization member (62) that is disposed on an outer periphery of the rotator (55) and pulverizes the raw material into a granule, a hot wind supply portion (20) that supplies a hot wind below the rotator (55) in the housing (10), and a discharge portion (11) that discharges the granule from an upper portion of the housing (10), with the granule pulverized by the pulverization member (62) being dried by the hot wind and discharged. In addition, the housing (10) has an annular liner (30) that opposes the pulverization member (62), and hot wind supply portion (20) has an outer circumferential portion (21) where the hot wind flows contacting the outer circumferential surface of the liner (30), and an inner circumferential portion (22) that guides the hot wind to the gap between the pulverization member (62) and the liner (30) through below the liner (30).

FIG.4



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Description

Technical Field

[0001] The present invention relates to an air flow drying device that pulverizes a lump of raw material containing moisture and dries the pulverized material by means of a hot wind.

Background Art

[0002] A conventional air flow drying device is disclosed in a patent document 1. This air flow drying device includes a vertical cylindrical housing formed of a steel plate and the like, and is provided, on a circumferential surface of the housing, with a raw material supply portion that supplies a raw material containing moisture. A pulverization portion for pulverizing a lump of raw material into a granule is disposed below the raw material supply portion in the housing. The pulverization portion is composed by disposing a plurality of pulverization members on a circumferential portion of a disc-shaped rotator that rotates on a vertical rotating shaft. The rotator is supported by a bearing portion disposed on a bottom portion of the housing.

[0003] The raw material finely pulverized by the rotation of the pulverization member collides with an inner wall of the housing under centrifugal force; accordingly, the inner wall of the housing is worn. Because of this, the housing has an annular liner that opposes the pulverization member and is formed of stainless steel and the like.

[0004] Below the pulverization portion, a hot wind inlet is disposed which is opened through the circumferential surface of the housing and introduces a hot wind into the housing. A discharge portion is opened through an upper portion of the housing and discharges the granule along with an air flow by means of a fan connected to the discharge portion. The discharge portion is provided with a classification portion that classifies the granule. In the classification portion, a classification rotor rotates which is composed of a plurality of classification blades which are each formed of an upright thin plate and disposed radially.

[0005] In the air flow drying device having the above structure, the raw material containing moisture is dropped and supplied from the raw material supply portion onto the rotator of the pulverization portion. The lump of raw material is finely broken and pulverized into the granule by collision with the pulverization member. A hot wind flows into the housing from the hot wind inlet, and the granule is blown up by the hot wind that ascends in the housing through the gap between the pulverization member and the liner. In this way, the granule is further dispersed and dried while ascending in the housing.

[0006] Besides, the classification rotor of the classification portion rotates to generate a whirling air flow in the housing upper portion, and centrifugal force due to the whirling air flow and sucking force due to the fan act on the granule that approaches the classification rotor. An insufficiently pulverized raw material and an insufficiently dispersed granule are subjected to the centrifugal force larger than the sucking force; accordingly, the raw material and the granule are blown away from the classification rotor and drop to be pulverized and dried again.

[0007] A granule that is dried, sufficiently pulverized and dispersed is subjected to the sucking force larger than the centrifugal force, so that the granule flows into the classification rotor from a gap between the classification blades and is discharged from the discharge portion. In this way, the dried granule of an even size is obtained.

Citation List

Patent Literature

[0008] PLT1: JP-A-2001-41652 (pages 5-7, Fig. 1)

Summary of Invention

Technical Problem

[0009] However, according to the conventional air flow drying device, an outer circumferential surface of the liner is exposed to outside air, and the liner is deprived of evaporation heat because of evaporation of the moisture of the raw material that collides with an inner circumferential surface. In this way, even if a hot wind of 300°C is supplied from the inlet, the temperature of the liner is dropped from about 80°C to 120°C. Because of this, the raw material (granule) contains much moisture near the liner, and the raw material adheres to the liner to grow. In this way, there is a problem that an air flow path between the pulverization member and the liner is clogged and drying efficiency of the air flow drying device declines because of increase in pressure loss.

[0010] It is an object of the present invention to provide an air flow drying device that is able to solve the above problem and improve the drying efficiency.

Solution to Problem

[0011] To achieve the above object, the present invention comprises: a vertical cylindrical housing; a raw material supply portion that supplies a raw material containing moisture into the housing; a disc-shaped rotator that is disposed below the raw material supply portion and rotates on a vertical rotating shaft; a pulverization member that is disposed on an outer periphery of the rotator and pulverizes the raw material into the granule; a hot wind supply portion that supplies a hot wind below the rotator in the housing; and a discharge portion that discharges the granule from an upper portion of the housing; the granule pulverized by the pulverization member being dried by the hot wind and discharged; wherein the housing has an annular liner that opposes the pulverization

member, and the hot wind supply portion has: an outer circumferential portion where the hot wind flows contacting an outer circumferential surface of the liner; and an inner circumferential portion that guides the hot wind to the gap between the pulverization member and the liner below the liner.

[0012] According to this structure, the hot wind, which flows in the outer circumferential portion of the hot wind supply portion contacting the outer circumferential surface of the liner, ascends between the pulverization member and the liner via the inner circumferential portion. The raw material dropping from the raw material supply portion is pulverized by the rotating pulverization member, blown up and dried in the housing by the hot wind, and discharged from the discharge portion.

[0013] Besides, the air flow drying device having the above structure according to the present invention includes: a bearing portion that is disposed on a bottom portion of the housing and supports the rotator; and an outside air inlet that introduces the outside air into the housing from below the hot wind supply portion. According to this structure, the bearing portion disposed on the housing bottom portion is cooled by the outside air flowing from the outside air inlet that is disposed below the hot wind supply portion.

[0014] Besides, in the air flow drying device having the above structure according to the present invention, the inner circumferential portion has a horizontal portion that extends horizontally from an upper end of a circumferential wall opposing an inner surface of the housing and approaches a lower surface of the rotator. According to this structure, the bearing portion is isolated from the hot wind by the circumferential wall and horizontal portion of the inner circumferential portion. Besides, the outside air flowing into the housing from the outside air inlet passes through the gap between the horizontal portion and the rotator to join the hot wind.

[0015] Besides, in the air flow drying device having the above structure according to the present invention, the outer circumferential portion is formed annularly to cover a whole circumference of the liner.

[0016] Besides, in the air flow drying device having the above structure according to the present invention, the liner has: a cylindrical body formed of a good thermal conductor; and a plurality of plate-shaped liner chips that are arranged in a circumferential direction on an inner circumferential surface of the cylindrical body.

[0017] According to this structure, an outer circumferential surface of the cylindrical body formed of a good thermal conductor such as metal or the like opposes the outer circumferential portion of the hot wind supply portion, and the liner chip is disposed to oppose the pulverization member. The cylindrical body formed of a good thermal conductor is raised in temperature by the hot wind flowing in the outer circumferential portion and the heat is conducted to the liner chip located on the inner surface.

[0018] Besides, in the air flow drying device having the above structure according to the present invention, the liner chip is formed of super-hard ally or ceramic or metal whose surface is treated to be wear-resistant.

[0019] Besides, in the air flow drying device having the above structure according to the present invention, a retaining member formed of metal is disposed which is formed on upper and lower surfaces of the cylindrical body and retains an inner surface of the liner chip; the liner chip is formed of super-hard alloy or ceramic; and a radial direction gap and an axial direction gap are disposed between the retaining member and the liner chip. According to this structure, thermal expansion difference caused by the hot wind between the liner chip formed of super-hard alloy or ceramic and the cylindrical body is absorbed by the gaps disposed between the retaining portion and the liner chip.

[0020] Besides, in the air flow drying device having the above structure according to the present invention, a classification rotor is disposed in an upper portion of the housing; the classification rotor classifying the granule, which ascends in the housing by using the hot wind, by means of rotation of a classification blade disposed radially; and an upper portion of an inner wall of the housing opposing the classification rotor is tapered to become narrow toward a top.

