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(54) **STOKER FURNACE**

(57) This stoker furnace (1), which comprises a feeder (4), a drying stage (11), a combustion stage (12), a post-combustion stage (13), and a discharge chute (17), has: a front arch (31) extending from the upper side of the feeder (4) to the upper side of the drying stage (11) or the combustion stage (12); a rear arch (32) extending from the upper side of the discharge chute (17) to the upper side of the post-combustion stage (13) or the combustion stage (12); and a square tubular furnace wall (33) that guides and discharges exhaust gas generated by the combustion of an object (B) to be incinerated, wherein the drying stage (11) is disposed to be inclined such that a downstream side thereof in a transport direction faces downward, the combustion stage (12) is disposed to be inclined such that a downstream side thereof in the transport direction faces upward, and the post-combustion stage (13) is disposed to be inclined such that a downstream side thereof in the transport direction faces upward, so that the main surface of each of the drying stage (11), the combustion stage (12), and the post-combustion stage (13) faces a main combustion part (M) created above the combustion stage (12).

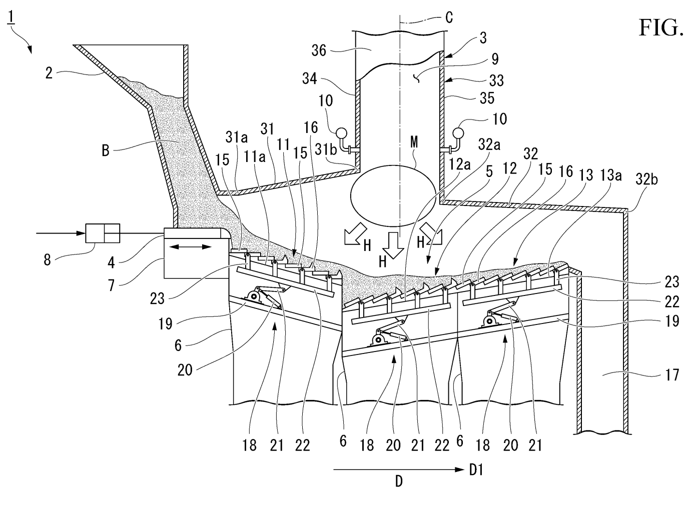

FIG. 1

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Description

[Technical Field]

[0001] The present invention relates to a stoker furnace.

[0002] Priority is claimed on Japanese Patent Application No. 2018-161818, filed on August 30, 2018, the content of which is incorporated herein by reference.

[Background Art]

[0003] A stoker furnace capable of efficiently incinerating a large amount of material to be incinerated without separation is known as an incinerator for incinerating incineration object such as waste. As a stoker furnace, a stoker furnace in which the stoker is configured as a stepped type, and which is equipped with a drying stage, a combustion stage, and a post-combustion stage performing each of the functions of drying, combustion, and post-combustion is known.

[0004] In order to reliably combust the incineration object, an inclination angle of the stoker has been studied. As described in Patent Documents 1 and 2, for example, the inclination angle of the stoker may be inclined so that a downstream side in a conveying direction of an installation surface of all the stages of the drying stage, the combustion stage, and the post-combustion stage is directed downward. Hereinafter, for example, when the downstream side in the conveying direction of the installation surface of the drying stage is directed downward, the drying stage is simply referred to as being directed downward (the same also applies to the combustion stage and the post-combustion stage).

[0005] Further, as described in Patent Document 3, there is a configuration in which the drying stage is inclined downward, and the combustion stage and the post-combustion stage are disposed horizontally, as described in Patent Document 4, there is a configuration in which the drying stage and the combustion stage are inclined downward and the downstream side in the conveying direction of the installation surface of the post-combustion stage is inclined upward, and as described in Patent Document 5, there is a configuration in which all the stages are inclined upward. For example, when the downstream side in the conveying direction of the installation surface of the combustion stage is directed upward, the combustion stage is simply referred to as being directed upward (the same also applies to the case of the drying stage and the post-combustion stage).

[Citation List]

[Patent Literature]

[0006]

[Patent Document 1]
Japanese Unexamined Patent Application, First Publication No. H6-265125
[Patent Document 2]
Japanese Unexamined Patent Application, First Publication No. S59-86814
[Patent Document 3]
Japanese Unexamined Utility Model Application, First Publication No. H6-84140
[Patent Document 4]
Japanese Examined Patent Publication, Second Publication No. S57-12053
[Patent Document 5]
Japanese Unexamined Utility Model Application, First Publication No. S57-127129

[Summary of Invention]

[Subject to be solved]

[0007] Incidentally, incineration objects with various properties (materials, forms, and moisture contents) may be charged into the stoker furnace, but an incineration object of a slippery material or a shape that is easy to roll, or incineration object with a high moisture content (large amount of water) was difficult to incinerate in the same stoker furnace as that used for other incineration objects.

[0008] That is, in the stoker furnaces described in Patent Documents 1, 2, 3 and 4, since the drying stage is inclined downward and the combustion stage is inclined downward or disposed horizontally, an incineration object of a slippery material or a shape that is easy to roll is conveyed earlier to the post-combustion stage than other incineration objects. Thus, the incineration object is discharged, while still combusting without being incinerated sufficiently.

[0009] Further, in the stoker furnaces described in Patent Document 5, since all of the drying stage, the combustion stage, and the post-combustion stage are inclined upward, an incineration object of a slippery material or a shape that is easy to roll, or incineration object with a high moisture content accumulates at the bottom of a step (a drop wall) disposed between the feeder and the drying stage and it is difficult for this to be conveyed to the combustion stage. Thus, it may be necessary to limit the charging amount or temporarily stop the charging.

[0010] Also, for example, the drying efficiency of moisture in the incineration object or the combustion efficiency of the incineration object depends on how radiant heat of the flame generated by combustion of the incinerated object impacts on the incinerated object. However, in the stoker furnace described in the above Patent Documents, consideration was not given to how to impact radiant heat, and combustion and ashing of the stoker as a whole was inefficient.

[0011] An object of the present invention is to provide a stoker furnace capable of continuously charging an incinerated object regardless of the properties of the incineration object, efficiently performing combustion and ashing as a whole stoker, and eliminating combustion residue of the incineration object.

[Solution to Subject]

[0012] According to the present invention, there is provided a stoker furnace which is configured to feed an incineration object from a feeder, performs each of drying, combustion and post-combustion, while sequentially conveying the incineration object, in a drying stage, a combustion stage and a post-combustion stage, which include a plurality of fixed fire grates and a plurality of movable fire grates, and discharge the incineration object after the post-combustion from a discharge chute connected to the post-combustion stage, the stoker furnace including: a front arch extending from an upper part of the feeder to an upper part of the drying stage or the combustion stage; a rear arch extending from an upper part of the discharge chute to an upper part of the post-combustion stage or the combustion stage; and a rectangular tubular furnace wall connected to the front arch and the rear arch and is configured to guide exhaust gas generated by combustion of the incineration object, wherein in order that main surfaces of each of the drying stage, the combustion stage and the post-combustion stage are directed to a main combustion section generated above the combustion stage, the drying stage is disposed to be inclined so that a downstream side in the conveying direction is directed downward, and the combustion stage is connected to the drying stage and is disposed to be inclined so that the downstream side in the conveying direction is directed upward, and the post-combustion stage is connected to the combustion stage and is disposed to be inclined so that the downstream side in the conveying direction is directed upward.

[0013] According to such a configuration, since all of the drying stage, the combustion stage, and the post-combustion stage are inclined such that their respective main surfaces are directed to the main combustion section, they can effectively receive the radiant heat of the main combustion section.

[0014] Therefore, it is possible to improve the drying efficiency in the drying stage, and to improve the combustion efficiency in the combustion stage. Also in the post-combustion stage, ashing can be effectively performed.

[0015] That is, in the stoker furnace of the present invention, regardless of the properties of the incineration object, the incineration object can be continuously charged, and the stoker as a whole can be efficiently combusted and ashed to eliminate the incineration residue of the incineration object.

[0016] In the stoker furnace, a center line of the rectangular tubular furnace wall may be on the combustion stage.

[0017] According to such a configuration, the position of the main combustion section is defined as the combustion stage, and radiant heat can be efficiently applied to the drying stage, the combustion stage, and the post-combustion stage.

[0018] In the stoker furnace, an end portion of the post-combustion stage on the downstream side in the conveying direction may be disposed at the same position in the vertical direction as the end portion of the combustion stage on the downstream side in the conveying direction or above the end portion of the combustion stage.

[0019] According to such a configuration, even in a case in which the incineration object falls down or the like in the drying stage, it is possible to prevent the incineration object from being discharged from the post-combustion stage without being sufficiently combusted.

[0020] In the stoker furnace, the fixed fire grate and the movable fire grate may be disposed to be inclined so that the downstream side in the conveying direction is directed upward with respect to the installation surfaces of the drying stage, the combustion stage, and the post-combustion stage.

