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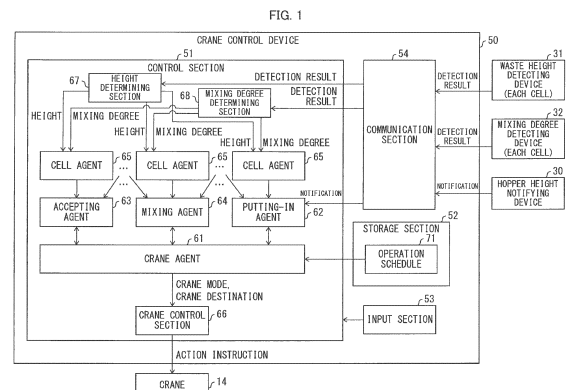
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(54) **CRANE CONTROL DEVICE, METHOD FOR CONTROLLING CRANE CONTROL DEVICE, CONTROL PROGRAM, AND RECORDING MEDIUM**

(57) A crane control device (50) includes (i) a mixing agent (64) that determines, based on a height and a degree of mixing of waste in each of a plurality of sections into which a waste storing section (11) is divided, a section to be set as a waste grabbing location when a crane (14) is controlled to execute mixing work and (ii) a crane control section (66) that controls the waste grabbing action to be executed at the determined section.



Description

Technical Field

5 **[0001]** The present invention relates to a crane control device and the like for controlling an action of a crane in a waste pit provided in a waste incineration plant.

Background Art

10 **[0002]** A waste incineration plant includes a waste pit for temporarily storing waste that has been brought in by a garbage truck. The waste inside the waste pit is mixed by a crane, and then transferred to an incinerator for incineration. The mixing is carried out in order to homogenize properties of waste that is to be fed into the incinerator, and is thus an important process for stably burning waste. For example, Patent Literatures 1 and 2 below can be cited as prior art documents relating to such automatic control of a crane.

15 **[0003]** Patent Literature 1 discloses an automatic crane operation device that detects a color distribution in a waste pit and transfers waste inside the waste pit such that the waste entirely has the same color distribution.

[0004] Patent Literature 2 discloses an automatic operation device which determines a height of a waste layer in a waste pit, grabs waste existing at a higher location, and automatically restacks the waste at a lower location.

20 Citation List

[Patent Literature]

25 **[0005]** Patent Literature 1: Japanese Patent Application Publication *Tokukaisho* No. 64-49815 (Publication Date: February 27, 1989)

[0006] Patent Literature 2: Japanese Patent Application Publication *Tokukaisho* No. 56-28188 (Publication Date: March 19, 1981)

Summary of Invention

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Technical Problem

[0007] However, the above conventional techniques are not sufficient for optimizing an action of the crane. For example, according to the technique disclosed in Patent Literature 1, although waste is mixed so that the color distribution becomes homogeneous, colors of waste do not necessarily represent waste properties and a degree of mixing cannot be determined based only on the colors of waste. From this, according to the technique of Patent Literature 1, it is sometimes impossible to obtain a mixed state in which the waste properties are homogeneous. Moreover, there has been no practical evaluation index of waste property so far, and this fact also makes it difficult to cause the crane to execute optimal actions (i.e., actions of grabbing waste at an optimal location and releasing the waste at an optimal location). Meanwhile, according to the technique of Patent Literature 2, although it is possible to automatically restack waste from a higher portion to a lower portion based on determined heights of a waste layer, homogenization of waste properties is not considered and it is impossible to obtain a mixed state in which the waste properties are homogeneous.

[0008] Therefore, conventionally, cranes are manipulated based on experiences and intuitions of operators in many waste incineration plants, and this causes a problem that it is impossible to avoid a certain degree of unevenness in waste properties, although it depends on qualifications of operators. Moreover, in recent years, a size of a waste incineration plant is becoming smaller, and this reduction in size enables decrease in production cost of the waste incineration plant. On the other hand, however, a waste storing section also becomes smaller and waste is stacked in such a small space, and this makes it difficult to carry out mixing work for homogenizing waste properties. Further, waste is brought into the small waste storing section one after another, and this causes increase in time taken to restack waste, and this further leads to time constraints on mixing of waste. Consequently, the waste is burned while being insufficiently mixed, and therefore combustion of the waste becomes unstable.

[0009] Pieces of work to be executed by the crane encompass, in addition to the above mixing work, restacking work to restack, in a mixing area, waste which has been stacked in an acceptance area into which waste is brought, putting-in work to put mixed waste into a hopper so that the waste is fed into the incinerator, and the like. In those pieces of work also, it is preferable to determine a waste grabbing location and a waste releasing location while taking into consideration both a height of waste and a degree of mixing waste.

[0010] The present invention is accomplished in view of the problems, and its object is to provide a crane control device and the like that can control a crane to execute predetermined work at an appropriate waste grabbing location

which corresponds to both a height of waste and a degree of mixing waste.

Solution to Problem

[0011] In order to attain the object, a crane control device in accordance with an aspect of the present invention is a crane control device that controls an action of a crane for transferring waste in a waste pit, the crane control device including: a location determining section that determines, based on a height and a degree of mixing of waste in each of a plurality of sections into which a waste storing section in the waste pit is divided, a section to be set as a waste grabbing location when the crane is controlled to execute predetermined work including a waste grabbing action; and a crane control section that controls the crane to execute the waste grabbing action at the section which has been determined by the location determining section when the crane is controlled to execute the predetermined work.

[0012] In order to attain the object, a method for controlling a crane control device in accordance with an aspect of the present invention is a method for controlling a crane control device that controls an action of a crane for transferring waste in a waste pit, the method including the steps of: determining, based on a height and a degree of mixing of waste in each of a plurality of sections into which a waste storing section in the waste pit is divided, a section to be set as a waste grabbing location when the crane is controlled to execute predetermined work including a waste grabbing action; and controlling the crane to execute the waste grabbing action at the section which has been determined by the determining step when the crane is controlled to execute the predetermined work.

Advantageous Effects of Invention

[0013] According to an aspect of the present invention, it is possible to bring about an effect of controlling the crane to execute predetermined work at an appropriate waste grabbing location which corresponds to both a height of waste and a degree of mixing waste.

Brief Description of Drawings

[0014]

Fig. 1 is a block diagram illustrating an example configuration of main parts in a crane control device in accordance with an embodiment of the present invention.