[0021] According to this structure, the classification rotor rotates to generate a whirling air flow, and a large-mass granule is blown away from the classification rotor by centrifugal force. A small-mass granule flows into the classification rotor from a gap of the classification blade and is discharged from the discharge portion. The hot wind is guided to the classification rotor along the inner wall of the tapered upper portion of the housing, dries and disperses the granule to prevent adhesion of the granule to the housing inner wall.

[0022] Besides, in the air flow drying device having the above structure according to the present invention, the rotator has a disc-shaped metal plate and is provided with a protrusion portion that protrudes from an upper surface of the rotator; the pulverization member is formed of super-hard alloy or ceramic and screwed to the rotator by means of a bolt with an axial direction gap left; a small diameter portion having a diameter smaller than the protrusion portion is formed on the protrusion portion by means of the rotator or the bolt; the pulverization member is provided with a through-hole that has a first fitting portion in which the protrusion portion is fitted and a second fitting portion in which the small diameter portion is fitted; and a gap between the first fitting portion and the protrusion portion is smaller than a gap between the second fitting portion and the small diameter portion.

[0023] According to this structure, the pulverization member formed of super-hard alloy or ceramic is screwed to the metal plate of the rotator by means of the bolt with the axial direction gap and the radial direction gap left. Thermal expansion difference between the pulverization member and the rotator or between the pulverization member and the bolt is absorbed by the gaps.

Besides, even if the pulverization member is moved by the rotation of the rotator, the large diameter protrusion portion and the first fitting portion collide with each other to prevent breakage of the small diameter portion.

[0024] Besides, in the air flow drying device having the above structure according to the present invention, the rotator has: a metal base that has a shaft portion protruding from an upper surface of the rotator, and an upper surface plate that has a shaft hole in which the shaft portion is fitted, is disposed on an upper surface of the base, and formed of super-hard alloy or ceramic; a holding member is disposed which has an O-ring and is mounted on the shaft portion; and an upper surface of the upper surface plate is pushed by the O-ring such that the upper surface plate is held on the base.

[0025] According to this structure, even if thermal expansion difference occurs because of the hot wind between the metal base and the upper surface plate formed of super-hard ally or ceramic, the upper surface plate is held on the base by the O-ring that pushes the upper surface plate.

Advantageous Effects of Invention

[0026] According to the present invention, the hot wind supply portion has: the outer circumferential portion where the hot wind flows contacting the outer circumferential surface of the liner; and the inner circumferential portion that guides the hot wind to the gap between the pulverization member and the liner; therefore, it is possible to keep the liner at a high temperature. Accordingly, it is possible to reduce adhesion of the raw material to the inner wall of the liner and improve the drying efficiency of the air flow drying device.

[0027] Besides, according to the present invention, the bearing portion is disposed on the bottom portion of the housing, and the outside air inlet is disposed which introduces outside air into the housing from below the hot wind supply portion; accordingly, the bearing portion is cooled by the outside air flowing from the outside air inlet. Because of this, it is possible to rotate the rotator at a high rotation speed and pulverize the raw material quickly. Accordingly, it is possible to more improve the drying efficiency of the air flow drying device.

[0028] Besides, according to the present invention, the inner circumferential portion of the hot wind supply portion has the horizontal portion that extends horizontally from the upper end of the circumferential wall opposing the inner surface of the housing and approaches the lower surface of the rotator. In this way, it is possible to prevent an outflow of the hot wind from the inner circumferential portion and curb a decrease in the hot wind supplied to the gap between the pulverization member and the liner. Accordingly, it is possible to improve more the drying efficiency of the air flow drying device.

[0029] Besides, according to the present invention, the outer circumferential portion of the hot wind supply portion is formed annularly to cover the whole circumference of the liner; accordingly, it is possible to keep an entirety of the annular liner at a high temperature and reduce more the adhesion of the raw material.

[0030] Besides, according to the present invention, as to the liner, the plurality of plate-shaped liner chips are arranged in the circumferential direction on the inner circumferential surface of the cylindrical body formed of a good thermal conductor; accordingly, even if the liner chip is worn, it is possible to easily replace the liner chip and improve a maintenance characteristic of the air flow drying device. Besides, it is possible to easily form the liner whose inner surface has high wear resistance and which has a large diameter.

[0031] Besides, according to the present invention, the retaining members disposed on the upper and lower surfaces of the cylindrical body retain the liner chip with the radial direction gap and the axial direction gap left. In this way, it is possible to reduce the wear of the liner caused by collision of the raw material by means of the liner chip formed of super-hard alloy or ceramic. Besides, the thermal expansion difference caused by the hot wind between the liner chip and the cylindrical body or between the liner chip and the retaining member is absorbed by the gaps and it is possible to prevent breakage of the liner chip caused by the thermal expansion.

[0032] Besides, according to the present invention, the upper portion of the inner wall of the housing opposing the classification rotor disposed in the upper portion of the housing is tapered to become narrow toward the top; accordingly, it is possible to reduce the adhesion of the raw material in the housing. Therefore, it is possible to improve the maintenance characteristic of the air flow drying device and improve the recovery efficiency of the granule.

[0033] Besides, according to the present invention, the rotator has the disc-shaped metal plate and the protrusion portion protrudes from the upper surface of the rotator, and a hammer formed of super-hard alloy or ceramic is screwed to the rotator by means of a bolt with an axial direction gap left. The hammer is provided with the first and second fitting portions in which the protrusion portion and the small diameter portion formed by the rotator or by the bolt are fitted respectively, and the gap between the first fitting portion and the protrusion portion is formed to be smaller than the gap between the second fitting portion and the small diameter portion. Because of this, the protrusion portion butts an inner surface of the first fitting portion to limit a movement range of the hammer, and collision between an inner surface of the second fitting portion and the small diameter portion is avoided. In this way, it is possible to prevent breakage of the bolt caused by repeated collision and form the rotator to have a light weight.

[0034] Besides, according to the present invention, the rotator has the metal base from which the axial portion protrudes, and the upper surface plate which is formed of super-hard alloy or ceramic and in which the shaft portion is fitted; and the O-ring mounted on the shaft portion

pushes the upper surface of the upper surface plate such that the upper surface plate is held on the base.

Brief Description of Drawings

[0035]

[Fig. 1] is a front view showing an air flow drying device according to an embodiment of the present invention.

[Fig. 2] is a top view showing an air flow drying device according to the embodiment of the present invention.

[Fig. 3] is a front sectional view showing a main body portion of an air flow drying device according to the embodiment of the present invention.

[Fig. 4] is a front sectional view showing a pulverization portion and hot wind supply portion of an air flow drying device according to the embodiment of the present invention.

[Fig. 5] is a plan view showing a pulverization portion of a main body portion of an air flow drying device according to the embodiment of the present invention.

[Fig. 6] is a front sectional view showing a classification portion of an air flow drying device according to the embodiment of the present invention.

Description of Embodiments

[0036] Hereinafter, an embodiment of the present invention is described with reference to the drawings. Fig. 1 and Fig. 2 show respectively a front view and a top view of an air flow drying device according to an embodiment of the present invention. As to the air flow drying device 1, a main body portion 2 and a drive motor 3 are disposed on a table 4. The table 4 is provided therein a belt (not shown) that connects the drive motor 3 and a shaft portion 52 (see Fig. 3) of a pulverization portion 50 later described.

[0037] The main body portion 2 includes a vertical cylindrical housing 10, a classification portion 40 and an exhaust duct 11 (discharge portion) are disposed on an upper portion of the housing 10. The exhaust duct 11 is connected to a fan (not shown) via a collector (not shown). As described later, a granule obtained by pulverizing and drying a raw material is discharged by driving the fan via the exhaust duct 11 and recovered by the collector.