[0021] With such a configuration, the movable fire grate can be operated to and convey the incineration object on the fixed fire grate to the downstream side in the conveying direction, while stirring.

[0022] In the stoker furnace, the combustion stages and the post-combustion stages may be continuously connected to each other without a step.

[0023] With such a configuration, it is possible to more continuously incinerate the incineration object.

[Advantageous Effects of Invention]

[0024] According to the present invention, it is possible to continuously charge the incineration object regardless of the properties of the incineration object, and it is possible to eliminate the combustion residue of the incineration object.

[Brief Description of Drawings]

[0025]

Fig. 1 is a schematic configuration diagram of a stoker furnace of a first embodiment of the present invention.

Fig. 2 is a view showing a stoker inclination angle of the stoker furnace of the first embodiment of the present invention.

Fig. 3 is a side view showing a fire grate shape of the stoker furnace of the first embodiment of the present invention.

Fig. 4 is a graph showing an appropriate range of the stoker inclination angle of a drying stage.

Fig. 5 is a graph showing an appropriate range of the stoker inclination angle of a combustion stage.

Fig. 6 is a graph showing an appropriate range of the stoker inclination angle of the combustion stage when considering both the drying stage and the combustion stage.

Fig. 7 is a view for explaining a stoker inclination angle of a stoker furnace of a second embodiment of the present invention.

[Description of Embodiments]

[First Embodiment]

[0026] Hereinafter, a stoker furnace of a first embodiment of the present invention will be described in detail with reference to the drawings.

[0027] The stoker furnace of the present embodiment is a stoker furnace for combustion of incineration object such as waste, and, as shown in Fig. 1, includes a hopper 2 for temporarily storing an incineration object B, an incineration furnace 3 for combusting the incineration object B, a feeder 4 for feeding the incineration object B to the incineration furnace 3, a stoker 5 (including fire grates 15 and 16 of a drying stage 11, a combustion stage 12, and a post-combustion stage 13) provided on a bottom side of the incineration furnace 3, and a wind box 6 provided below the stoker 5.

[0028] The feeder 4 pushes the incineration object B continuously fed onto a feed table 7 via the hopper 2 into the incinerator 3. The feeder 4 reciprocates on the feed table 7 by a feeder driving device 8 with a predetermined stroke.

[0029] The wind box 6 supplies primary air from a blower (not shown) to each part of the stoker 5.

[0030] The incinerator 3 has a combustion chamber 9 provided above the stoker 5 and including a primary combustion chamber and a secondary combustion chamber. The incinerator 3 has a secondary air supply nozzle 10 for feeding secondary air to the combustion chamber 9.

[0031] The stoker 5 is a combustion device in which the fire grates 15 and 16 are arranged in a stepwise manner. The incineration object B is combusted on the stoker 5.

[0032] Hereinafter, a direction in which the incineration object B is conveyed is referred to as a conveying direction D. The incineration object B is conveyed on the stoker 5 in the conveying direction D. In Figs. 1, 2 and 3, a right side is a downstream side D1 in the conveying direction. Further, a surface onto which the fire grates 15 and 16 are attached is referred to as an installation surface, and an angle on the conveying direction D formed by a horizontal surface and the installation surface centered on the upstream end portions (11b, 12b and 13b) of the drying stage 11, the combustion stage 12 or the post-combustion stage 13 is referred to as a stoker inclination angle (an installation angle). When the downstream side in the conveying direction of the installation surface is directed upward from the horizontal plane, the stoker inclination angle is set as a positive value, and when the downstream side in the conveying direction of the installation surface is directed downward from the horizontal plane, the stoker inclination angle is set as a negative value.

[0033] The stoker 5 has, in order from the upstream side in the conveying direction of the incineration object B, a drying stage 11 for drying the incineration object B, a combustion stage 12 for incinerating the incineration object B, and a post-combustion stage 13 for completely incinerating (post-combustion) unburnt components. In the stoker 5, each of the drying, the combustion, and the post-combustion is performed, while sequentially conveying the incineration object B in the drying stage 11, the combustion stage 12, and the post-combustion stage 13.

[0034] Each of the stages 11, 12 and 13 has a plurality of fixed fire grates 15 and a plurality of movable fire grates 16.

[0035] The fixed fire grates 15 and the movable fire grates 16 are alternately arranged in the conveying direction D. The movable fire grates 16 reciprocate in the conveying direction D of the incineration object B. The incineration object B on the stoker 5 is conveyed and stirred by the reciprocating motion of the movable fire grates 16. That is, lower layer portions of the incineration object B are moved and replaced with upper layer portions of the incineration object B.

[0036] The drying stage 11 receives the incineration object B that is pushed out by the feeder 4 and fallen into the incinerator 3, evaporates the moisture in the incineration object B and partially thermally decomposes the incineration object B. The combustion stage 12 ignites the incineration object B dried in the drying stage 11 by the primary air fed from the wind box 6 below the combustion stage 12 and combusts the volatile matter and the fixed carbon content. The post-combustion stage 13 combusts unburnt content such as the fixed carbon content having passed through without being sufficiently combusted in the combustion stage 12 until the unburnt content is completely ashed.

[0037] A discharge chute 17 is provided at the outlet of the post-combustion stage 13. The ash is discharged from the incinerator 3 through the discharge chute 17.

[0038] The stoker furnace 1 has a front arch 31 extending from the upper part of the feeder 4 to at least the upper part of the drying stage 11, and a rear arch 32 extending from the upper part of the discharge chute 17 to at least the upper part of the rear post-combustion stage 13. That is, the end portion 31b of the front arch 31 on the downstream side D1 in the conveying direction is located above the drying stage 11 or the combustion stage 12. Further, an end portion 32a of the rear arch 32 on the upstream side in the conveying direction is located above the combustion stage 12 or the post-combustion stage 13.

[0039] The front arch 31 and the rear arch 32 are connected to a furnace wall 33 of the incinerator 3. The furnace wall 33 has a rectangular tubular shape and guides the exhaust gas generated by the combustion of the incineration object B. The furnace wall 33 has a front wall

34 and a rear wall 35 directed in the conveying direction D, and a pair of side walls 36 extending along the conveying direction D. The interval between the front wall 34 and the rear wall 35 and the interval between the pair of side walls 36 are, for example, 3 m to 4 m. The front wall 34 is disposed on the upstream side of the rear wall 35 in the conveying direction D.

[0040] A center line C of the rectangular tubular furnace wall 33 lies on the combustion stage 12. That is, the center line C passing through the center of the furnace wall 33 along the front wall 34, the rear wall 35 and the side wall 36 intersects the combustion stage 12.

[0041] The secondary air supply nozzle 10 is disposed on the front wall 34 and the rear wall 35. The secondary air supply nozzle 10 is oriented to inject the secondary air from the front wall 34 and the rear wall 35 toward the center of the furnace wall 33.

[0042] In this embodiment, the secondary air supply nozzle 10 is disposed on the front wall 34 and the rear wall 35, but may be disposed in the front arch 31 and the rear arch 32.

[0043] The front arch 31 and the rear arch 32 are parts that form a ceiling (an upper wall) of the stoker 5. An end portion 31a of the front arch 31 on the upstream side in the conveying direction is located above the feeder 4. A vertical interval between the end portion 31a of the front arch 31 on the upstream side in the conveying direction and the feeder 4 is about 1 m.

[0044] The front arch 31 is inclined so that the end portion 31b on the downstream side D1 in the conveying direction is higher than the end portion 31a on the upstream side in the conveying direction. That is, the front arch 31 is inclined so that the space in the stoker 5 becomes wider toward the downstream side D1 in the conveying direction.

[0045] The vertical interval between the end portion 32b of the rear arch 32 on the downstream side D1 in the conveying direction and the end portion on the downstream side D1 in the conveying direction of the post-combustion stage 13 is about 1 m.

[0046] An end portion 32b of the rear arch 32 on the downstream side D1 in the conveying direction is located above the discharge chute 17. The rear arch 32 is inclined so that the end portion 32b on the downstream side D1 in the conveying direction is lower than the end portion 32a on the upstream side in the conveying direction. That is, the rear arch 32 is inclined so that the space in the stoker 5 becomes narrower toward the downstream side D1 in the conveying direction.

[0047] Each of the drying stage 11, the combustion stage 12, and the post-combustion stage 13 has a drive mechanism 18 for driving the movable fire grates 16. That is, the drying stage 11, the combustion stage 12, and the post-combustion stage 13 each have a separate drive mechanism 18 for driving the plurality of movable fire grates 16.

[0048] The drive mechanism 18 is attached to a beam 19 provided on the stoker 5. The drive mechanism 18 has a hydraulic cylinder 20 attached to the beam 19, an arm 21 operated by the hydraulic cylinder 20, and a beam 22 connected to a distal end of the arm 21. The beam 22 and the movable fire grates 16 are connected to each other via a bracket 23.