Fig. 2 is a cross-sectional view schematically illustrating a configuration of a waste incineration plant including a waste pit.

Fig. 3 is a view illustrating a waste storing section and a hopper in the waste pit seen from above.

Fig. 4 is a view illustrating an example of setting sections in the waste storing section.

Fig. 5 is a view illustrating an example of setting areas.

Fig. 6 is a view illustrating a relation between agents.

Fig. 7 is a view showing an example of an operation schedule.

Fig. 8 is a flowchart illustrating an example of processes carried out by the crane control device when waste is mixed or restacked in accordance with an operation schedule.

Fig. 9 is a flowchart illustrating an example of processes carried out by the crane control device when the crane control device has detected a putting-in instruction.

Description of Embodiments

[0015] The following description will discuss an embodiment of the present invention with reference to Figs. 1 through 9. The present invention relates to a crane control device and the like for controlling actions of a crane that transfers waste in a waste pit. Accordingly, first, a waste pit and a waste incineration plant including the waste pit will be described with reference to Fig. 2.

[Overview of waste incineration plant]

[0016] Fig. 2 is a cross-sectional view schematically illustrating a configuration of a waste incineration plant including a waste pit. The waste incineration plant which is illustrated in Fig. 2 includes (i) a waste pit 1 for temporarily storing waste that has been brought in by a garbage truck P and (ii) an incinerator 2 for burning waste in the waste pit 1. The waste pit 1 and the incinerator 2 are connected with each other via a hopper 12 for supplying waste into the incinerator 2. Waste in the waste pit 1 is supplied to the incinerator 2 through the hopper 12 and is then burned.

[0017] A bottom of the waste pit 1 is a waste storing section 11. The garbage truck P drops waste into the waste

storing section 11 via a bring-in door 11a, and the waste is stored in the waste storing section 11 (see waste G in Fig. 2).

[0018] The waste storing section 11 and the hopper 12 are covered with a building 13. In a ceiling part of the building 13, a crane 14 is provided. The crane 14 includes a girder 15, a transverse carriage 16, a bucket 17, a wire 18, and a winder 19. The girder 15 is provided so as to extend between rails (extending in a depth direction in Fig. 2) which are respectively provided on facing wall surfaces of the building 13. The girder 15 is configured to move along the rails in the depth direction in Fig. 2. The transverse carriage 16 is provided on the girder 15, and is configured to move on the girder 15 in the left-right direction in Fig. 2 (i.e., in a direction that is perpendicular to a moving direction of the girder 15). On the transverse carriage 16, the winder 19 (e.g., a winch) is placed, and the bucket 17 for grabbing waste G is provided at an end of the wire 18 that extends from the winder 19. The bucket 17 can open and close.

[0019] As such, the girder 15 can be moved in the depth direction in Fig. 2 and the transverse carriage 16 can be moved in the left-right direction in Fig. 2. Therefore, a combination of these movements enables the bucket 17 to move to an arbitrary location in the waste storing section 11. The wire 18 is extended from the winder 19 so as to drop the bucket 17, and thereby the bucket 17 can grab waste G in the waste storing section 11. The waste G thus grabbed can be restacked on another location in the waste storing section 11 or put into the hopper 12 by control of motions of the girder 15, the transverse carriage 16, the bucket 17, and the winder 19.

[0020] Such motion control of the crane 14 can be carried out manually in a control room 21 that is provided in a lateral wall part 13a of the building 13 so that the waste storing section 11 can be monitored. Alternatively, the motion control of the crane 14 can be automatically carried out by a crane control device as later described.

[0021] In Fig. 2, only one crane 14 is illustrated. Note, however, that it is possible to provide a plurality of cranes 14. In a case where the plurality of cranes 14 are provided, it is possible to carry out mixing more sufficiently, as compared with a case where only one crane 14 is provided. For example, in a case where two cranes 14 are provided, one of the two cranes 14 can be used exclusively for mixing, while the other is used to restack waste and to put waste into the hopper 12.

[0022] The incinerator 2 includes a combustion chamber 3, a waste guiding path 4, an ash outlet 5, and a flue 6. The waste G which has been put into the hopper 12 is supplied to the combustion chamber 3 through the waste guiding path 4 and then burned in the combustion chamber 3. Ash generated by incineration is taken out via the ash outlet 5, and smoke generated by incineration is discharged through the flue 6. Note that, although not illustrated, a boiler is provided in the incinerator 2. Heat generated by burning the waste G is supplied to the boiler, and electricity is generated with use of vapor generated in the boiler.

[Waste storing section]

[0023] Next, the following description will discuss details of the waste storing section 11 with reference to Fig. 3. Fig. 3 is a view illustrating the waste storing section 11 and the hopper 12 seen from above. The waste storing section 11 illustrated in Fig. 3 has a horizontally-long rectangular shape. Three bring-in doors 11a are provided on one of longer sides of the waste storing section 11, and two hoppers 12 (i.e., a hopper 1 and a hopper 2) are provided on the opposite longer side. In the example illustrated in Fig. 3, the waste storing section 11 is divided into 80 sections in a matrix of 5 (longitudinal) $\times$ 16 (transverse). Two rows of sections on a bring-in door 11a side serve as an acceptance area for accepting waste that has been brought in, and three rows of sections on a hopper 12 side serve as a mixing area for mixing waste. The hoppers 12 can be used to supply waste into the same incinerator 2 or can be used to supply waste into respectively different incinerators 2. That is, in the waste incineration plant in accordance with the present embodiment, it is possible to provide a plurality of incinerators 2.

[0024] In management of the waste pit 1, it is important to appropriately mix and transfer waste by efficiently operating the crane 14 in the waste storing section 11 that has a limited capacity. Note that a shape of the waste storing section 11 is not limited to the rectangular shape and can be a square shape. Moreover, a location, the number of pieces, and a shape of the hopper 12 are also not limited to particular ones.

[Crane control device]

[0025] Next, the following description will discuss, with reference to Fig. 1, the crane control device which controls the crane 14 to automatically operate. Fig. 1 is a block diagram illustrating an example configuration of main parts in a crane control device 50. Note that the crane control device 50 can be provided in the control room 21 or can be provided elsewhere.