[0038] A substantially central portion of the housing 10 is provided with a raw material supply portion 12. The raw material supply portion 12 is provided with a screw feeder (not shown), and the screw feeder rotates to drop and supply a lump of raw material containing moisture into the housing 10. A hot wind supply portion 20 is disposed below the raw material supply portion 12. The hot wind supply portion 20 is connected, via a hot wind inlet 20a, to a hot wind generation device (not shown) which generates and sends out a hot wind, and supplies a hot wind into the housing 10.

[0039] Fig. 3 shows a front sectional view of the main body portion 2. The housing 10 is formed by connecting, from bottom, a first casing 13, a liner 30, a second casing 14, a third casing 15, and a fourth casing 16. The first casing 13 disposed on a bottom portion of the housing 10 is fixed, by means of a bolt 13 a, to a bottom plate 17 that is fixed on the table 4 (see Fig. 1) by means of a bolt 17a. An outside air inlet 13b, from which outside air flows in, is opened through a circumferential surface of the first casing 13.

[0040] An angle 23, which has a C shape in section and forms the hot wind supply portion 20, is integrally formed with an upper surface of the first casing 13 by means of welding. The liner 30 is disposed above a bottom surface portion 23a of the angle 23. The second casing 14 is fixed to an upper surface of angle 23 by means of a bolt 14a. A circumferential surface of the second casing 14 is provided with the hot wind supply portion 12, and a window portion 14b through which an inside of the housing 10 is observed.

[0041] The third casing 15 is fixed on the second casing 14 by means of a bolt 15a, and an upper portion of an inner wall of the third casing 15 is tapered to become narrow toward the top. The fourth casing 16 is fixed on the third casing 15 by means of a bolt 16a. A circumferential surface of the fourth casing 16 is provided with the exhaust duct 11 to form an L-shaped exhaust path 16b. Besides, as described later, a classification rotor 43 is attached to the fourth casing 16.

[0042] A pulverization portion 50 for pulverizing the raw material is disposed in a lower portion below the raw material supply portion 12 in the housing 10. The pulverization portion 50 includes a rotator 55 and a hammer 62 (pulverization member). The rotator 55 is formed to have a disk shape, and a shaft portion 52 forming a rotating shaft is supported by a bearing portion 51 fixed to the bottom plate 17. In this way, the bearing portion 51 is disposed to oppose the outside air inlet 13b. The shaft portion 52 is connected to the drive motor 3 (see Fig. 1) via the belt (not shown). A plurality of hammers 62 are disposed on an outer periphery of the rotator 55 and disposed to oppose the liner 30.

[0043] Fig. 4 is a front sectional view showing details of the hot wind supply portion 20 and pulverization portion 50. Fig. 5 is a plan view showing main portions of the liner 30 and pulverization portion 50. The hot wind supply portion 20 has an outer circumferential portion 21 formed outside the housing 10 and an inner circumferential portion 22 formed inside the housing 10. The angle 23 of the hot wind supply portion 20 is formed to have an annular shape that has a C shape in front section and includes a bottom surface portion 23a, a side surface portion 23b and an upper surface portion 23c.

[0044] The bottom surface portion 23a disposed horizontally is welded to an upper end of the first casing 13, and disposed to extend inward and outward beyond the

first casing 13. The side surface portion 23b is formed to have a cylindrical shape that extends vertically from an outer circumferential end of the bottom surface portion 23a, and the upper surface portion 23c is formed to have an annular shape that extends horizontally inward from an upper end of the side surface portion 23b. The side surface portion 23b is provided with the hot wind inlet 20a (see Fig. 3) through which the hot wind flows in.

[0045] The bottom surface portion 23a of the angle 23 is provided thereon a stand 31 on which a plurality of leg portions 31 a are disposed uprightly in a circumferential direction, and the liner 30 is disposed on the leg portion 31a. The stand 31 is positioned by a pin 31d that is inserted into the bottom surface portion 23a, and an opening portion 31c is formed between the leg portions 31 a.

[0046] The liner 30 includes a cylindrical body 32, an upper surface retaining member 33, a lower surface retaining member 34, and a liner chip 35. The cylindrical body 32 is formed of a good thermal conductor such as metal (stainless steel and the like) or the like to have a cylindrical shape. The upper retaining member 33 and the lower retaining member 34 are each formed of a good thermal conductor such as metal (stainless steel and the like) or the like to have an annular shape, and fixed to an upper surface and a lower surface of the cylindrical body 32 by means of bolts 33a and 34a, respectively. Inner circumferential ends of the upper surface retaining member 33 and lower surface retaining member 34 are provided respectively with retaining claws 33b, 34b that are bent in a direction to approach each other. Besides, the lower surface retaining member 34 is placed on the leg portion 31a and positioned by a pin 31b.

[0047] The liner chip 35 is formed of super-hard alloy or ceramic (alumina, zirconia or the like), which has high hardness and is excellent in wear resistance, to have a plate shape. The liner chip 35 may be formed of another wear-resistant material, or may be formed by applying a wear resistance treatment to a surface of a metal member such as stainless steel or the like.

[0048] A plurality of liner chips 35 are disposed and arranged to touch one another in a circumferential direction along an inner circumferential surface of the cylindrical body 32. In this way, the inner circumferential surface of the liner 30 opposing the hammer 62 is formed to have a polygonal shape. Upper and lower ends of an inner circumferential surface of the liner chip 35 are each formed to have an inclined surface 35a. The retaining claws 33b, 34b of the upper surface retaining member 33 and lower surface retaining member 34 oppose the inclined surface 35a to retain the liner chip 35, so that the cylindrical body 32 and the liner chip 35 are unified with each other.

[0049] In this way, the liner chip 35 with the high wear resistance is disposed to oppose the hammer 62; accordingly, it is possible to reduce wear of the liner 30 caused by collision of the raw material. Besides, even if the liner chip 35 is worn, it is possible to easily replace the liner chip 35, and improve a maintenance characteristic of the air flow drying device 1. Further, it is difficult to form the liner 30 having a diameter of 1 m or more into the cylindrical shape by using super-hard alloy, ceramic or the like, but according to the above structure, it is possible to easily form the liner 30 whose diameter exceeds 1 m.

[0050] Gaps of a predetermined size are disposed in an axial direction and a radial direction between the liner chip 35 and the upper surface retaining member 33 and between the liner chip 35 and the lower surface retaining member 34. In this way, thermal expansion difference, which is caused by the hot wind flowing through the hot wind supply portion 20 between the liner chip 35 and each of the cylindrical body 32, upper surface retaining member 33, and lower surface retaining member 34 that are formed of metal or the like, is absorbed by the gaps. Accordingly, it is possible to prevent breakage of the liner chip 35 caused by the thermal expansion.

[0051] An annular liner pusher 37 is disposed on the upper surface retaining member 33 of the liner 30. A gap between the upper surface portion 23c of the angle 23 and the liner 30 is closed by the liner pusher 37. In this way, the outer circumferential portion 21 of the hot wind supply portion 20 is enclosed by the angle 23, the liner 30, and the liner pusher 37 to cover the whole circumference of the liner 30, so that the hot wind flows contacting an outer circumferential surface of the liner 30.

[0052] Besides, when necessary, an inner cylinder 38 (see Fig. 3) is disposed over the pulverization portion 50 in the housing 10. A ring 38a integrally formed with the inner cylinder 38 is pushed by a bolt 37a screwed into a circumferential surface of the liner pusher 37 to support the inner cylinder 38. An air flow path is formed on an outer periphery of an inside of the housing 10 by the inner cylinder 38.

[0053] A guard 24 is mounted on the bottom surface portion 23a of the angle 23 by means of a bolt 24a in the housing 10. The guard 24 has: an annular portion 24b that is disposed uprightly on the bottom surface portion 23a; and a horizontal portion 24c that extends from an upper end of the annular portion 24b in a horizontal direction. The annular portion 24b opposes an inner wall of the housing 10 to form a circumferential wall of the inner circumferential portion 22. In this way, the inner circumferential portion 22 communicates with the outer circumferential portion 21 via the opening portion 31 c below the liner 30 and guides the hot wind to the gap between the hammer 62 and the liner 30. Besides, the horizontal portion 24c is close to a lower surface of the rotator 55, and an inner circumferential end of the horizontal portion 24c is close to the shaft portion 52 of the rotator 55.