[0049] According to the drive mechanism 18 of this embodiment, the arm 21 is operated by expansion and contraction of the rod of the hydraulic cylinder 20. With the operation of the arm 21, the beam 22 configured to move along each of the installation surface 11a of the drying stage 11, the installation surface 12a of the combustion stage 12, and the installation surface 13a of the post-combustion stage 13 move, and the movable fire grates 16 connected to the beam 22 are driven.

[0050] Although the hydraulic cylinder 20 may be used as the drive mechanism 18 of this embodiment, there is no limitation thereto, and for example, a hydraulic motor, an electrical cylinder, a conductive linear motor, or the like can be adopted. Further, the form of the drive mechanism 18 is not limited to that of the above-described embodiment, and any form may be adopted as long as the movable fire grate 16 can be made to reciprocate. For example, instead of disposing the arm 21, the beam 22 and the hydraulic cylinder 20 may be connected directly to each other and driven.

[0051] The stoker furnace 1 of this embodiment can set the driving speed of the movable fire grates 16 in the drying stage 11, the combustion stage 12, and the post-combustion stage 13 to the same speed or to different speeds in at least some of the drying stage 11, the combustion stage 12, and the post-combustion stage 13.

[0052] For example, when the incineration object B required to be sufficiently combusted in the combustion stage 12 is charged, by decreasing the driving speed of the movable fire grate 16 of the combustion stage 12, and by decreasing the conveying speed of the incineration object B on the combustion stage 12, the incineration object B can be sufficiently combusted.

[0053] As shown in Figs. 2 and 3, the fixed fire grate 15 and the movable fire grate 16 are disposed to be inclined such that the downstream side in the conveying direction is directed upward with respect to the installation surfaces 11a, 12a and 13a of each of the drying stage 11, the combustion stage 12, and the post-combustion stage 13.

[0054] Some of the movable fire grates 16 of the drying stage 11 may be a fire grate with a protrusion 16P (others are normal fire grates as will be described later). As shown in Fig. 2, in the length of the drying stage 11 in the conveying direction D, the movable fire grate 16 in the range R1 of 50% to 80% from the downstream side in the conveying direction is the fire grate with the protrusion 16P. By using the fire grate with the protrusion 16P, it is possible to improve the stirring power.

[0055] As shown in Fig. 3, the fire grate with the protrusion 16P has a plate-like fire grate body 25, and a triangular protrusion 26 provided at the distal end of the fire grate body 25. The protrusion 26 protrudes upward from the upper surface of the fire grate body 25. The shape of the protrusion 26 is not limited thereto, and it may be, for example, a trapezoidal shape or a round shape.

[0056] Here, the fixed fire grate 15 of FIG. 3 is a fire grate with no protrusion on the upper surface of its distal end, and this shape is called a normal fire grate.

[0057] Further, in the present embodiment, some of the movable fire grates 16 are defined as the fire grate with the protrusion 16P, but there is no limitation thereto, and both of the movable fire grate 16 and the fixed fire grate 15 may be defined as a fire grate with a protrusion.

[0058] Further, the range in which the fire grates with the protrusion 16P are provided is not limited to the above-mentioned range, and for example, fire grates with the protrusion 16P may be used for all the fire grates of the drying stage 11.

[0059] Furthermore, depending on the properties or types of the incineration object B, all the fire grates (the fixed fire grate and the movable fire grate) in the drying stage may be the normal fire grate.

[0060] As in the drying stage 11, some of the movable fire grates 16 of the combustion stage 12 are the fire grates with the protrusion 16P. Specifically, in the length of the combustion stage 12 in the conveying direction D, the movable fire grate 16 in the range R2 of 50% to 80% from the downstream side in the conveying direction is the fire grate with the protrusion 16P. Other movable fire grates 16 of the combustion stage 12 are the normal fire grates. As with the drying stage, both the movable fire grate 16 and the fixed fire grate 15 may be defined as the fire grate with the protrusion, depending on the properties and types of the incineration object B, and all the fire grates (the fixed fire grate and the movable fire grate) may be defined as the normal fire grate.

[0061] In the fire grate of the post-combustion stage 13, both the movable fire grate 16 and the fixed fire grate 15 are shown as the normal fire grates in Fig. 2, but as with the drying stage 11 and the combustion stage 12, the fire grate with the protrusion may be adopted.

[0062] Next, stoker inclination angles (installation angles) of the drying stage 11, the combustion stage 12, and the post-combustion stage 13 will be described.

[0063] The drying stage 11, the combustion stage 12, and the post-combustion stage 13 are inclined so that their main surfaces face a main combustion section M. Here, the main combustion section M is a part which is generated near the lower end of the rectangular tubular furnace wall 33 (in other words, near the end portion 31b of the front arch 31 and the end portion 32a of the rear arch 32), near the center line C of the furnace wall 33 and above the incineration object B, due to the combustion of the incineration object B. Radiant heat H from the flame of the main combustion section M is emitted radially around the main combustion section M.

[0064] As shown in Fig. 2, the drying stage 11 of the stoker 5 of the present embodiment is disposed downward. That is, an installation surface 11a of the drying stage 11 is inclined so that the downstream side D1 in the conveying direction is lowered down. Specifically, a stoker inclination angle θ1 of the drying stage 11, which is an angle between a horizontal plane centered on the end portion 11b on the upstream side of the drying stage 11 and the conveying direction side of the installation surface 11a, is an angle between -15° (minus 15°) and -25° (minus 25°).

[0065] As a result, the main surface (the installation surface 11a) of the drying stage 11 faces the main combustion section M and efficiently receives the radiant heat H.

[0066] The combustion stage 12 of the stoker 5 of the present embodiment is disposed upward. That is, the installation surface 12a of the combustion stage 12 is inclined so that the downstream side D1 in the conveying direction becomes higher. Specifically, a stoker inclination angle θ2 of the combustion stage 12, which is an angle between the horizontal plane centered on the upstream end portion 12b of the combustion stage 12 and the conveying direction side of the installation surface 12a, is an angle between +5° (plus 5°) and +15° (plus 15°), preferably an angle between +8° (plus 5°) and +12° (plus 15°).

[0067] As a result, the main surface (the installation surface 12a) of the combustion stage 12 faces the main combustion section M and efficiently receives the radiant heat H.

[0068] The post-combustion stage 13 of the stoker 5 of the present embodiment is disposed upward. That is, the installation surface 13a of the post-combustion stage 13 is inclined so that the downstream side D1 in the conveying direction becomes higher.

[0069] A stoker inclination angle θ3 of the post-combustion stage 13, which is an angle between the horizontal plane centered on the upstream end portion 13b of the post-combustion stage 13 and the conveying direction side of the installation surface 13a, is the same as the stoker angle θ2 of the combustion stage 12. Specifically, the stoker inclination angle θ3 of the post-combustion stage 13, which is the angle between the horizontal plane centered on the upstream end portion 13b of the post-combustion stage 13 and the conveying direction side of the installation surface 13a, is an angle between +5° (plus 5°) and +15° (plus 15°), preferably an angle between +8° (plus 8°) and +12° (plus 12°).

[0070] As a result, the main surface (the installation surface 13a) of the post-combustion stage 13 faces the main combustion section M and efficiently receives the radiant heat H.

[0071] As well, the stoker inclination angle θ3 of the post-combustion stage 13 may be $\theta 2 \neq \theta 3$ or may be $\theta 2 = \theta 3$.

[0072] A step (a drop wall) 27 is formed between the drying stage 11 and the combustion stage 12. The end portion 11c of the drying stage 11 on the downstream side in the conveying direction is formed to be higher in the vertical direction than the end portion 12b of the combustion stage 12 on the upstream side in the conveying direction.

[0073] There is no step (a drop wall) between the combustion stage 12 and the post-combustion stage 13. That is, the combustion stage 12 and the post-combustion stage 13 are continuously connected to each other. In other words, the combustion stage 12 and the post-combustion stage 13 are formed such that the end portion 12c of the combustion stage 12 on the downstream side in the conveying direction and the end portion 13b of the post-combustion stage 13 on the upstream side in the conveying direction are located at the same height.

[0074] Therefore, the end portion 13c of the post-combustion stage 13 is disposed to be higher in the vertical direction than the end portion 12c of the combustion stage 12.

[0075] Next, the reason why the stoker inclination angle of the drying stage 11 is set to an angle between -15° (minus 15°) and -25° (minus 25°) will be described.

[0076] The function of the drying stage 11 is to efficiently dry the moisture in the incineration object B by the radiant heat H from the main combustion section M above the incineration object B and the sensible heat of the primary air from the lower part of the fire grate.

[0077] Here, the radiation heat H from the flame of the main combustion section M has a higher contribution to the drying than the sensible heat of the primary air, and the drying of the upper layer portion of the incineration object B easily proceeds.