[0026] As illustrated in Fig. 1, the crane control device 50 includes (i) a control section 51 which comprehensively controls sections included in the crane control device 50 and (ii) a storage section 52 which stores various kinds of data used by the crane control device 50. Moreover, the crane control device 50 includes (i) an input section 53 which accepts an input from a user with respect to the crane control device 50 and (ii) a communication section 54 with which the crane control device 50 communicates with another device.

[0027] The control section 51 includes a crane agent (area setting section/conflict adjusting section) 61, a putting-in agent (location determining section/putting-in managing section) 62, an accepting agent (location determining section/acceptance managing section) 63, a mixing agent (location determining section/mixing managing section) 64, a cell agent (section managing part) 65, a crane control section 66, a height determining section 67, and a mixing degree determining section 68. The storage section 52 stores an operation schedule 71.

[0028] The crane agent 61 is a software agent that determines an action of the crane 14. In a case where two or more cranes 14 are provided, one crane agent 61 can be provided for each of the cranes 14. The crane agent 61 sets, in accordance with the operation schedule 71, a waste grabbing area in which a waste grabbing action is to be executed and a waste grabbing area in which a waste releasing action is to be executed (details of this operation will be described later). Then, the crane agent 61 determines details of an action of the crane 14, that is, a location to which the crane 14 is to be moved and work (mixing/restacking/putting-in) to be executed by the crane 14, in accordance with an instruction given from another agent. Further, the crane agent 61 notifies the crane control section 66 of the work (which is also referred to as "crane mode") and a destination (coordinates) of the crane 14 which have been determined as above described.

[0029] The putting-in agent 62 is a software agent that manages putting-in work to put waste into the hopper 12. Specifically, in a case where the putting-in agent 62 has received, via the communication section 54, a notice from a hopper height notifying device 30 which gives a notice indicating that a height of waste in the hopper 12 has become equal to or lower than a predetermined lower limit, the putting-in agent 62 detects that a putting-in instruction on putting waste into the hopper 12 has been given. In a case where the putting-in agent 62 has detected the putting-in instruction, the putting-in agent 62 determines, based on index values calculated by the cell agents 65, a section (i.e., a section to be set as a waste grabbing location) from which waste is to be put into the hopper 12 (details of this operation will be described later). Note that details of the "section" will be described later with reference to Fig. 4. The hopper height notifying device 30 notifies the putting-in agent 62 of also information indicating a height of waste in the hopper 12, and therefore the putting-in agent 62 sets, for the putting-in work, a degree of urgency which corresponds to the height notified by the hopper height notifying device 30 (here, the degree of urgency becomes higher as the height is smaller).

[0030] The accepting agent 63 is a software agent that manages restacking work to restack waste from an acceptance area to a mixing area. The acceptance area is an area for accepting waste which is brought into the waste pit 1, and the mixing area is an area for mixing waste. The accepting agent 63 determines, based on index values calculated by the cell agents 65, a section that is to be set as a waste grabbing location (which is in the acceptance area) and a section that is to be set as a waste releasing location (which is in the mixing area) for the restacking work (details of this operation will be described later).

[0031] The mixing agent 64 is a software agent that manages mixing work in which waste is grabbed in a mixing area and then the waste thus grabbed is released in the same mixing area. The mixing agent 64 determines, based on index values calculated by the cell agents 65, a section that is to be set as a waste grabbing location and a section that is to be set as a waste releasing location for the mixing work (details of this operation will be described later).

[0032] The cell agent 65 is a software agent which is provided for each of a plurality of sections into which the waste storing section 11 has been divided. One cell agent 65 manages one section and maintains, as pieces of information indicative of a state of the section, (i) information indicative of a height of waste in the section which is managed by that cell agent 65 and (ii) information indicative of a degree of mixing waste in the section. The cell agent 65 calculates, with use of those pieces of information, an index value that indicates a degree of necessity of a waste grabbing action or a waste releasing action in the section managed by the cell agent 65. Note that the degree of necessity corresponds to a height of waste and a degree of mixing waste in the section managed by the cell agent 65.

[0033] The crane control section 66 controls the crane 14 to execute work of a crane mode (that is, mixing, restacking, or putting-in) that has been notified by the crane agent 61. Destinations (i.e., a waste grabbing location and a waste releasing location) of the crane 14 for the work are determined based on an instruction given from the crane agent 61.

[0034] The height determining section 67 determines a height of waste in each of cells (i.e., each of sections) in the waste storing section 11 based on a detection result obtained by a waste height detecting device 31. Specifically, the waste height detecting device 31 in accordance with the present embodiment is an image capturing device that captures an image inside the waste storing section 11. Therefore, the height determining section 67 receives the image via the communication section 54 and analyzes the image, and thus determines a height of waste in each of the sections. Note that a method for determining a height of waste in each of the sections is not limited to this example, and it is possible to determine the height with use of a sensor or the like or it is possible to determine the height based on a length of the wire 18 with which length the bucket 17 has reached the waste. Fig. 1 illustrates the example in which one communication section 54 is used in communication with the hopper height notifying device 30 and the waste height detecting device 31. Note, however, that communication can be carried out with use of separate communication sections.

[0035] The mixing degree determining section 68 determines a degree of mixing in each of cells (i.e., each of sections) in the waste storing section 11 based on a detection result obtained by a mixing degree detecting device 32. Specifically, the mixing degree detecting device 32 in accordance with the present embodiment retains and updates the number of

mixing actions for each cell. Therefore, the mixing degree determining section 68 obtains the number of mixing actions (i.e., the accumulated number of mixing actions after waste was brought into the waste storing section 11) on waste for each cell from the mixing degree detecting device 32 and determines that the number of mixing actions is a degree of mixing for each cell.