[0054] The rotator 55 of the pulverization portion 50 is formed in a disc shape, and an upper surface plate 57 is disposed on an upper surface of a base 56. The upper surface plate 57 is formed of super-hard alloy or ceramic (alumina, zirconia or the like) which has high hardness and is excellent in wear resistance. The upper surface plate 57 may be formed of another wear-resistant mate-

rial, or may be formed by applying a wear resistance treatment to a surface of a metal member such as stainless steel or the like.

[0055] By forming the upper surface plate 57 of ceramic or the like, it is possible to reduce wear of an upper surface of the rotator 55 that collides with the raw material. The shaft portion 52 forming the rotating shaft of the rotator 55 is formed of metal (stainless steel or the like), and has a flange portion 52a that protrudes from a circumferential surface and a boss 52b that protrudes upward from the flange portion 52a.

[0056] The base 56 and the upper surface plate 57 are provided respectively with shaft holes 56a, 57a in which the boss 52b is fitted. The boss 52b is inserted into the shaft hole 56a, and the base 56 is fixed to the flange portion 52a by means of a bolt 56b. In this way, the base 56 and the shaft portion 52 are unified with each other, and a portion of the boss 52b protrudes from the upper surface of the base 56.

[0057] A holding member 53 is mounted on an upper surface of the boss 52b by means of a bolt 53a. The holding member 53 protrudes beyond the boss 52b toward an outer circumference, and an O-ring 54 is disposed into an annular groove portion 53b that is formed to oppose the upper surface plate 57. The O-ring 54 pushes an upper surface of the upper surface plate 57, and the upper surface plate 57 is held on the base 56 in a relatively stretchable and shrinkable state. In this way, thermal expansion differences, caused by the hot wind, between the upper surface plate 57 formed of super-hard alloy or ceramic and each of the metal base 56 and the metal shaft portion 52, are absorbed. Accordingly, it is possible to prevent breakage of the upper surface plate 57 caused by the thermal expansion.

[0058] A plurality of hammers 62 are mounted on an outer periphery of the rotator 55 in a circumferential direction at predetermined intervals. The hammer 62 collides with the raw material at a high speed; accordingly, the hammer 62 is formed of super-hard alloy or ceramic (alumina, zirconia or the like) which has high hardness and is excellent in wear resistance. The hammer 62 may be formed of another wear-resistant material, or may be formed by applying a wear resistance treatment to a surface of a metal member such as stainless steel or the like.

[0059] A plurality of recess portions 56c, which have a circular shape when seen from top, are formed on an outer periphery of the base 56, and a cylindrical metal (stainless steel or the like) boss member 61 penetrating the upper surface plate 57 is set in the recess portion 56c. The boss member 61 is prevented from rotating by a pin 64, and screwed to the base 56 by means of a bolt 63 that penetrates the hammer 62 and the boss member 61. In this way, the metal base 56 and the metal boss member 61 are unified with each other, and a protrusion portion 61 a, which protrudes from the upper surface of the rotator 55, is formed by the boss member 61.

[0060] The bolt 63 is formed in multi-steps, and a small diameter portion 63a smaller than the boss member 61 is disposed on an upper surface of the boss member 61. A through-hole of the hammer 62, in which the bolt 63 is inserted, has a first fitting portion 62a in which the protrusion portion 61 a is fitted and a second fitting portion 62b in which the small diameter portion 63 a is fitted, and spot facing is applied above the second fitting portion 62b.

[0061] The hammer 62 is prevented from rotating with respect to the boss member 61 by a pin 65, and when the boss member 61 is fixed by the bolt 63, an axial direction gap is formed between the hammer 62 and the bolt 63. In this way, the hammer 62 is able to move somewhat, and thermal expansion difference, caused by the hot wind, between the metal boss member 61 and the hammer 62 formed of super-hard alloy or ceramic is absorbed. Accordingly, it is possible to prevent breakage of the hammer 62 caused by the hot wind.

[0062] Besides, a gap between the first fitting portion 62a and the protrusion portion 61 a is formed to be smaller than a gap between the second fitting portion 62b and the small diameter portion 63a. Because of this, the hammer 62 moved by the rotation of the rotator 55 is limited in a movement range by the boss member 61 butting an inner surface of the first fitting portion 62a. In this way, collision between an inner surface of the second fitting portion 62b and the small diameter portion 63 is avoided, and it is possible to prevent breakage of the bolt 63 caused by repeated collisions.

[0063] Besides, in the case where the hammer 62 is formed of ceramic, the metal portion above the boss member 61 is formed to be thinner; accordingly, it is possible to form the rotator 55 to be lighter than using a large diameter bolt like the boss member 61. In the meantime, the small diameter portion 63a may be formed in the boss member 61 unified with the base 56.

[0064] Fig. 6 shows a front sectional view of the classification portion 40. The classification portion 40 includes a classification motor 41 (see Fig. 2) disposed on the fourth casing 16, and a shaft 42 driven by the classification motor 41 by using a belt protrudes into the housing 10 to be disposed uprightly. A classification rotor 43 is disposed below the shaft 42. As to the classification rotor 43, a plurality of thin-plate classification blades 46 are disposed radially on a disc 44 that is screwed to an lower end of the shaft 42. Upper portions of the classification blades 46 are connected to one another by an annular member 45.

[0065] In the air flow drying device 1 having the above structure, by driving the hot wind generation device, the hot wind flows in the outer circumferential portion 21 of the hot wind supply portion 20. In this way, the cylindrical body 32 forming the outer circumferential surface of the liner 30 is raised in temperature. The cylindrical body 32 is formed the good thermal conductor; accordingly, the liner chip 35 forming the inner circumferential surface of the liner 30 is raised in temperature by heat conduction and is kept at a high temperature (e.g., 600°C). The hot wind flowing in the outer circumferential portion 21 flows

in the inner circumferential portion 22 via the opening portion 31 c and is guided to the gap between the hammer 62 and the liner 30.

[0066] Besides, by driving the fan connected to the exhaust duct 11, an ascending air flow is formed in the housing 10. In this way, the hot wind flowing in from the hot wind supply portion 20 ascends in the housing 10 and outside air flows into the housing 10 via the outside air inlet 13b. The outside air flowing in from the outside air inlet 13b flows in a gap between the horizontal portion 24c of the guard 24 and the shaft portion 52 and a gap between the horizontal portion 24c and the lower surface of the rotator 55, joins the hot wind in the inner circumferential portion 22, and ascends.

[0067] During this time, the bearing portion 51 opposing the outside air inlet 13b is cooled by the outside air flowing in from the outside air inlet 13b. Because of this, it is possible to rotate the rotator 55 rotated by the driving of the drive motor 3 at a rotation speed (e.g., circumferential speed of 100 m/s to 150 m/s) higher than conventional and to quickly pulverize the raw material. Besides, it is possible to supply the hot wind of a temperature higher than conventional from the hot wind supply portion 20 into the housing 10.

[0068] The lump of raw material containing moisture drops from the raw material supply portion 12 onto the rotator 55. The raw material is guided to an outer circumference of the rotator 55 by centrifugal force due to the rotation of the rotator 55. And, the raw material collides with the hammer 62 to be finely broken and pulverized into a granule. During this time, the liner 30 is kept at a high temperature; accordingly, the raw material, which contains moisture and collides with the liner 30, is dried, and it is possible to reduce adhesion of the raw material to the liner 30.

[0069] The granule pulverized by the hammer 62 is dried by the hot wind, further dispersed, blown upward, and ascends together with the hot wind in the housing 10. The granule ascending in the housing 10 is guided to the center, where the classification rotor 43 is disposed, along the inner wall of the tapered third casing 15 in the upper portion of the housing 10. If the third casing 15 opposing the classification rotor 43 is formed to have a cylindrical shape, the granule is prone to adhere to and accumulate on the inner circumferential surface of the upper portion of the housing 10. By tapering the third casing 15 to make the upper portion become narrow toward the top, the air flow flows along the inclined surface, and it is possible to prevent adhesion of the raw material to the upper portion of the housing 10.