[0078] For this reason, the drying speed is improved by moving the lower layer portion of the incineration object B upward by a stirring operation of the fire grate and by replacing the lower layer portion with the upper layer portion.

[0079] However, even if the stirring operation is performed, it is necessary to secure a length enough for moisture evaporation to sufficiently proceed in the drying stage 11. As the length increases, the size of the incinerator increases, and the cost also increases. Thus, it is required to make the stoker length as short as possible.

[0080] If an absolute value of the stoker inclination angle is larger than an angle of repose of the incineration object B, since the incineration object B collapses under its own weight and a layer of the incineration object B is not formed, the stoker 5 does not work properly. On the other hand, if the absolute value of the stoker inclination angle is smaller than the angle of repose of the incineration object B, the stoker 5 does work properly, but the movement of the incineration object B due to gravity (movement due to its own weight) decreases. Further, when the installation surface is directed upward, that is, when the stoker inclination angle is inclined at a positive value (plus value), the gravity acts in a direction of pushing back the incineration object B from the conveying direction.

[0081] When the conveying amount of the incineration object B due to the stoker 5 is less than the charged amount of the incineration object B, the conveyance limit is reached and processing becomes impossible.

[0082] The optimum stoker inclination angle differs depending on the amount of incineration object B to be charged and the moisture content of the incineration object B. Here, the description will be provided on the assumption that a case in which the amount of the incineration object B to be charged is high and the moisture content is high (the amount of moisture is large) is a case in which the load of the charged incineration object is large. On the contrary, a case in which the amount of incineration object B to be charged is small and the moisture content is low is assumed to be a case in which the load of the charged incineration target is small.

[0083] Fig. 4 shows a graph in which a horizontal axis represents a stoker inclination angle of the drying stage 11, a vertical axis represents a required stoker length of the drying stage 11, and in order from a case (1) in which the load of the charged incineration object is the largest to a case (4) in which the load of the charged incineration object is the smallest, a relationship between the stoker inclination angle of the drying stage 11 and the required stoker length of the drying stage 11 is plotted.

[0084] Here, the required stoker length is a distance at which 95% of the moisture of the charged incineration object B is dried. "Angle of repose" on the horizontal axis represents the angle of repose of the incineration object B.

[0085] As shown in the graph of Fig. 4, the stoker inclination angle of -30° is a limit for forming the layer of the incineration object B. With respect to the stoker inclination angle of the layer formation limit, the required stoker length decreases as the stoker inclination angle gets loose. However, when the stoker inclination angle turns to a positive value, the required stoker length gradually becomes longer. This is because when the stoker inclination angle becomes a positive value, the installation surface is directed upward and the conveying speed becomes slower, and as a result, the layer of the incineration object B becomes thick and drying of the incineration object B of the lower layer is hard to proceed. It is noted that, from the four cases from the case (1) in which the load of the incineration object B to be charged is the largest to the case (4) in which the load of the incineration object B to be charged is the smallest, no matter what property or quantity of the incineration object B is, the stoker inclination angle of the optimum drying stage 11 at which the incineration object B can be properly processed and the stoker length can be set to be shortest has an appropriate range of an angle between -15° (minus 15°) and -25° (minus 25°) corresponding to the stoker length in the vicinity of the lowest point of the curve of the case (1). Further, the optimum value is -20° (minus 20°).

[0086] Next, in the case in which the stoker inclination angle of the drying stage 11 is set to be within the appropriate range as described above, the reason why it is appropriate to set the stoker inclination angle of the combustion stage 12 to an angle between +8° (plus 8°) and

+12° (plus 12°) will be explained.

[0087] The function of the combustion stage 12 is to maintain the temperature of the layer of the incineration object B by radiant heat H from the flame of the main combustion section M and self-combustion heat, and perform generation acceleration of the combustible gas by thermal decomposition of the volatile matter, and combustion of the fixed carbon that is left after thermal decomposition.

[0088] Here, since the time required for combustion of the fixed carbon is longer than the time required for volatilization of the volatile combustible gas, the required stoker length of the combustion stage 12 is determined by the time required for combustion of the fixed carbon.

[0089] Fig. 5 shows a graph in which, in a case in which the stoker inclination angle of the drying stage 11 is set in the appropriate range as described above, a horizontal axis represents the stoker inclination angle of the combustion stage, a vertical axis represents the required stoker length of the combustion stage, and in order from the case (1) in which load of the charged incineration object is the largest to the case (4) in which load of the charged incineration object is the smallest, a relationship between the stoker inclination angle of the combustion stage and the required stoker length of the combustion stage is plotted. Here, the required stoker length of the combustion stage is the distance at which 95% of the combustible content volatilizes or combusts.

[0090] As shown in Fig. 5, the stoker inclination angle of -30° is the limit of forming the layer of the incineration object B. For the stoker inclination angle of the layer formation limit, the required stoker length decreases as the angle becomes loose. Considering the conveyance limit, the appropriate range of the stoker inclination angle can be set to the range surrounded by the one-dot chain line shown in Fig. 5.

[0091] Even when the load of the charged incineration object is large in the drying stage 11, since the drying stage 11 has the stoker inclination angle within the appropriate range, the water content reduction and the volume reduction of the waste are accelerated. Therefore, for example, even if the load corresponds to (1) in the drying stage 11, since the load changes to those corresponding to (3) and (4) in the combustion stage 12, the larger stoker inclination angle can be adopted in the combustion stage 12. That is, since the combustion stage can be directed upward, it is possible to secure the retention time required for combustion of fixed carbon, and the stoker length can be further shortened.

[0092] Fig. 6 is a graph in which a horizontal axis represents the stoker inclination angle of the combustion stage 12, a vertical axis represents the stoker length required for both the drying stage 11 and the combustion stage 12, and in order from the case (1) in which the load of the incineration object B to be charged is the largest to the case (4) in which the load of the incineration object B to be charged is the smallest, a relationship between the stoker inclination angle of the combustion stage 12 and the stoker length required for both the drying stage 11 and the combustion stage 12 is plotted. Here, the stoker inclination angle of the drying stage 11 is set to an optimum value of -20° (minus 20°).

[0093] As shown in Fig. 6, when considering the conveyance limit, the appropriate range of the stoker inclination angle of the combustion stage 12 is an angle between +5° (plus 5°) and +15° (plus 15°), more specifically, an angle between +8° (plus 8°) and +12° (plus 12°). Further, in the case in which the stoker inclination angle of the drying stage 11 is the optimum value of -20° (minus 20°), the optimum value of the stoker inclination angle of the combustion stage 12 is +10° (+10°).

[0094] Since the required stoker lengths of the drying stage 11 and the combustion stage 12 can be made as short as possible by setting the respective stoker inclination angles to appropriate ranges, particularly optimum values, even if the post-combustion stage 13 is included, it is possible to provide a stoker furnace of a relatively small size and low cost.

[0095] As well, the stoker inclination angle $\theta 3$ of the post-combustion stage 13 may be set to $\theta 2 \neq \theta 3$ or may be set to $\theta 2 = \theta 3$ within the same angle range as the stoker inclination angle $\theta 2$ of the above-described combustion stage 12.

[0096] According to the above embodiment, since the main surfaces of the drying stage 11, the combustion stage 12, and the post-combustion stage 13 face the main combustion section M, it is possible to effectively receive the radiant heat H of the main combustion section M. Therefore, it is possible to improve the drying efficiency in the drying stage 11, and to improve the combustion efficiency in the combustion stage 12. Also in the post-combustion stage 13, the incineration object B can be incinerated effectively.

[0097] Further, since the drying stage 11 is inclined downward, it is possible to convey the incineration object B of any property to the combustion stage 12 without any delay, and since the combustion stage 12 and the post-combustion stage 13 are inclined upward, the incineration object B is combusted and conveyed sufficiently without easily sliding down or rolling down to the downstream side of the combustion stage 12.

[0098] That is, in the case of an incineration object B of a slippery material or a shape which readily rolls, since the incineration object B is conveyed early to the combustion stage 12 by rolling over the drying stage 11 or the like, there is a possibility that the incineration object B cannot be sufficiently dried in the drying stage 11. However, since the combustion stage 12 and the post-combustion stage 13 are inclined upward, the incineration object B rolling and falling down the drying stage 11 does not further roll down the combustion stage 12 and the post-combustion stage 13, but is always sufficiently dried and incinerated in the combustion stage 12. Since the incineration object B having high water content is conveyed to the combustion stage 12 while being dried without staying in the drying stage 11, and similarly, the incineration object B is always sufficiently incinerated in the combustion stage 12.

[0099] As a result, it is possible to continuously charge the incineration object B regardless of the properties of the incineration object B, and it is possible to eliminate the combustion residue of the incineration object B.