[0036] Note that the mixing degree detecting device 32 monitors actions of the crane 14 and bringing-in of waste, and updates the number of mixing actions for each cell every time the crane 14 carries out work or every time waste is brought in. Specifically, in a case where waste has been brought in, the mixing degree detecting device 32 changes the number of mixing actions into zero on waste in an uppermost layer in a cell that has accepted the waste which has been brought in. Note that, in a case where waste already exists in the cell, the number of mixing actions in the cell is not updated and is maintained. In a case where the crane 14 has carried out a waste grabbing action, the mixing degree detecting device 32 updates the number of mixing actions at the waste grabbing location into the number of mixing actions on waste that becomes in an uppermost layer by the waste grabbing action at the location. Then, the mixing degree detecting device 32 updates the number of mixing actions at a waste releasing location into a value obtained by adding 1 to the number of mixing actions at the location at which the waste has been grabbed immediately before the release. For example, the following description will assume a case where a height of waste at a waste grabbing location is 1.0 m, the number of mixing actions in a layer A (having a thickness of 0.5 m from an upper surface) is 2, and the number of mixing actions in a layer B (having a thickness of 0.5 m from the bottom of the waste storing section 11) is 1. In this case, with use of the above described model, the layer B for which the number of mixing actions is 1 becomes an uppermost layer by a waste grabbing action, and therefore the number of mixing actions at a waste grabbing location is updated to be 1. Moreover, waste of the layer A for which the number of mixing actions is 2 is dropped onto a waste releasing location, and therefore the number of mixing actions at the waste releasing location is updated to be $2 + 1 = 3$. Note that such an update of the number of mixing actions can be carried out by the mixing degree determining section 68.

[0037] The operation schedule 71 is information indicative of a schedule of operating the crane 14, specifically, information indicative of a waste grabbing area and of a setting of the waste grabbing area. Details of the operation schedule 71 will be described later with reference to Fig. 7.

[Section setting]

[0038] The following description will discuss an example of setting sections with reference to Fig. 4. Fig. 4 is a view illustrating an example of setting sections in the waste storing section 11. In the example shown in Fig. 4, the waste storing section 11 is divided into 80 sections in a matrix of 5 (longitudinal) $\times$ 16 (transverse), and a height of waste and the number of mixing actions in each of the sections are indicated. A method for determining sections is not limited in particular but it is preferable to set a range which corresponds to one grab of the crane 14 as one section, because an update of a state after an action of the crane 14 and the like are simplified.

[0039] In Fig. 4, locations of the respective sections are represented by (X,Y) coordinates (here, $X = 1, 2, \dots, 16$, and $Y = 1, 2, \dots, 5$). Moreover, area settings (later described in detail with reference to Fig. 5) are indicated by different colors. Specifically, a range of $1 \leq X \leq 15, 1 \leq Y \leq 3$ is set as a mixing area. A range $1 \leq X \leq 15, 4 \leq Y \leq 5$ is set as an acceptance area. A range of $X = 16, 1 \leq Y \leq 3$ is set as a non-mixing area that is not used for mixing.

[0040] In a case where the sections are set as above described, the number of cell agents 65 to be provided is 80 which is identical with the number of the sections. Each of the cell agents 65 maintains, as information indicative of a state of a corresponding section, a height of waste and the number of mixing actions in the section. For example, a section at coordinates (5,3) is a section in the mixing area, and a cell agent 65 that manages the section maintains a height = 1400 mm and the number of mixing actions = 4 as information indicative of a state of the section. In the present embodiment, an example is described in which the number of mixing actions is used as information indicative of a degree of mixing waste. Note, however, that information indicative of a degree of mixing waste is not limited to this example. For example, it is possible to use granularity, a bulk specific gravity, or the like of waste as information indicative of a degree of mixing waste.

[Area setting]

[0041] The waste storing section 11 in the waste pit 1 is managed while being divided into a plurality of areas. The following description will discuss how area setting for the waste storing section 11 is carried out, with reference to Fig. 5. Fig. 5 is a view illustrating an example of setting areas. In an example illustrated in (a) of Fig. 5, a mixing area, an acceptance area, and non-mixing areas (indicated by $\times$ -marks) are set in the waste storing section 11 which has a rectangular shape when viewed from above. Note that the acceptance area is provided on a bring-in door 11a side. Waste which has been brought in by the garbage truck P is dropped into the acceptance area (see Fig. 3), and therefore this area is dealt with as a non-mixing area at least during a period in which waste is to be brought in. The acceptance area and the mixing area can be partitioned by a bank or the like.

[0042] In an example illustrated in (a) of Fig. 5, only one mixing area is provided. In each of examples illustrated in (b) through (d) of Fig. 5, a plurality of mixing areas are provided. It is preferable to provide a plurality of mixing areas because waste in a certain mixing area can be restacked in another mixing area as shown in <<A-A cross section>> and <<B-B cross section>> in Fig. 5, and this makes it possible to mix even waste in a deep part.

[0043] In an example illustrated in (b) of Fig. 5, an intermediate area is set between two mixing areas. The intermediate area and each of the mixing areas can be partitioned by a bank or the like. As shown in <<A-A cross section>> of Fig. 5, an upper surface of waste in the intermediate area sometimes inclines. In a case where the bucket 17 is dropped onto such an inclined part, it sometimes happens that the bucket 17 is tilted and therefore cannot grab waste. In view of this, it is preferable that the intermediate area is also dealt with as a non-mixing area.

[0044] The operation schedule 71 defines which one(s) of such areas is set as a waste grabbing area(s) and which one(s) of the areas is set as a waste releasing area(s). Therefore, in a case where the crane 14 is operated in accordance with the operation schedule 71, an action of the crane 14 between predetermined areas is guaranteed. For example, in a case where the areas are set as illustrated in (c) of Fig. 5, the operation schedule 71 can define that the mixing area 1 is set as a waste grabbing area, and the mixing area 2 is set as a waste releasing area. Therefore, in a case where the crane 14 is operated in accordance with the operation schedule 71, it is possible to surely restack waste from the mixing area 1 to the mixing area 2.

[0045] In an example illustrated in (d) of Fig. 5, a half of the mixing area in (c) of Fig. 5 is set as a leaving area. The leaving area is an area for leaving waste which has been stacked in the area as it is for a predetermined period (e.g., 2 to 3 days). In a case where the area setting is applied, in the operation schedule 71, the leaving area is set to be neither a waste grabbing area nor a waste releasing area until the predetermined period elapses. From this, waste in the leaving area is not mixed and no waste is newly restacked in the leaving area until the predetermined period elapses. Moreover, the mixing area 2 can be used as an area for blending waste of the mixing area 1 and waste of the mixing area 3. Therefore, the mixing area 2 is indicated as a blending area. Note that, in the examples illustrated in (c) and (d) of Fig. 5 also, it is of course possible that a boundary part between the mixing areas or a boundary part between the mixing area and the leaving area is set as an intermediate area.

[0046] It is only necessary that the area setting is determined at the latest by a time point at which an action of the crane 14 is initiated. For example, the area setting can be made by a user via the input section 53 when an action of the crane 14 is to be initiated. Moreover, in this case, the user may also input an operation schedule 71 via the input section 53.