[0070] The classification rotor 43 generates a whirling air flow in the upper portion of the housing 10 by means of the classification blades 46 rotated by the classification motor 41. Centrifugal force due to the whirling air flow and force directed to the center by the fan connected to the exhaust duct 11 act on the granule that ascends in the housing 10 and approaches the classification rotor 43. The centrifugal force acts more greatly on a granule which is insufficiently dried and aggregates to have a large mass, so that the granule is blown away from the classification rotor 43, thereafter, circulated to the pulverization potion 50 located below. On the other hand, the force directed to the center acts more greatly on a granule which is sufficiently dispersed and dried and has a small mass, so that the granule flows from the gap between the classification blades 46 into the classification rotor 43 and is discharged from the exhaust duct 11. In this way, the granule, which has an even size and is dried, is recovered.

[0071] According to the present embodiment, the hot wind supply portion 20 has: the outer circumferential portion 21 where the hot wind flows contacting the outer circumferential surface of the liner 30; and the inner circumferential portion 22 that guides the hot wind to the gap between the hammer 62 (pulverization member) and the liner 30; therefore, it is possible to keep the liner 30 at a high temperature. Accordingly, it is possible to reduce adhesion of the raw material to the inner wall of the liner 30 and improve the drying efficiency of the air flow drying device 1.

[0072] Besides, the bearing portion 51 is disposed on the bottom portion of the housing 10, and the outside air inlet 13b is disposed which introduces outside air into the housing 10 from below the hot wind supply portion 20; accordingly, the bearing portion 51 is cooled by the outside air flowing in from the outside air inlet 13b. Because of this, it is possible to rotate the rotator 55 at a high rotation speed and pulverize the raw material quickly. Accordingly, it is possible to more improve the drying efficiency of the air flow drying device 1.

[0073] Besides, as to the inner circumferential portion 22 of the hot wind supply portion 20, the circumferential wall opposing the inner surface of the housing 10 is formed by the annular portion 24b of the guard 24, and the horizontal portion 24c extending horizontally from the upper end of the annular portion 24b approaches the lower surface of the rotator 55. In this way, it is possible to prevent an outflow of the hot wind from the inner circumferential portion 22 and curb a decrease in the hot wind supplied to the gap between the hammer 62 and the liner 30. Accordingly, it is possible to improve more the drying efficiency of the air flow drying device 1.

[0074] Besides, the angle 23 of the hot wind supply portion 20 is disposed on the first casing 13 from which the outside air inlet 13b is opened; accordingly, the bottom surface portion 23a of the angle 23 and the liner 30 are disposed to be near each other. And, the inner circumferential portion 22 forms a flown path for the hot wind along the inner wall of the housing 10 by means of the annular portion 24b. Because of this, it is possible to obtain a high flow speed of the hot wind that flows from the opening portion 31c into the inner circumferential portion 22 and flows in the inner circumferential portion 22. In this way, the granule dropping onto the bottom surface portion 23a is easily guided upward by the hot wind that ascends in the inner circumferential portion 22, and it is

possible to more improve a recovery rate of the granule.

[0075] Besides, the outer circumferential portion 21 of the hot wind supply portion 20 is formed annularly to cover the whole circumference of the liner 30; accordingly, it is possible to keep the entirety of the annular liner 30 at a high temperature and reduce more the adhesion of the raw material.

[0076] Besides, as to the liner 30, the plurality of plate-shaped liner chips 35 are arranged in the circumferential direction on the inner circumferential surface of the cylindrical body 32 formed of a good thermal conductor; accordingly, even if the liner chip 35 is worn, it is possible to easily replace the liner chip 35 and improve the maintenance characteristic of the air flow drying device 1. Besides, it is possible to easily form the liner 30 whose inner surface has high wear resistance and which has a large diameter.

[0077] Besides, the liner chip 35 is formed of super-hard alloy or ceramic; accordingly, it is possible to easily achieve the liner 30 whose inner surface has high wear resistance. Likewise, also in the case where the liner chip 35 is formed of metal to which a wear resistance treatment is applied, it is possible to easily achieve the liner 30 whose inner surface has high wear resistance.

[0078] Besides, the upper surface retaining member 33 and lower surface retaining member 34 disposed on the upper and lower surfaces of the cylindrical body 32 retain the liner chip 35 with the radial direction gap and the axial direction gap left. In this way, it is possible to reduce the wear of the liner 30 caused by the collision of the raw material by means of the liner chip 35 formed of super-hard alloy or ceramic. Besides, the thermal expansion difference caused by the hot wind between the liner chip 35 and each of the cylindrical body 32, upper surface retaining member 33, and lower surface retaining member 34 is absorbed by the gaps. Accordingly, it is possible to prevent the breakage of the liner chip 35 caused by the thermal expansion.

[0079] Besides, the upper portion of the inner wall of the third casing 15 opposing the classification rotor 43 disposed in the upper portion of the housing 10 is tapered to become narrow toward the top; accordingly, it is possible to reduce the adhesion of the raw material in the housing 10. Therefore, it is possible to improve the maintenance characteristic of the air flow drying device 1 and improve more the recovery efficiency of the granule.

[0080] Besides, the rotator 55 has the disc-shaped base 56 (metal plate) and the protrusion portion 61a protrudes, and the hammer 62 formed of super-hard alloy or ceramic is screwed by means of the bolt 63 with the axial direction gap left. The hammer 62 is provided with the first and second fitting portions 62a, 62b in which the protrusion portion 61a and the small diameter portion 63 a are fitted respectively, and the gap between the first fitting portion 62a and the protrusion portion 61 a is formed to be smaller than the gap between the second fitting portion 62b and the small diameter portion 63a.

[0081] Because of this, the boss member 61 butts the inner surface of the first fitting portion 62a to limit the movement range of the hammer 62, and the collision between the inner surface of the second fitting portion 62b and the small diameter portion 63a is avoided. In this way, it is possible to prevent breakage of the bolt 63 caused by repeated collision. Besides, in the case where the hammer 62 is formed of ceramic, it is possible to form the rotator 55 to have a light weight compared with the case where a large bolt is used.

[0082] Besides, the rotator 5 has the metal base 56 that protrudes beyond the boss 52b of the shaft portion 52, and the upper surface plate 57 which is formed of super-hard alloy or ceramic and in which the shaft portion 52 is fitted; and the O-ring 54 disposed in the holding member 53 mounted on the shaft portion 52 pushes the upper surface of the upper surface plate 57 such that the upper surface plate 57 is held on the base 56. In this way, the thermal expansion difference caused by the hot wind between the upper surface plate 57 formed of super-hard alloy or ceramic and each of the metal base 56 and the shaft portion 52 is absorbed. Accordingly, it is possible to prevent breakage of the upper surface plate 57 caused by the thermal expansion.

[0083] In the present embodiment, instead of the hammer 62, a plurality of thin-plate blades may be uprightly disposed radially on the rotator 55.

Industrial Applicability

[0084] The present invention is applicable to an air flow drying device that pulverizes a lump of raw material and dries it by means of a hot wind.