[0100] Even if the incineration object B rolling down the drying stage 11 has a strong momentum and passes through the combustion stage 12 with its momentum, since the end portion 13C of the post-combustion stage 13 on the downstream side in the conveying direction is located to be higher in the vertical direction than the end portion 12C of the combustion stage 12 on the downstream side in the conveying direction, the incineration object B stops at least in the post-combustion stage 13 and is not discharged from the post-combustion stage 13. Further, since the post-combustion stage 13 and the combustion stage 12 are continuously connected to each other without a step, even if the incineration object B which is not sufficiently combusted advances by rolling or the like up to the post-combustion stage 13, the incineration object B returns to the combustion stage 12 by its own weight, and combustion can be performed. That is, it is possible to minimize the discharge of incompletely combusted incineration object B as much as possible.

[0101] Further, since the center line C of the rectangular tubular furnace wall 33 is on the combustion stage 12, the position of the main combustion section M is located on the combustion stage 12, and the radiant heat H can be efficiently applied to the drying stage 11, the combustion stage 12, and the post-combustion stage 13.

[Second Embodiment]

[0102] Hereinafter, a stoker furnace according to a second embodiment of the present invention will be described in detail with reference to the drawings. In this embodiment, differences from the above-described first embodiment will be mainly described, and description of similar portions will be omitted.

[0103] As shown in Fig. 7, a step (drop wall) 28 is formed between the combustion stage 12 and the post-combustion stage 13 of the stoker 5 of the present embodiment.

[0104] The end portion 12c of the combustion stage 12 on the downstream side in the conveying direction and the end portion 13c of the post-combustion stage 13 on the downstream side in the conveying direction are at the same position in the vertical direction, or the end portion 13c of the post- combustion stage 13 is disposed above the end portion 12c of the combustion stage 12 in the vertical direction. The stoker furnace 1 of the present embodiment is an example in which an end portion 12c of the combustion stage 12 on the downstream side in the conveying direction and an end portion 13c of the post-combustion stage 13 on the downstream side in the conveying direction are set at the same position in the vertical direction.

[0105] Thus, even in the case in which the incineration object B rolls down or the like in the drying stage 11, it is possible to prevent the incineration object B from being discharged from the post-combustion stage 13 without being sufficiently combusted.

[0106] Although the embodiments of the present invention have been described in detail with reference to the drawings, the specific configuration is not limited to this embodiment, and design changes and the like within the scope not deviating from the gist of the present invention are also included.

[0107] In the above embodiment, the distal ends of the fire grates 15, 16 are disposed to face the downstream side D1 in the conveying direction. However, the present invention is not limited thereto. For example, the distal ends of the fire grates 15, 16 of the drying stage 11 may be disposed to face the upstream side in the conveying direction.

[Reference Signs List]

[0108]

1 Stoker furnace
2 Hopper
3 Incinerator
4 Feeder
5 Stoker
6 Wind box
7 Feed table
8 Feeder driving device
9 Combustion chamber
10 Secondary air supply nozzle
11 Drying stage
11a Installation surface of drying stage
12 Combustion stage
12a Installation surface of combustion stage
13 Post-combustion stage
13a Installation surface of post-combustion stage
15 Fixed fire grate
16 Movable fire grate
16P Fire grate with protrusion
17 Discharge chute
18 Driving mechanism
19 Beam
20 Hydraulic cylinder
21 Arm
22 Beam
23 Bracket
25 Fire grate body
26 Protrusion
27, 28 Step (drop wall)
31 Front arch
32 Rear arch
33 Furnace wall
34 Front wall
35 Rear wall
36 Side wall

B Incineration object
C Center line
D Conveying direction
D1 Downstream side in conveying direction
F Radiant heat
M Main combustion section
θ1, θ2, θ3 Stoker inclination angle

Claims

1. A stoker furnace which is configured to feed an incineration object from a feeder, perform each of drying, combustion and post-combustion, while sequentially conveying the incineration object, into a drying stage, a combustion stage and a post-combustion stage, which include a plurality of fixed fire grates and a plurality of movable fire grates, and discharge the incineration object after the post-combustion from a discharge chute connected to the post-combustion stage, the stoker furnace comprising:

    a front arch extending from an upper part of the feeder to an upper part of the drying stage or the combustion stage;
    a rear arch extending from an upper part of the discharge chute to an upper part of the post-combustion stage or the combustion stage; and
    a rectangular tubular furnace wall connected to the front arch and the rear arch and is configured to guide exhaust gas generated by combustion of the incineration obj ect,
    wherein in order that main surfaces of each of the drying stage, the combustion stage and the post-combustion stage are directed to a main combustion section generated above the combustion stage, the drying stage is disposed to be inclined so that a downstream side in the conveying direction is directed downward, and the combustion stage is connected to the drying stage and is disposed to be inclined so that the downstream side in the conveying direction is directed upward, and
    the post-combustion stage is connected to the combustion stage and is disposed to be inclined so that the downstream side in the conveying direction is directed upward.

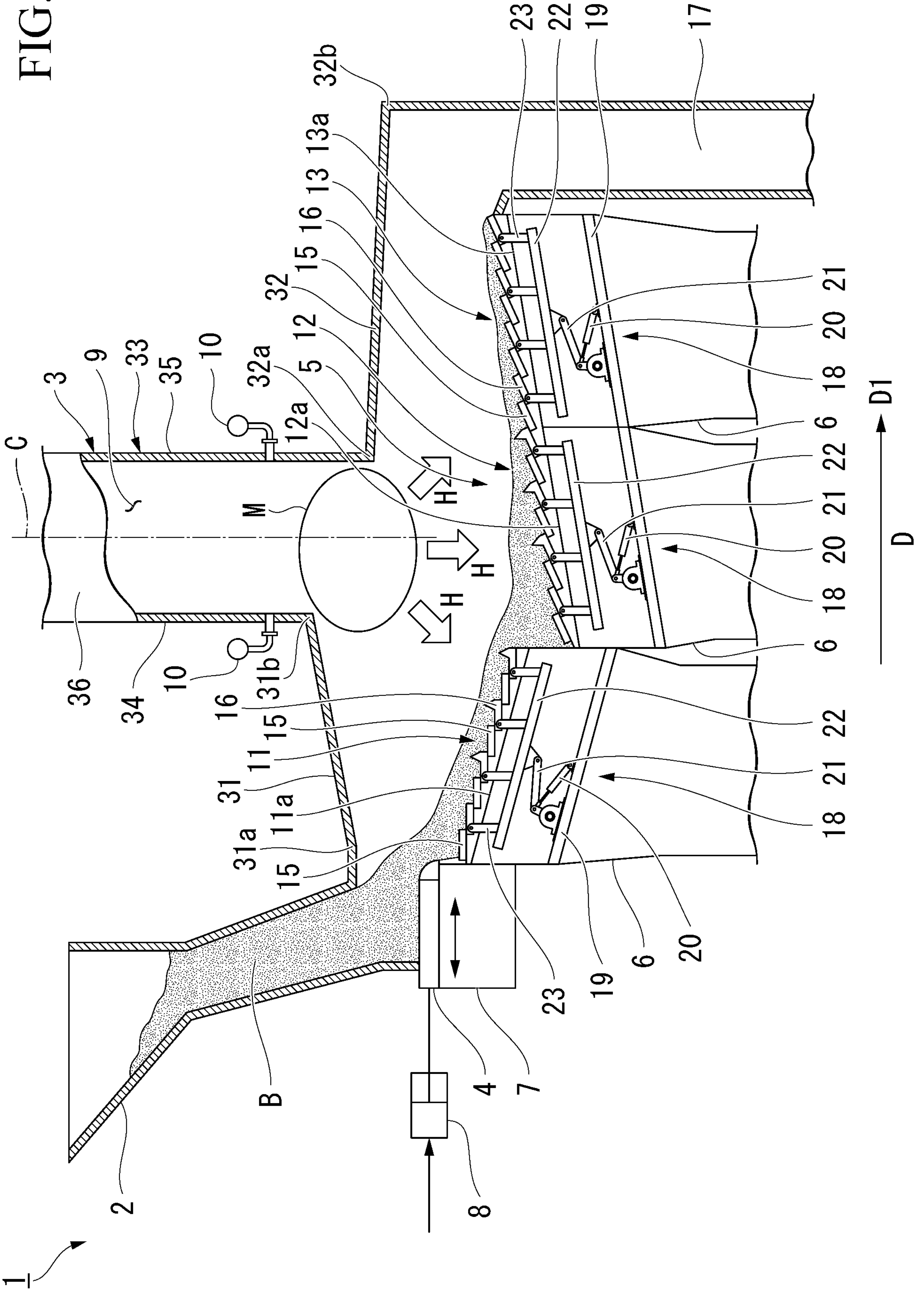
2. The stoker furnace according to claim 1, wherein a center line of the rectangular tubular furnace wall is on the combustion stage.