[Relation between agents]

[0047] The following description will discuss a relation between agents with reference to Fig. 6. Fig. 6 is a view illustrating a relation between agents. As illustrated in Fig. 6, the agents are classified into three levels. Specifically, a highest level includes the crane agent 61, a lowest level includes the cell agents 65, and an intermediate level therebetween includes the putting-in agent 62, the accepting agent 63, and the mixing agent 64.

[0048] The putting-in agent 62 determines a section to be set as a waste grabbing location in putting-in work based on index values calculated by cell agents 65 for sections included in an area from which waste is to be put into the hopper 12, and the putting-in agent 62 notifies the crane agent 61 of the section thus determined. Moreover, the putting-in agent 62 also sets a degree of urgency (which becomes higher as a height of waste is lower) corresponding to a height of waste in the hopper 12, and the putting-in agent 62 notifies the crane agent 61 of the degree of urgency thus set. A waste grabbing location in putting-in work is basically a section in a mixing area. Note, however, that it is possible to set a section in an acceptance area as a waste grabbing location during a time zone in which the acceptance area is used for mixing.

[0049] The accepting agent 63 determines a section to be set as a waste grabbing location in restacking work based on index values calculated by cell agents 65 for sections included in an acceptance area. The accepting agent 63 also determines a section to be set as a waste releasing location in the restacking work based on index values calculated by cell agents 65 for sections included in a mixing area. Then, the accepting agent 63 notifies the crane agent 61 of the sections thus determined.

[0050] It is possible that the accepting agent 63 sets a degree of urgency (which becomes higher as a height of waste increases) corresponding to a height of waste in a section at which a waste grabbing action is to be executed, and the accepting agent 63 notifies the crane agent 61 of the degree of urgency thus set. This is because, in a case where a height of waste in the acceptance area becomes excessively high, a problem may occur in bringing waste in, and therefore the height of waste in the acceptance area is desirably managed more strictly than a mixing area. For example, it is possible that the height of waste is classified into three levels, i.e., upper, middle, and lower levels, and degrees of urgency corresponding to the levels are set to be 3, 2, and 1, respectively. From this, it is possible to control the crane 14 to preferentially carry out restacking work as compared with mixing work and putting-in work to put waste into the hopper 12, depending on a height of waste in the acceptance area. Note that the degree of urgency can be set based

on a maximum height of waste in the acceptance area or on an average height of waste in the acceptance area.

[0051] The mixing agent 64 determines, based on index values calculated by cell agents 65 for sections included in an area in which mixing is to be executed, a section at which the crane 14 is to execute a waste grabbing action and a section at which the crane 14 is to execute a waste releasing action in mixing work. Then, the mixing agent 64 notifies the crane agent 61 of the sections thus determined. A waste grabbing location and a waste releasing location in mixing work are basically sections in a mixing area. Note, however, that it is possible to set sections in an acceptance area as a waste grabbing location and a waste releasing location during a time zone in which the acceptance area is used for mixing.

[0052] The crane agent 61 determines to cause the crane 14 to execute putting-in work in accordance with a notice given from the putting-in agent 62, and determines to cause the crane 14 to execute restacking work in accordance with a notice given from the accepting agent 63. Moreover, the crane agent 61 determines to cause the crane 14 to execute mixing work in accordance with a notice given from the mixing agent 64.

[0053] In a case where the notices from respective of the putting-in agent 62, the accepting agent 63, and the mixing agent 64 conflict with each other, the crane agent 61 determines one of the notices which one corresponds to work to be preferentially executed by the crane 14.

[Example of operation schedule]

[0054] Next, the following description will discuss an example of an operation schedule with reference to Fig. 7.

[0055] Fig. 7 is a view showing an example of an operation schedule. The example illustrated in Fig. 7 shows an operation schedule for 24 hours from 6:00 on a weekday on which waste is to be brought in to 6:00 on the next day. In the example shown in Fig. 7, two mixing areas are set. Note that, as in the example illustrated in (b) of Fig. 5, it is possible to set an intermediate area between the two mixing areas.

[0056] In the operation schedule in accordance with the present embodiment, a waste grabbing area and a waste releasing area are set for each time zone. In Fig. 7, a section set as a waste grabbing area is indicated by a sign "+", and a section set as a waste releasing area is indicated by a sign "-". That is, in Fig. 7, a section with the sign "+" indicates that a waste grabbing action is to be carried out in the section, and a section with the sign "-" indicates that a waste releasing action is to be carried out in the section. Note that sections (i.e., the non-mixing areas and the acceptance area in the example of Fig. 7) which are free of any signs are sections at which neither a waste grabbing action nor a waste releasing action is to be carried out.

[0057] Specifically, at the time point of 6:00 which is a time to finish restacking (i.e., restacking from the acceptance area to the mixing area) for accepting waste, a left mixing area is set as a waste grabbing area, and the sections in the area are respectively indicated by the signs "+". Moreover, a right mixing area is set as a waste releasing area, and the sections in the area are respectively indicated by the signs "-". From this, at and after 6:00, the crane 14 carries out mixing work in which the crane 14 grabs waste in the left mixing area and releases the waste in the right mixing area.

[0058] At a time point of 9:00 at which bringing-in of waste starts, the entire acceptance area is set as a waste grabbing area, and the entire mixing areas are set as waste releasing areas. That is, according to the operation schedule, locations and ranges of the waste grabbing area and the waste releasing area are changed at 9:00. From this, at and after 9:00, the crane 14 carries out restacking work in which the crane 14 grabs waste in the acceptance area and releases the waste in the mixing area. Note that, at the time point, the waste grabbing area is the acceptance area, and therefore the accepting agent 63 determines sections to be set as waste grabbing locations and sections to be set as waste releasing locations.

[0059] At a time point of 17:00 at which bringing-in of waste ends, the entire acceptance area and the right mixing area are set as waste grabbing areas, and the left mixing area is set as a waste releasing area. From this, at and after 17:00, the crane 14 carries out restacking work in which the crane 14 grabs waste in the acceptance area and releases the waste in the left mixing area, and the crane 14 carries out mixing work in which the crane 14 grabs waste in the right mixing area and releases the waste in the left mixing area. Note that the accepting agent 63 determines waste grabbing locations and waste releasing locations in the restacking work, and the mixing agent 64 determines waste grabbing locations and waste releasing locations in the mixing work.