Reference Signs List

[0085]

1	air flow drying device
2	main body portion
3	drive motor
4	table
10	housing
11	exhaust duct
12	raw material supply portion
13	first casing
13b	outside air inlet
14	second casing
14b	window portion
15	third casing
16	fourth casing
16b	exhaust path
17	bottom plate
20	hot wind supply portion
20a	hot wind inlet
21	outer circumferential portion
22	inner circumferential portion
23	angle
23a	bottom surface portion

23b	side surface portion
23c	upper surface portion
24	guard
24b	annular portion
24c	horizontal portion
30	liner
31	stand
31a	leg portion
31c	opening portion
32	cylindrical body
33	upper surface retaining member
33b, 34b	retaining claws
34	lower surface retaining member
35	liner chip
37	liner pusher
38	inner cylinder
40	classification portion
41	classification motor
42	shaft
43	classification rotor
44	disc
45	annular member
46	classification blade
50	pulverization portion
51	bearing portion
52	shaft portion
53	holding member
54	O-ring
55	rotator
56	base
57	upper surface plate
61	boss member
61a	protrusion portion
62	hammer
62a	first fitting portion
62b	second fitting portion
63	bolt
63a	small diameter portion

Claims

1. An air flow drying device comprising:

a vertical cylindrical housing,
a raw material supply portion that supplies a raw material containing moisture into the housing,
a disc-shaped rotator that is disposed below the raw material supply portion and rotates on a vertical rotating axis,
a pulverization member that is disposed on an outer periphery of the rotator and pulverizes the raw material into a granule,
a hot wind supply portion that supplies a hot wind below the rotator in the housing, and
a discharge portion that discharges the granule from an upper portion of the housing,
the granule pulverized by the pulverization member being dried by the hot wind and discharged, wherein
the housing has an annular liner that opposes the pulverization member, and
the hot wind supply portion has: an outer circumferential portion where the hot wind flows contacting an outer circumferential surface of the liner; and an inner circumferential portion that guides the hot wind to a gap between the pulverization member and the liner through below the liner.

2. The air flow drying device according to claim 1, comprising:

a bearing portion that is disposed on a bottom portion of the housing and supports the rotator, and
an outside air inlet that introduces outside air into the housing from below the hot wind supply portion.

3. The air flow drying device according to claim 2, wherein
the inner circumferential portion has a horizontal portion that extends horizontally from an upper end of a circumferential wall opposing an inner surface of the housing and approaches a lower surface of the rotator.

4. The air flow drying device according to any one of claims 1 to 3, wherein
the outer circumferential portion is formed annularly to cover a whole circumference of the liner.

5. The air flow drying device according to any one of claims 1 to 3, wherein
the liner has: a cylindrical body formed of a good thermal conductor; and a plurality of plate-shaped liner chips that are arranged in a circumferential direction on an inner circumferential surface of the cylindrical body.

6. The air flow drying device according to claim 5, wherein
the liner chip is formed of super-hard ally, ceramic, or metal whose surface is treated to be wear-resistant.

7. The air flow drying device according to claim 5, wherein
a retaining member formed of metal is disposed which is formed on upper and lower surfaces of the cylindrical body and retains an inner surface of the liner chip,
the liner chip is formed of super-hard alloy or ceramic, and
a radial direction gap and an axial direction gap are

disposed between the retaining member and the liner chip.

8. The air flow drying device according any one of claims 1 to 3, wherein
a classification rotor is disposed in an upper portion of the housing, the classification rotor classifying the granule, which ascends in the housing by using the hot wind, by means of rotation of a classification blade disposed radially, and
an upper portion of an inner wall of the housing opposing the classification rotor is tapered to become narrow toward a top.

9. The air flow drying device according any one of claims 1 to 3, wherein
the rotator has a disc-shaped metal plate and is provided with a protrusion portion that protrudes from an upper surface of the rotator,
the pulverization member is formed of super-hard alloy or ceramic and screwed to the rotator by means of a bolt with an axial direction gap left,
a small diameter portion having a diameter smaller than the protrusion portion is formed on the protrusion portion by means of the rotator or the bolt,
the pulverization member is provided with a through-hole that has a first fitting portion in which the protrusion portion is fitted and a second fitting portion in which the small diameter portion is fitted, and
a gap between the first fitting portion and the protrusion portion is smaller than a gap between the second fitting portion and the small diameter portion.

10. The air flow drying device according any one of claims 1 to 3, wherein
the rotator has: a metal base that has a shaft portion protruding from an upper surface of the rotator; and an upper surface plate that has a shaft hole in which the shaft portion is fitted, is disposed on an upper surface of the base, and formed of super-hard alloy or ceramic,
a holding member is disposed which has an O-ring and is mounted on the shaft portion, and
an upper surface of the upper surface plate is pushed by the O-ring such that the upper surface plate is held on the base.