3. The stoker furnace according to claim 2, wherein an end portion of the post-combustion stage on the downstream side in the conveying direction is disposed at the same position in the vertical direction as the end portion of the combustion stage on the downstream side in the conveying direction or above the end portion of the combustion stage.

4. The stoker furnace according to claim 3, wherein the fixed fire grate and the movable fire grate are disposed to be inclined so that the downstream side in the conveying direction is directed upward with respect to installation surfaces of the drying stage, the combustion stage, and the post-combustion stage.

5. The stoker furnace according to any one of claims 1 to 4, wherein the combustion stage and the post-combustion stage are continuously connected to each other without a step.

FIG. 1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20
21
22
23
31
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34
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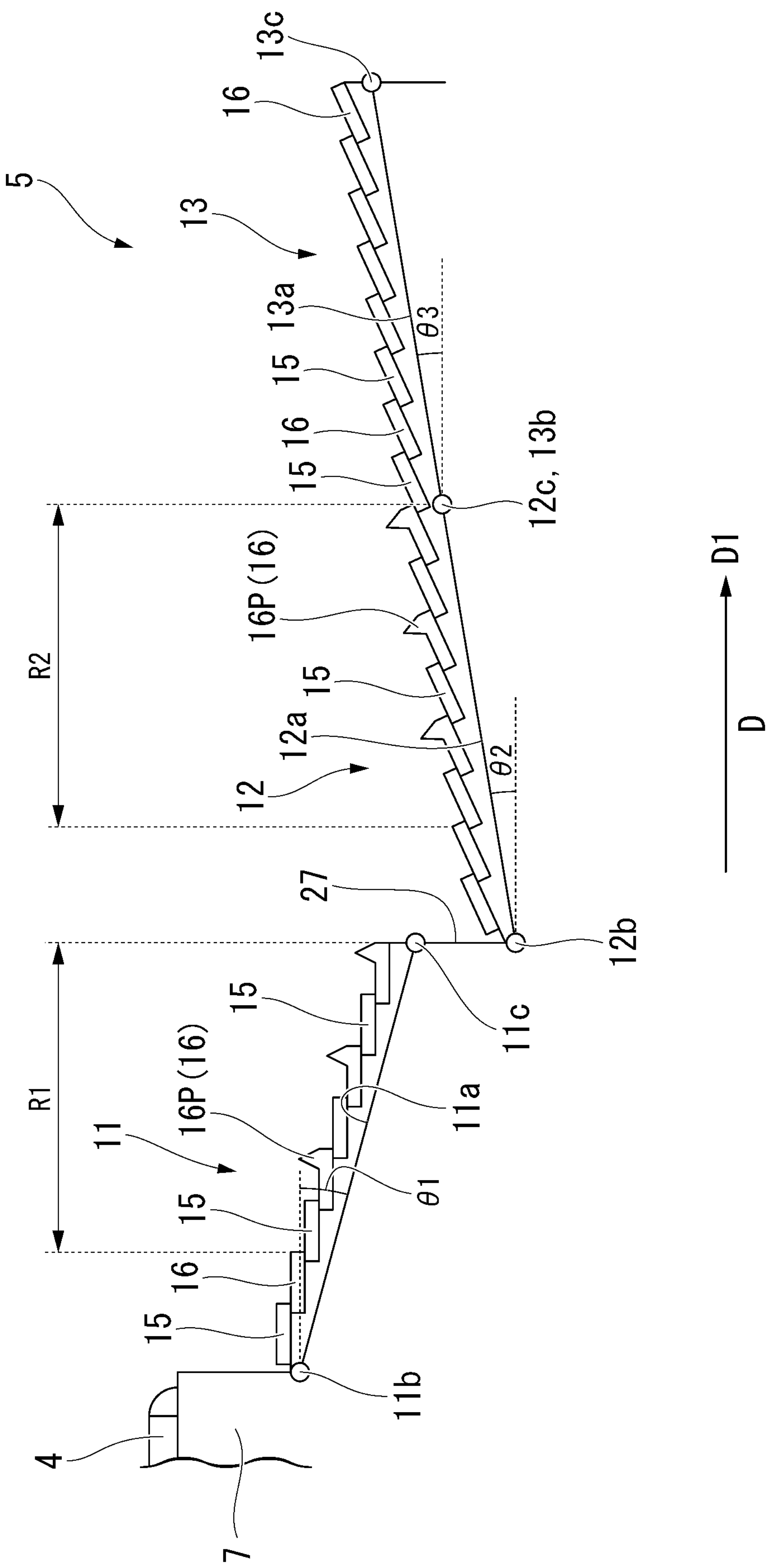
B
C
M
H
D
D1

FIG. 2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θ3
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16
15
12c, 13b
R2
16P (16)
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12a
θ2
12
27
12b
D1
D
R1
11
16P (16)
15
11a
11c
θ1
15
16
15
11b
4
7

FIG. 3

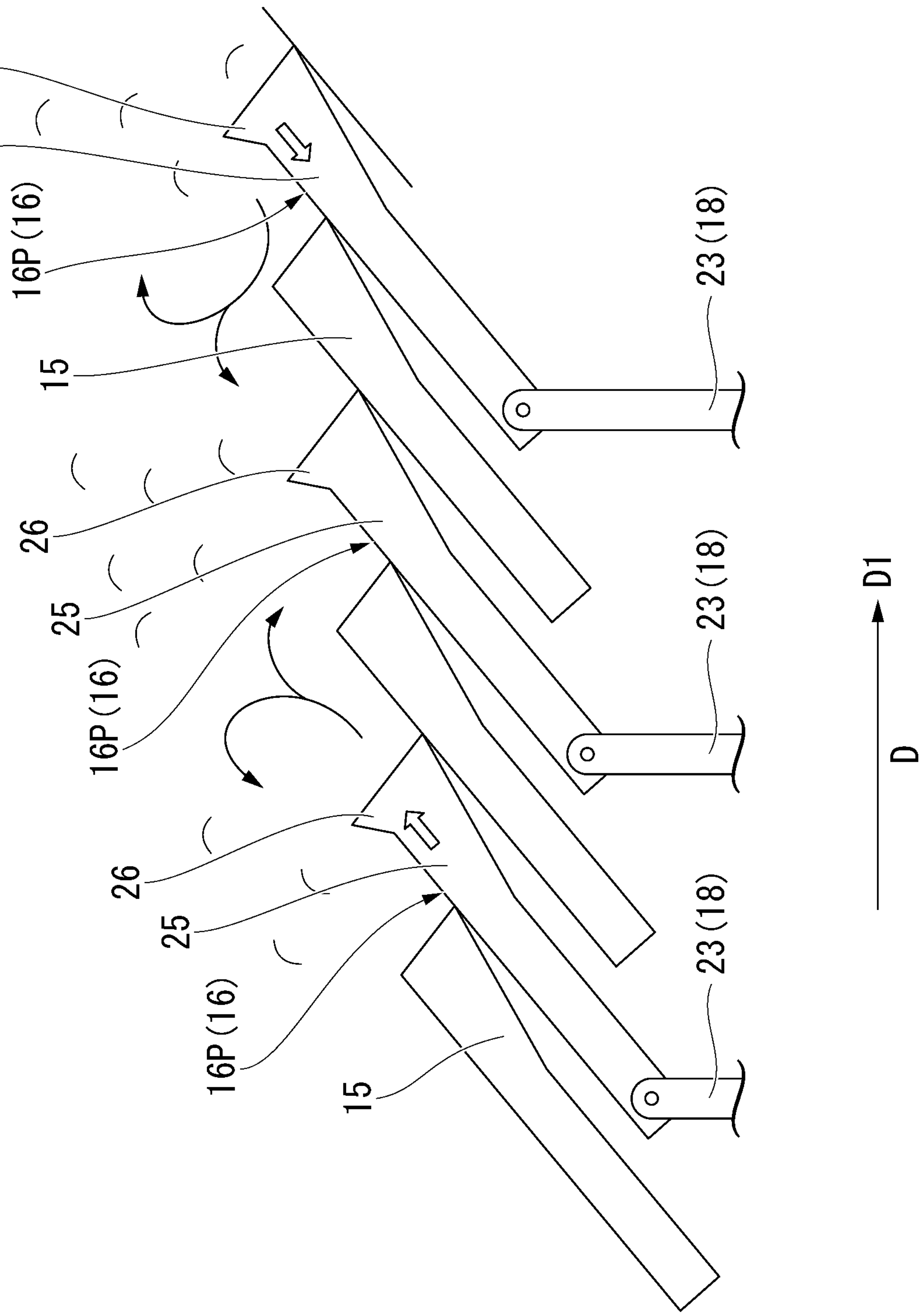
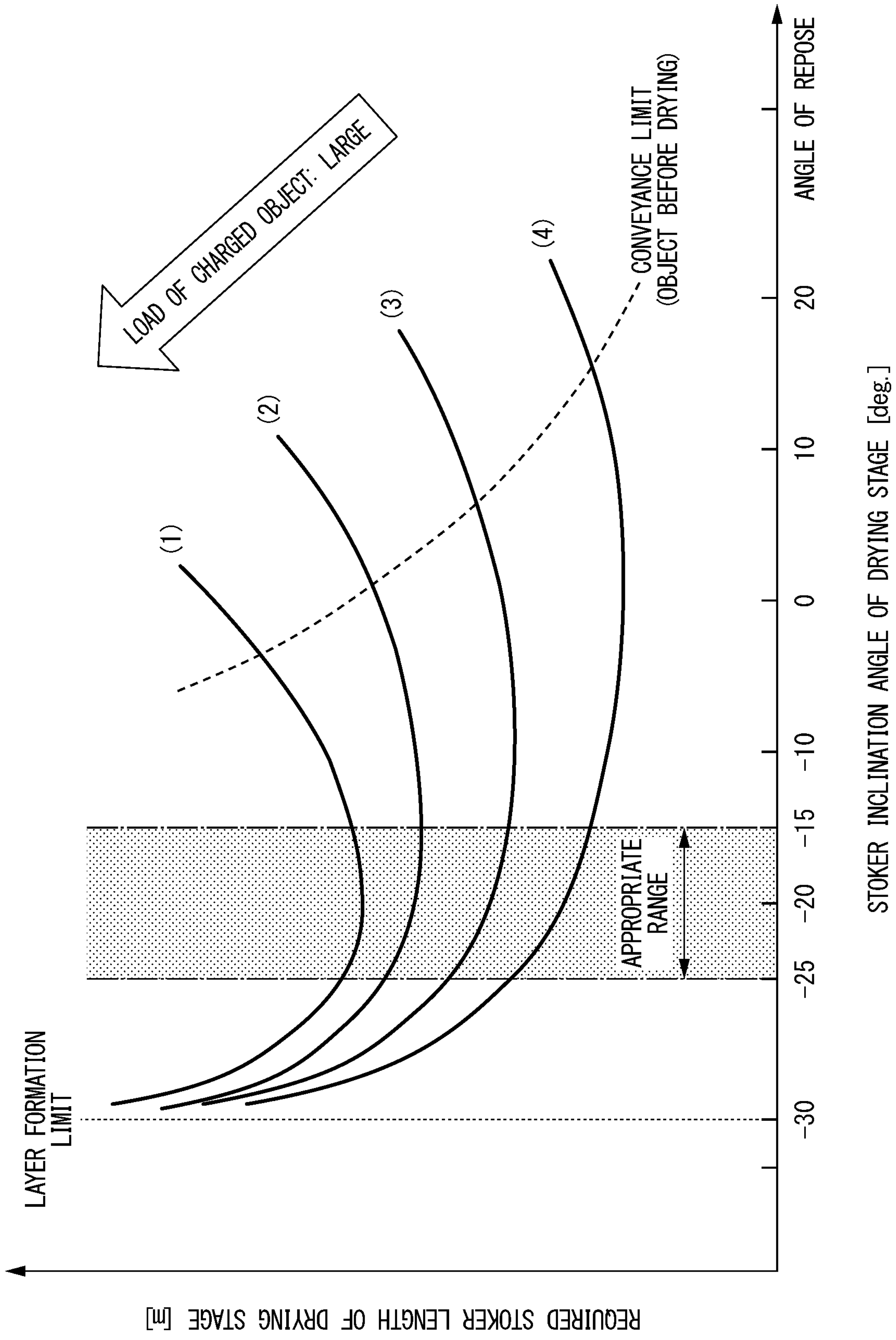