[0060] The operation schedule 71 which is stored in the storage section 52 is information that indicates a waste grabbing area(s) and a waste releasing area(s) for each of those time zones. Note that it is of course possible to change settings of a waste grabbing area and a waste releasing area at any point in time other than the three time points (6:00, 9:00, 17:00) shown in Fig. 7. Alternatively, it is possible that an order of settings of a waste grabbing area and a waste releasing area is defined, and a time to apply each of the settings is not defined. In this case, one setting can be switched to a next setting after work of the one setting is finished.

[0061] In the example illustrated in Fig. 7, the acceptance area is not set as a waste releasing area in all the time zones. Note, however, that the acceptance area can be set as a waste releasing area in a time zone (in this example, 17:00 to 9:00 on the next day) in which waste is not to be brought in. From this, it is possible to carry out restacking work

and mixing work with respect to waste while effectively utilizing the acceptance area.

[Determination of waste grabbing locations and waste releasing locations]

[0062] After the waste grabbing area and the waste releasing area are set as above described, waste grabbing locations (i.e., sections at which waste is to be grabbed) in the waste grabbing area and waste releasing locations (i.e., sections at which waste is to be released) in the waste releasing area are determined. That is, after the waste grabbing area and the waste releasing area are set, sections at which waste is to be grabbed and sections at which waste is to be released are determined. The determination is carried out based on index values calculated by cell agents 65 corresponding to the respective sections included in the waste grabbing area and the waste releasing area.

[0063] Specifically, for restacking work or mixing work, cell agents 65 corresponding to respective sections in the waste grabbing area calculate index values each of which indicates a degree of necessity for carrying out a waste grabbing action at the corresponding section. More specifically, an index value F_P is calculated based on a mathematical formula (1) below, where "H" represents a height of waste in the section and "G" represents the number of mixing actions in the section. Note that " w_H " in the mathematical formula (1) is a weight assigned to the height, and " w_G " is a weight assigned to the degree of mixing. The weights can be set in advance depending on which one of the height and the degree of mixing is to be regarded as important. That is, in a case where a section to be set as a waste grabbing location is determined while setting importance on the height, w_H may be set to be a value that is relatively larger than w_G . In a case where a section to be set as a waste grabbing location is determined while setting importance on the degree of mixing, w_G may be set to be a value that is relatively larger than w_H . Alternatively, in order that a particular section is more likely to be set as a waste grabbing location, at least one of w_H and w_G can be a value greater than those for the other sections. On the contrary, in order that a particular section is less likely to be set as a waste grabbing location, at least one of w_H and w_G can be a value smaller than those for the other sections. The same applies to mathematical formulae (2) and (3) which will be described later.

$$F_P = \{H \times w_H + (1/G) \times w_G\} \cdots (1)$$

[0064] The index value F_P that is calculated based on the mathematical formula becomes larger as the height of waste in a section increases, and also becomes larger as the number of mixing actions decreases. That is, each of all cell agents 65 corresponding to the respective sections in the waste grabbing area requests the crane 14 to execute a waste grabbing action, and the index value F_P indicates intensity of the request. Selection of a section for which the index value F_P is large makes it possible to set, as a waste grabbing location, a section in which the height of waste is large and the number of mixing actions is small, that is, a section for which a degree of necessity for a waste grabbing action is high.

[0065] Cell agents 65 corresponding to respective sections in the waste releasing area calculate index values each of which indicates a degree of necessity for carrying out a waste releasing action at the corresponding section. More specifically, an index value F_D is calculated based on a mathematical formula (2) below, where "H" represents a height of waste in the section and "G" represents the number of mixing actions in the section. Moreover, " w_H " in the mathematical formula (2) is a weight assigned to the height, and " w_G " is a weight assigned to the degree of mixing. Note that the weight values in the mathematical formula (1) may be identical with or different from those in the mathematical formula (2). The weight values may vary for each cell agent 65, and the weight values may vary between a mixing area and an acceptance area. The same applies to a mathematical formula (3) which will be described later.

$$F_D = \{(1/H) \times w_H + G \times w_G\} \cdots (2)$$

[0066] The index value F_D that is calculated based on the mathematical formula becomes larger as the height of waste in a section decreases, and also becomes larger as the number of mixing actions increases. That is, each of all cell agents 65 corresponding to the respective sections in the waste releasing area requests the crane 14 to execute a waste releasing action, and the index value F_D indicates intensity of the request. Selection of a section for which the index value F_D is large makes it possible to set, as a waste grabbing location, a section in which the height of waste is small and the number of mixing actions is large, that is, a section for which a degree of necessity for a waste releasing action is high (that is, a section suitable for carrying out a waste releasing action).

[0067] In this example, the mathematical formula for determining the waste grabbing location is different from the mathematical formula for determining the waste releasing location. Note, however, that it is possible to use the same mathematical formula. For example, both a waste grabbing location and a waste releasing location can be determined

with use of the mathematical formula (1). In this case, a section whose evaluation value calculated based on the mathematical formula (1) is high can be set as a waste grabbing location, and a section whose evaluation value calculated based on the mathematical formula (1) is low can be set as a waste releasing location.

[0068] In a case where the accepting agent 63 determines a waste grabbing location, the accepting agent 63 controls cell agents 65 corresponding to respective sections in the acceptance area to calculate index values based on the mathematical formula (1). Moreover, the accepting agent 63 controls cell agents 65 corresponding to respective sections in the waste releasing area to calculate index values based on the mathematical formula (2).

[0069] Then, the accepting agent 63 selects, from among the cell agents 65 corresponding to the respective sections in the acceptance area, a cell agent 65 which has calculated a largest index value, and the accepting agent 63 determines a section that corresponds to the selected cell agent 65 as a waste grabbing location. Similarly, the accepting agent 63 selects, from among the cell agents 65 corresponding to the respective sections in the waste releasing area, a cell agent 65 which has calculated a largest index value, and the accepting agent 63 determines a section that corresponds to the selected cell agent 65 as a waste releasing location. As such, the waste grabbing location and the waste releasing location for restacking work are determined.