FIG.1

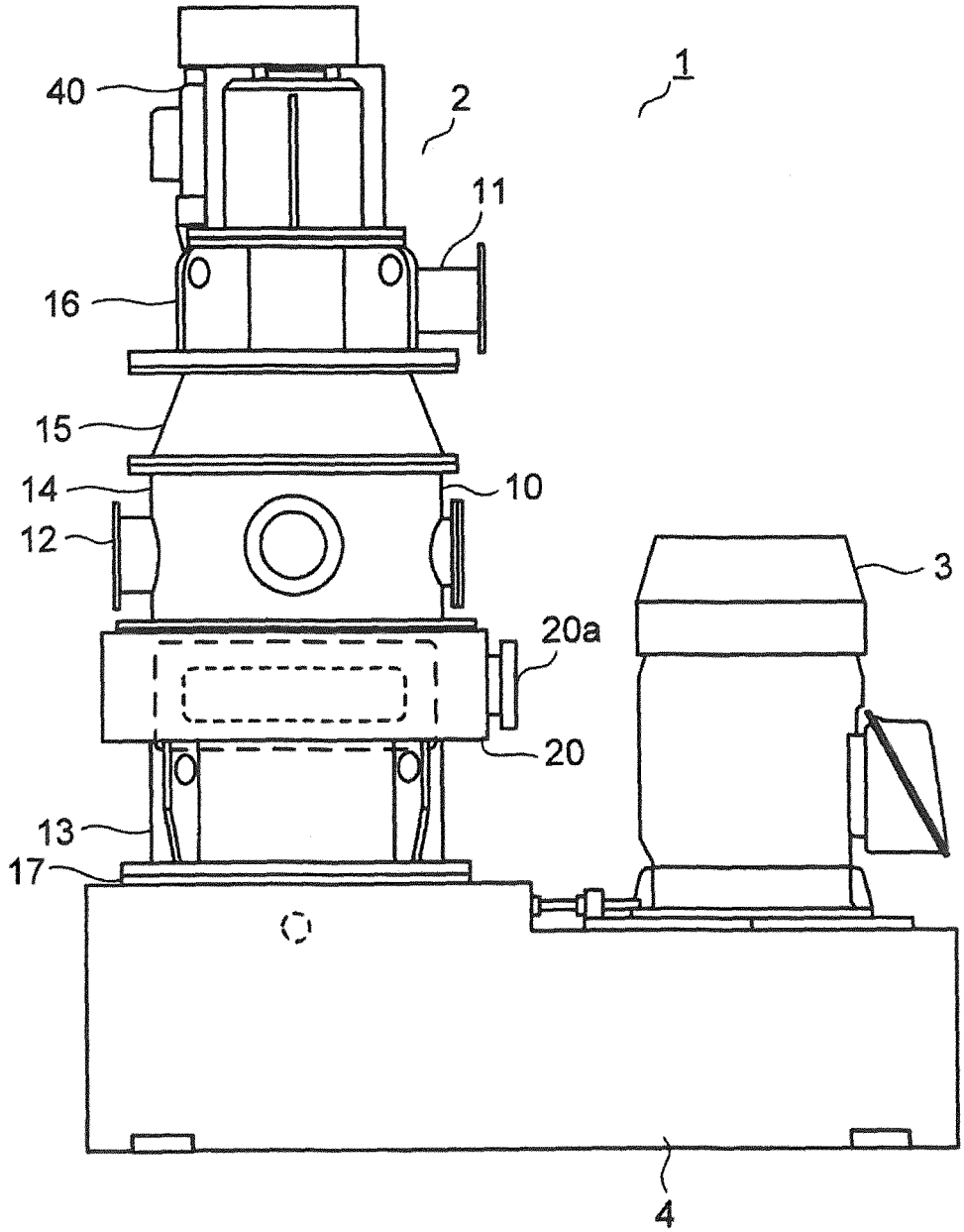


FIG.2

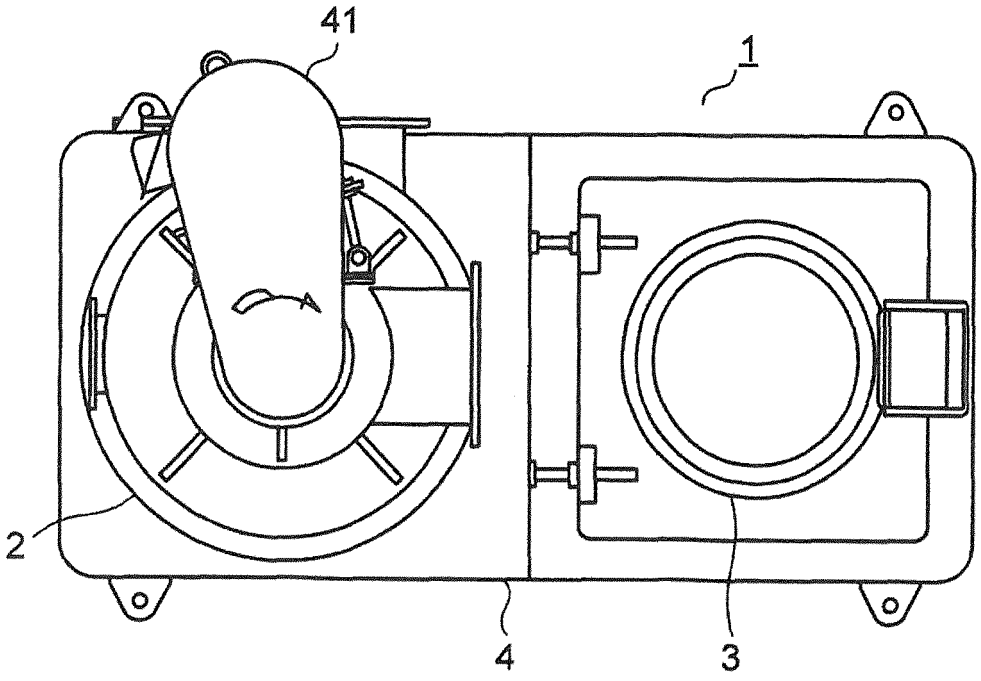
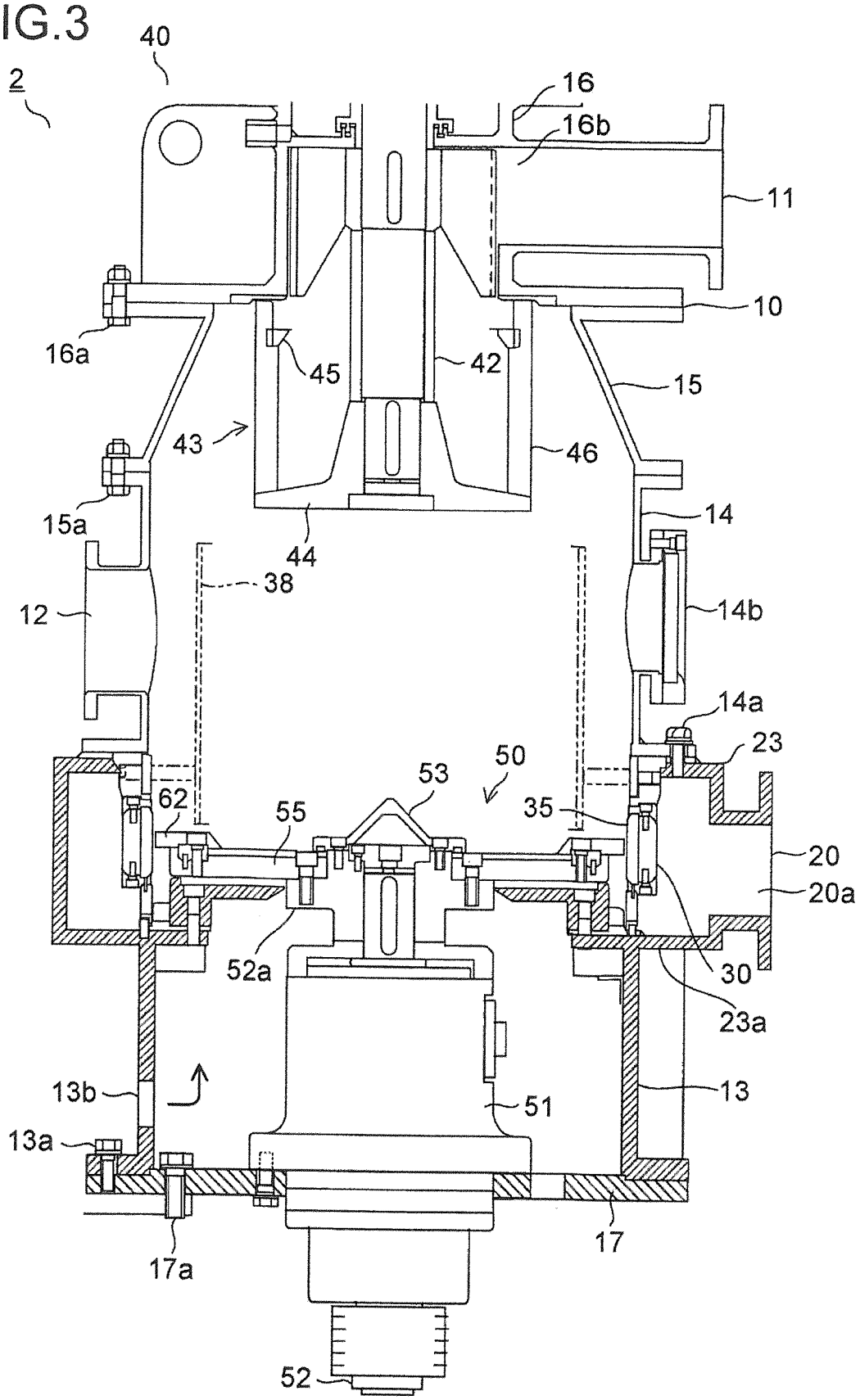


FIG.3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17a
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FIG.4

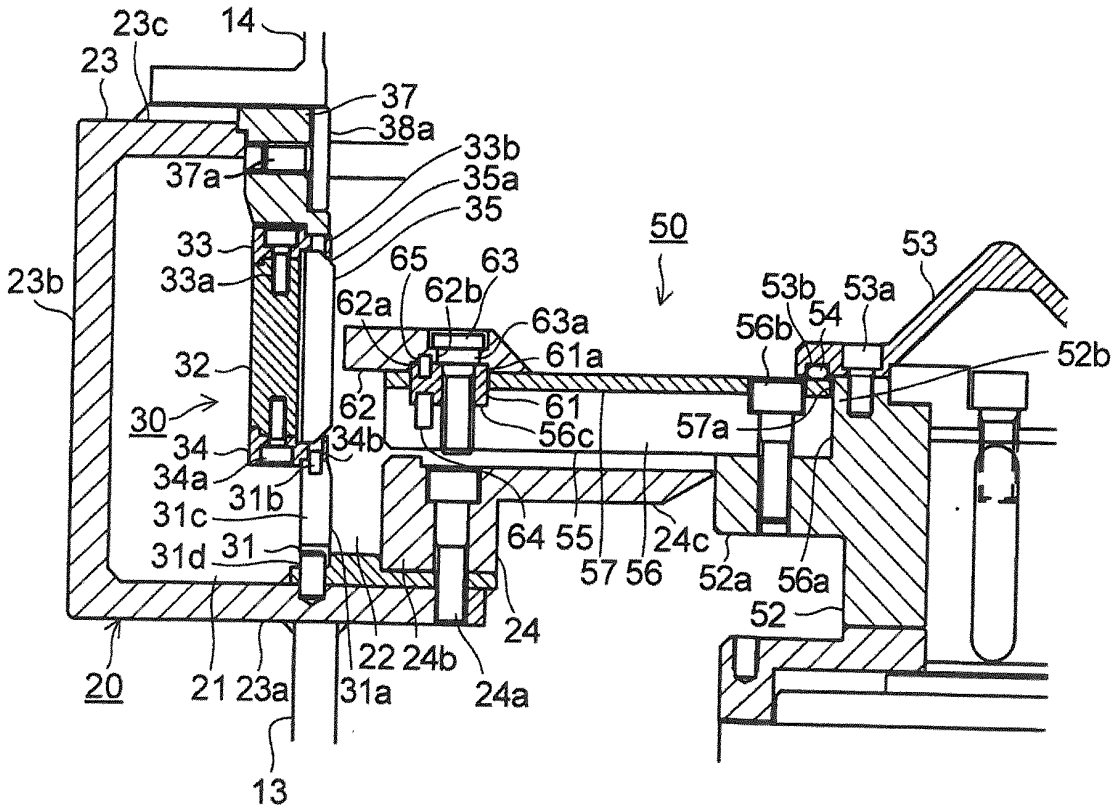
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FIG.5