FIG. 4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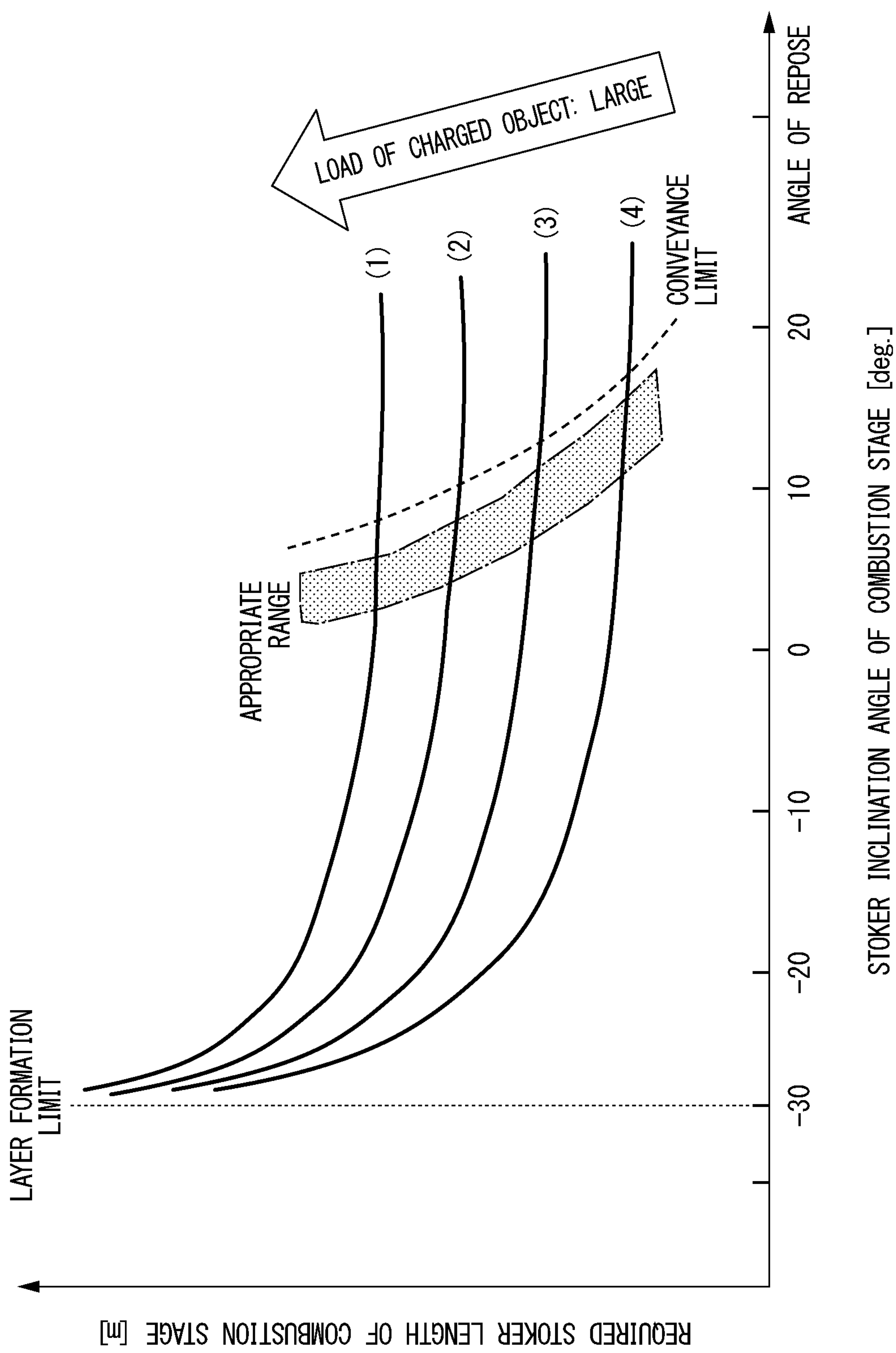
(1)
(2)
(3)
(4)
CONVEYANCE LIMIT
(OBJECT BEFORE DRYING)
LAYER FORMATION
LIMIT
APPROPRIATE
RANGE
ANGLE OF REPOSE
REQUIRED STOKER LENGTH OF DRYING STAGE [m]
STOKER INCLINATION ANGLE OF DRYING STAGE [deg.]
−30
−25
−20
−15
−10
0
10
20

FIG. 5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(4)
CONVEYANCE LIMIT
APPROPRIATE RANGE
LAYER FORMATION LIMIT
ANGLE OF REPOSE
-30
-20
-10
0
10
20
STOKER INCLINATION ANGLE OF COMBUSTION STAGE [deg.]
REQUIRED STOKER LENGTH OF COMBUSTION STAGE [m]