[0070] A process for determining a waste grabbing location and a waste releasing location by the mixing agent 64 is similar to the above described process. That is, the mixing agent 64 controls cell agents 65 corresponding to respective sections in the waste grabbing area to calculate index values based on the mathematical formula (1), and controls cell agents 65 corresponding to respective sections in the waste releasing area to calculate index values based on the mathematical formula (2). Then, the mixing agent 64 determines a section whose index value calculated based on the mathematical formula (1) is largest as a waste grabbing location, and determines a section whose index value calculated based on the mathematical formula (2) is largest as a waste releasing location. As such, the waste grabbing location and the waste releasing location for mixing work are determined.

[0071] Meanwhile, in a case where the putting-in agent 62 determines a waste grabbing location, it is preferable that waste at a section at which waste has been sufficiently mixed and a height of waste is large is put into the hopper 12. In view of this, the cell agent 65 calculates an index value F_P based on a mathematical formula (3) below. Selection of a section for which the index value F_P is large makes it possible to set, as a waste grabbing location, a section at which the height of waste is large and the number of mixing actions is large, that is, a section that is suitable for putting waste into the hopper 12.

$$F_P = \{H \times w_H + G \times w_G\} \cdots (3)$$

[Flow of processes when operation schedule is executed]

[0072] The following description will discuss, with reference to Fig. 8, a flow of processes (i.e., a method for controlling the crane control device) which are carried out when the crane control device 50 executes an operation schedule. Fig. 8 is a flowchart illustrating an example of processes carried out by the crane control device 50 when waste is mixed or restacked in accordance with an operation schedule.

[0073] First, the crane agent 61 reads out the operation schedule 71 from the storage section 52 (S1), and sets symbols (e.g., the signs "+" and "-" as illustrated in Fig. 7) in areas in accordance with the operation schedule 71 which has been read out (S2). In other words, the crane agent 61 sets a waste grabbing area (which is constituted by sections to which the symbols "+" are set) and a waste releasing area (which is constituted by sections to which the symbols "-" are set). Then the crane agent 61 notifies the accepting agent 63 and the mixing agent 64 of the symbols which have been set.

[0074] Next, at least one of the accepting agent 63 and the mixing agent 64 controls cell agents 65 corresponding to respective sections in the area in which the symbols "+" or "-" are set to calculate index values (S3).

[0075] Specifically, in a case where the acceptance area has been set as a waste grabbing area, the accepting agent 63 controls cell agents 65 corresponding to respective sections in the acceptance area to calculate index values. Moreover, the accepting agent 63 controls cell agents 65 corresponding to respective sections in the waste releasing area to calculate index values.

[0076] Meanwhile, in a case where the mixing area has been set as a waste grabbing area, the mixing agent 64 controls cell agents 65 corresponding to respective sections in the waste grabbing area and cell agents 65 corresponding to respective section in the area to calculate index values. Note that, in a case where the mixing area and the acceptance area have been both set as waste grabbing areas, the mixing agent 64 and the accepting agent 63 both control cell agents 65 to calculate index values.

[0077] Subsequently, at least one of the accepting agent 63 and the mixing agent 64 determines a waste grabbing location and a waste releasing location of the crane 14 (S4, determining step). In a case where the accepting agent 63 has determined a waste grabbing location and a waste releasing location in the step S4, the accepting agent 63 transmits,

to the crane agent 61, the waste grabbing location and the waste releasing location which have been thus determined and an instruction on executing restacking work. In a case where a degree of urgency has been set, the accepting agent 63 also notifies the crane agent 61 of the degree of urgency thus set.

[0078] Meanwhile, in a case where the mixing agent 64 has determined a waste grabbing location and a waste releasing location, the mixing agent 64 transmits, to the crane agent 61, the waste grabbing location and the waste releasing location which have been thus determined and an instruction on executing mixing work. Note that, in a case where both the accepting agent 63 and the mixing agent 64 have determined waste grabbing locations and waste releasing locations, both the accepting agent 63 and the mixing agent 64 transmit, to the crane agent 61, instructions on executing pieces of work (i.e., restacking and mixing) and the waste grabbing locations and the waste releasing locations for those pieces of work.

[0079] Next, the crane agent 61 determines an action of the crane 14 in accordance with the pieces of information transmitted from at least one of the accepting agent 63 and the mixing agent 64. Then, the crane agent 61 notifies the crane control section 66 of a crane mode and a destination of the crane 14 so as to operate the crane 14 (S5, crane controlling step). Specifically, in a case where the crane agent 61 has received an instruction on executing restacking work from the accepting agent 63, the crane agent 61 determines to execute the restacking work, and notifies the crane control section 66 of a crane mode (i.e., restacking) and destinations (i.e., a waste grabbing location and a waste releasing location). Meanwhile, in a case where the crane agent 61 has received an instruction on executing mixing work from the mixing agent 64, the crane agent 61 notifies the crane control section 66 of a crane mode (i.e., mixing) and destinations (i.e., a waste grabbing location and a waste releasing location).

[0080] Note that, in a case where the mixing agent 64 has determined a waste grabbing location and a waste releasing location for mixing work and then the accepting agent 63 has determined a waste grabbing location and a waste releasing location before the mixing work is carried out, the crane agent 61 cancels an instruction on executing the mixing work. Then, the crane agent 61 transmits an instruction on executing restacking work to the crane control section 66. In this case, the mixing work instructed by the mixing agent 64 can be carried out after the restacking work is executed or the mixing work does not need to be carried out. In a case where a degree of urgency is set with respect to the restacking work, it is possible to determine, in accordance with the degree of urgency, which one of the restacking work and the mixing work is to be preferentially executed. For example, in a case where a degree of urgency of the restacking work is low, the crane agent 61 can cancel an instruction on executing the restacking work and give an instruction on executing the mixing work.

[0081] After the crane control section 66 has controlled the crane 14 to execute an action, at least a cell agent 65 that relates to the action updates a state to be held, that is, a height of waste and the number of mixing actions (S6).

[0082] Note that the height of waste can be determined by the height determining section 67. It is possible that correspondences between (i) actions of the crane 14 and (ii) changes in heights of waste are stored in advance as models, and the height is updated with use of the models. For example, in mixing work or restacking work, it is possible to update heights at a grabbing location and a releasing location by using a model in which a height decreases by 0.5 m per action of grabbing waste and the height increases by 0.5 m per action of releasing waste. Alternatively, it is possible to update the height by calculating a height of waste based on a length of the wire 18 in carrying out a waste grabbing action.