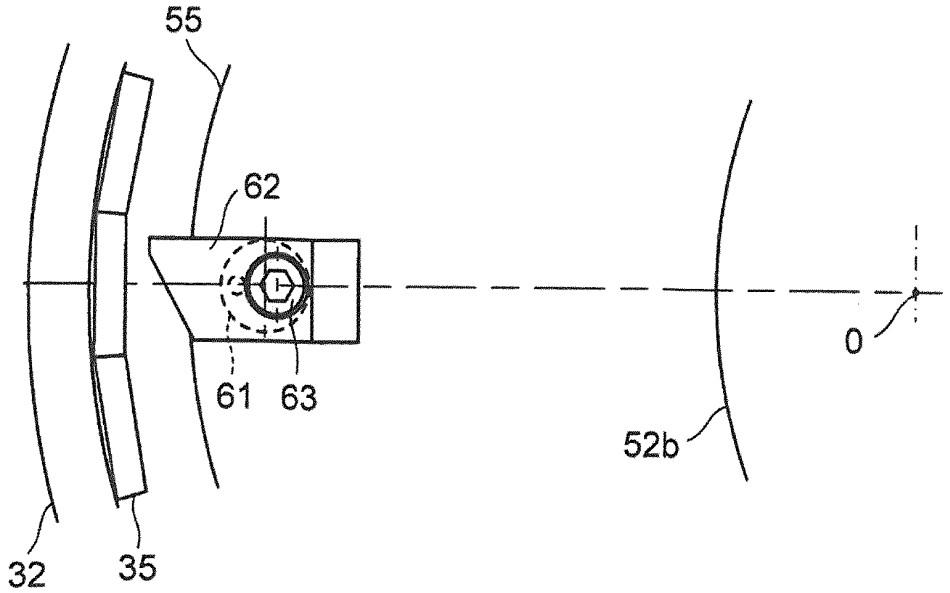
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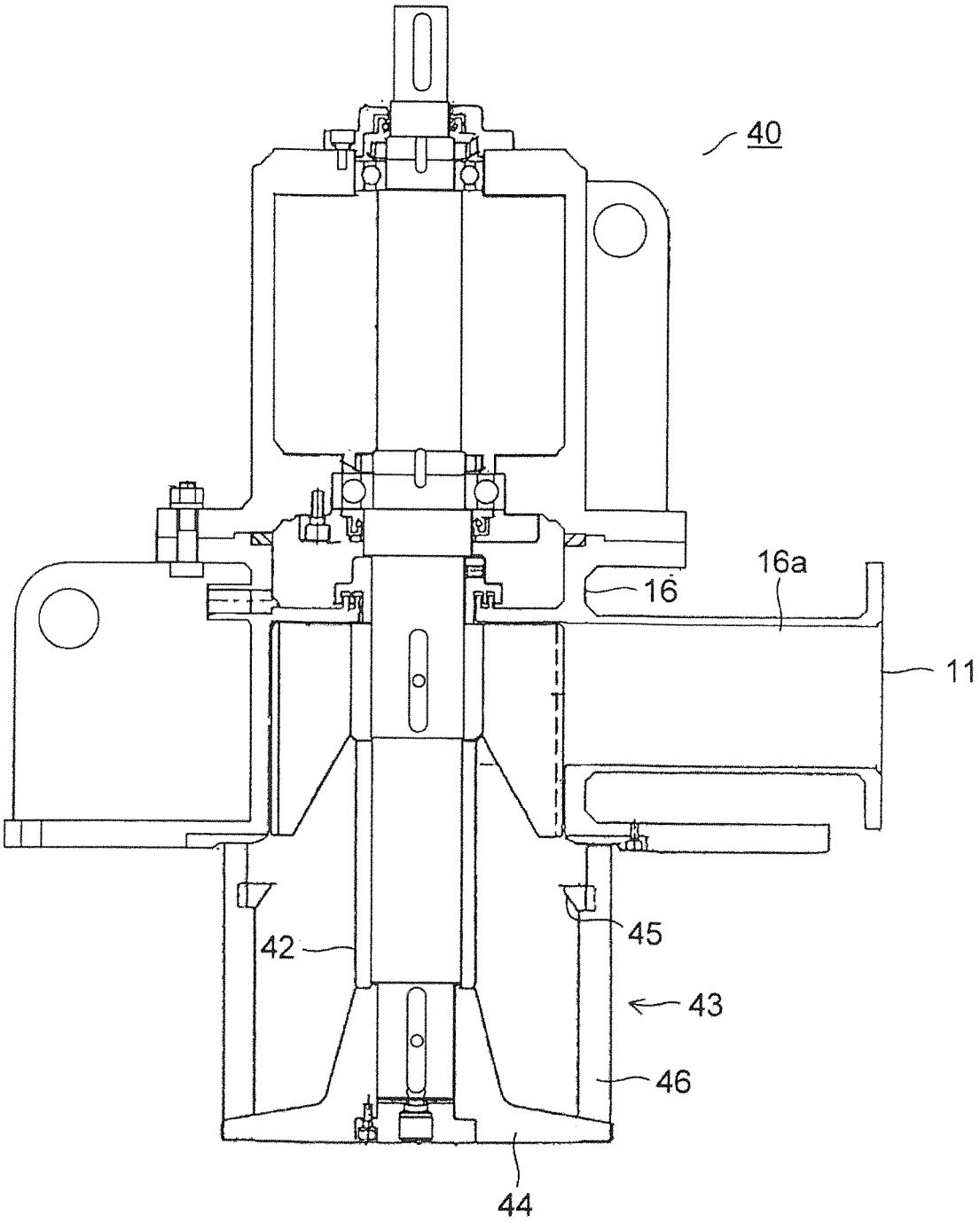
FIG.6



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/076863

A. CLASSIFICATION OF SUBJECT MATTER
F26B17/10(2006.01)i, *F26B21/00*(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)
F26B17/10, F26B21/00

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 1996-2013
Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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.
Y A	JP 2001-41652 A (Hosokawa Micron Corp.), 16 February 2001 (16.02.2001), entire text; all drawings & US 6397490 B1 & EP 1072854 A1 & DE 60010812 T2 & KR 10-2001-0015480 A & CA 2314634 A1	1-4,8 5-7,9-10
Y	JP 2010-46646 A (Hosokawa Micron Corp.), 04 March 2010 (04.03.2010), paragraph [0029]; fig. 1 & EP 2351616 A1 & WO 2010/024038 A1 & CN 102131586 A & KR 10-2011-0065460 A	1-4,8
A	JP 2004-69115 A (Hosokawa Micron Corp.), 04 March 2004 (04.03.2004), entire text; all drawings (Family: none)	1-10

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

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

Date of the actual completion of the international search	Date of mailing of the international search report
30 October, 2013 (30.10.13)	12 November, 2013 (12.11.13)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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

REFERENCES CITED IN THE DESCRIPTION

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