FIG. 6

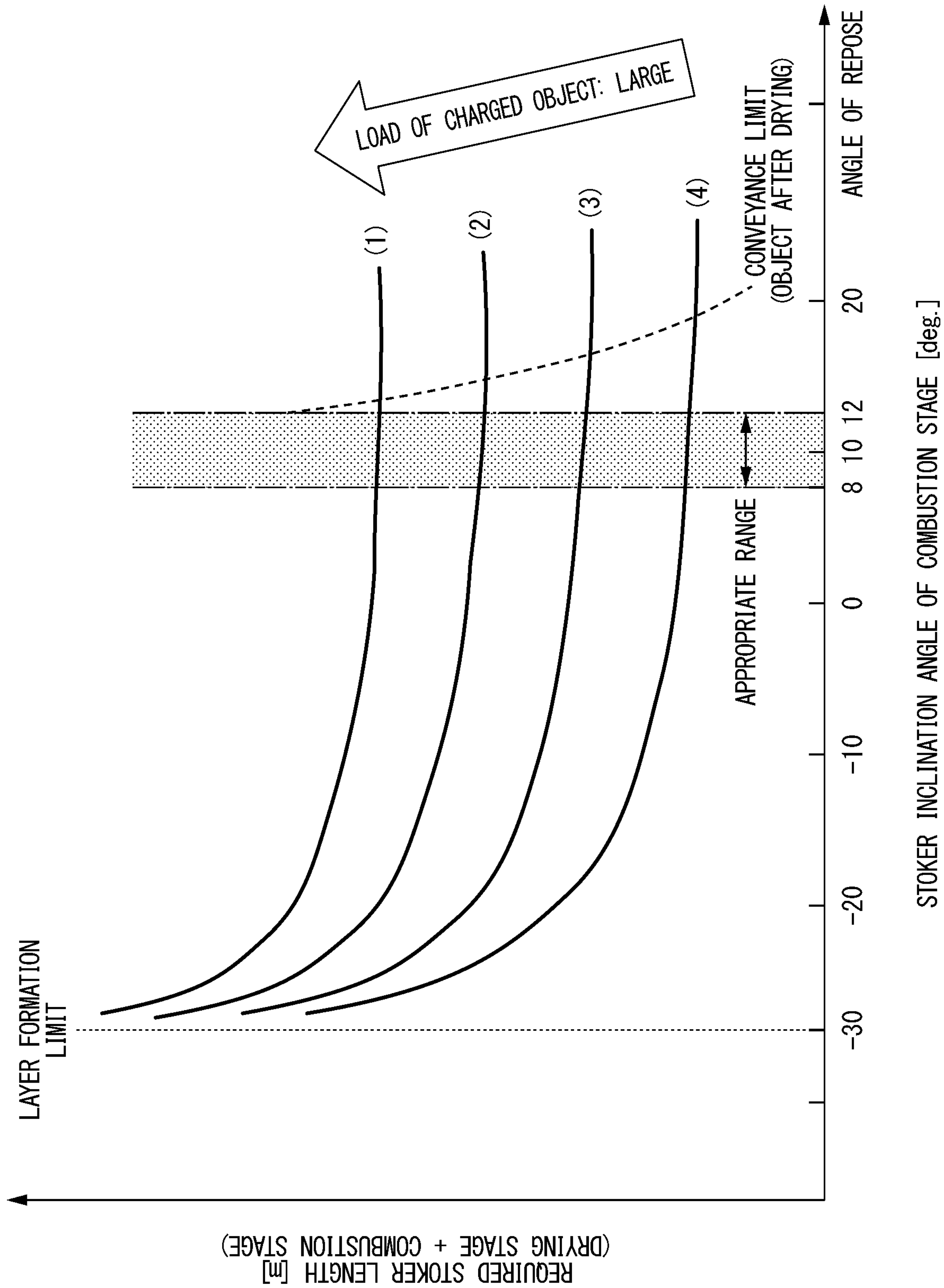
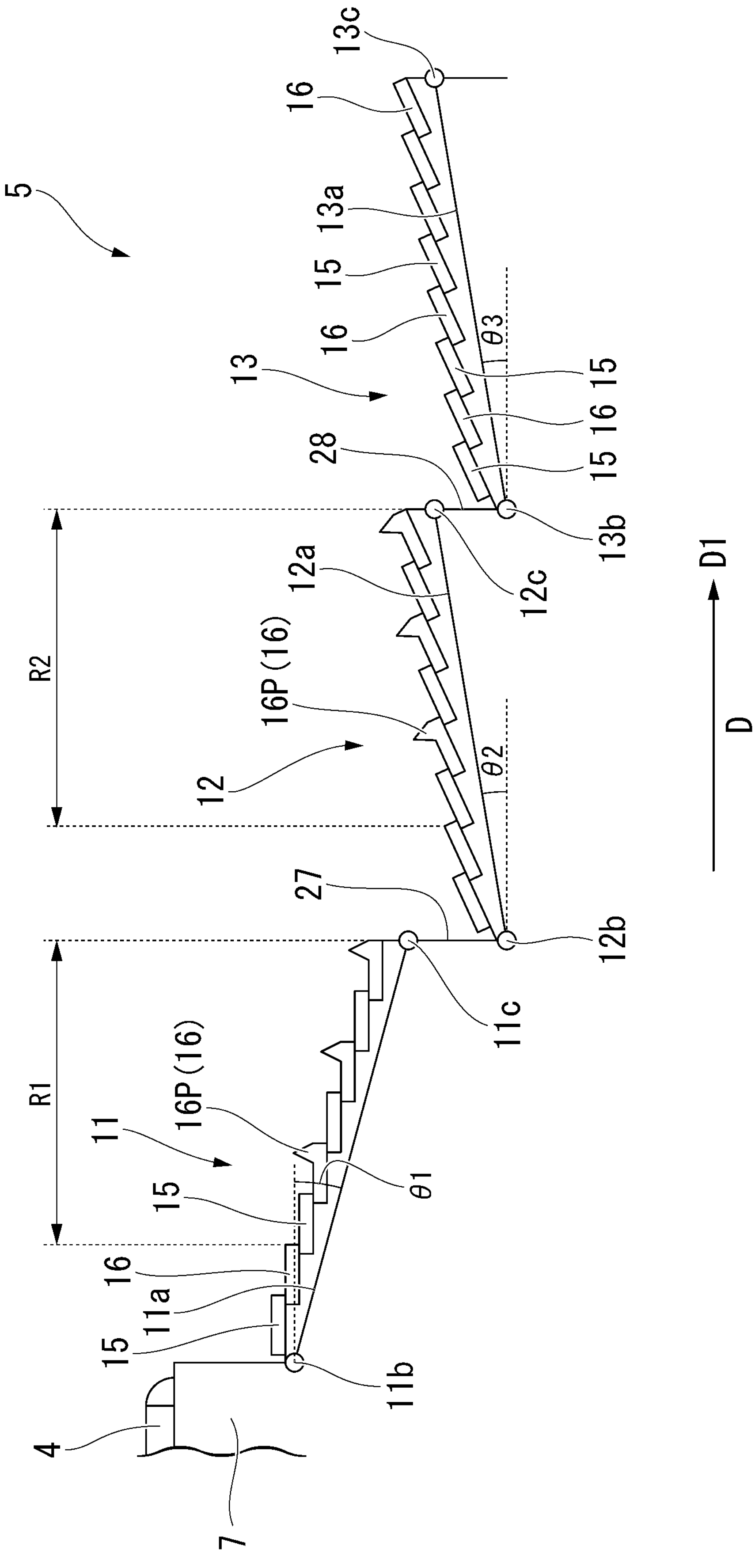

LOAD OF CHARGED OBJECT: LARGE
(1)
(2)
(3)
(4)
CONVEYANCE LIMIT
(OBJECT AFTER DRYING)
ANGLE OF REPOSE
APPROPRIATE RANGE
LAYER FORMATION
LIMIT
-30
-20
-10
0
8 10 12
20
STOKER INCLINATION ANGLE OF COMBUSTION STAGE [deg.]
REQUIRED STOKER LENGTH [m]
(DRYING STAGE + COMBUSTION STAGE)

FIG. 7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13c
16
13a
15
16
θ3
13
15
16 15
15 16
28
13b
R2
12a
12c
D1
16P (16)
12
θ2
D
27
12b
R1
11c
16P (16)
11
θ1
15
16
11a
15
11b
4
7

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2018/039873

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F23G5/00(2006.01)i, F23G5/50(2006.01)i, F23H7/08(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)
Int. Cl. F23G5/00, F23G5/50, F23H7/08

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2018
Registered utility model specifications of Japan 1996-2018
Published registered utility model applications of Japan 1994-2018

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	JP 9-280520 A (MITSUBISHI HEAVY INDUSTRIES, LTD.) 31 October 1997, paragraphs [0026]-[0054], fig. 1 (Family: none)	1-5
Y	JP 2009-121747 A (HITACHI ZOSEN CORP.) 04 June 2009, paragraphs [0015], [0016], fig. 1 (Family: none)	1-5
Y	JP 59-86814 A (SANKI ENG CO., LTD.) 19 May 1984, page 2, upper left column, line 3 to upper right column, line 12, fig. 1 (Family: none)	1-5

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

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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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
07.12.2018	18.12.2018

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

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

REFERENCES CITED IN THE DESCRIPTION

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- JP H6265125 A **[0006]**
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- JP S57127129 U **[0006]**