[0083] In a case where the crane 14 has carried out work, the mixing degree detecting device 32 updates the number of mixing actions with respect to waste. The mixing degree determining section 68 obtains the number of mixing actions thus updated, and notifies the cell agent 65 of the number of mixing actions thus obtained. From this, the cell agent 65 updates the number of mixing actions to be held.

[0084] Next, the crane agent 61 determines whether or not to end the pieces of work (i.e., mixing work and restacking work) in the target areas (i.e., the waste grabbing area and the waste releasing area) to which the symbols were set in the step S2 (S7).

[0085] A criterion of the determination is not particularly limited, provided that the determination is made in accordance with a purpose or an aim for work to be carried out in each of time zones in an operation schedule of the crane 14. For example, in a case where waste is intended to be sufficiently mixed up to a deep part in a time zone during which no waste is to be brought in, the criterion for determination can be whether or not the target area has entered a predetermined state. Specific examples of the criterion encompass a fact that a maximum height of waste in the acceptance area has become equal to or lower than a predetermined level, a fact that the number of mixing actions in each of all sections included in the mixing area has become equal to or larger than a predetermined number of times, and the like. For example, in a case where at least a surface layer is intended to be mixed promptly in a time zone during which waste is to be brought in, the criterion for determination can be whether or not a waste grabbing action has been carried out one time at each of all sections included in the waste grabbing area. Alternatively, for example, the criterion for determination can be whether or not it is a time to update the waste grabbing area and the waste releasing area (i.e., update the symbols set in the step S2). In this case, it is possible to execute work as much as possible until a predetermined time. Note that the criterion for determination can be used in combination with another criterion for determination. That is, it is possible that work ends at a time point when another criterion for determination is satisfied before the predetermined

time or, if the another criterion is not satisfied, the work ends at the predetermined time.

[0086] In a case where it is determined that the process does not end at a step S7 (NO in S7), the process returns to the step S3 and the process in the target area continues. On the other hand, in a case where it is determined that the process ends (YES in S7), the crane agent 61 determines whether or not all pieces of work defined in the operation schedule 71 have finished (S8). Then, in a case where the crane agent 61 has determined that all pieces of work have finished (YES in S8), the process shown in Fig. 8 ends. On the other hand, in a case where the crane agent 61 has determined that all pieces of work have not finished yet (NO in S8), the process returns to the step S2.

[Flow of processes in detecting putting-in instruction]

[0087] Next, the following description will discuss, with reference to Fig. 9, a flow of processes carried out when an instruction on putting waste into the hopper 12 has been detected. Fig. 9 is a flowchart illustrating an example of processes carried out by the crane control device 50 when the crane control device 50 has detected a putting-in instruction.

[0088] In a case where the putting-in agent 62 has detected an instruction on putting waste into the hopper 12 based on a notice given from the hopper height notifying device 30, the putting-in agent 62 controls cell agents 65 which correspond to respective of all sections other than sections that do not relate to putting-in work (such as sections set as a non-mixing area) to calculate index values (S10). Note that waste to be put into the hopper 12 is preferably mixed sufficiently. Moreover, the crane 14 can more easily grab waste as a height of the waste is larger, and therefore each of the index values is calculated based on the above mathematical formula (3).

[0089] Next, the putting-in agent 62 determines, based on the index values thus calculated, a waste grabbing location from which waste is to be put into the hopper 12 (S11). For example, the putting-in agent 62 can determine, as a grabbing location, a section for which a maximum index value has been calculated. Then, the putting-in agent 62 notifies the crane agent 61 of the grabbing location thus determined, and also instructs the crane agent 61 to execute work to put waste into the hopper 12. Moreover, the putting-in agent 62 sets a degree of urgency corresponding to a height notified by the hopper height notifying device 30, and notifies the crane agent 61 of the degree of urgency thus set.

[0090] The crane agent 61 which has received the instruction on executing putting-in work determines whether or not the crane 14 is executing any work (S12). In a case where the crane 14 is not executing any work (NO in S12), the process proceeds to a step S16. Whereas, in a case where the crane 14 is executing work (YES in S12), the process proceeds to a step S13. Then, in the step S13, the crane agent 61 determines, based on the degree of urgency which has been notified, whether or not it is necessary to urgently execute putting-in work. Note that a value of a degree of urgency for determining that urgent putting-in work is necessary is set in advance.

[0091] In a case where the crane agent 61 has determined that urgent putting-in work is necessary in the step S13 (YES in S13), the crane agent 61 instructs the crane control section 66 to discontinue the executing work (S14), and the process proceeds to the step S16. On the other hand, in a case where the crane agent 61 has determined that urgent putting-in work is not necessary (NO in S13), the crane agent 61 waits until the executing work finishes (S15), and then the process proceeds to the step S16. Note that which one of the processes in the steps S14 and S15 is to be carried out can be determined based on a degree of urgency of the executing work and a degree of urgency of putting-in work. For example, in a case where restacking work whose degree of urgency is high is being executed, the process of the step S15 can be carried out if a degree of urgency of putting-in work is lower than the degree of urgency of the restacking work, and the process of the step S14 can be carried out if the degree of urgency of the putting-in work is higher than the degree of urgency of the restacking work.

[0092] In the step S16, the crane agent 61 notifies the crane control section 66 of a crane mode (i.e., putting-in) and a destination (i.e., waste grabbing location) so that waste is put into the hopper 12. Then, after the crane control section 66 has controlled the crane 14 to execute an action, at least a cell agent 65 that relates to the action updates a state to be held, that is, a height of waste and the number of mixing actions (S17). Update of the state can be carried out in a manner similar to that of the step S6 in Fig. 8. Note that, when waste is put into the hopper 12, operations which are not carried out in mixing and restacking are carried out, that is, bulk of the waste is adjusted and the like. Therefore, the state can be updated based on models which are different from those for mixing and restacking.

[Modification example]

[0093] A waste grabbing location and a waste releasing location can be determined while taking into consideration a location of the crane 14 (specifically, a location of the bucket 17), in addition to the above described index values. This makes it possible to determine appropriate waste grabbing location and waste releasing location while shortening a moving distance of the crane 14 and reducing electric power consumed by an action of the crane 14.

[0094] Specifically, in a case where a waste grabbing location and a waste releasing location for mixing work are to be determined, it is possible to determine, as a waste grabbing location, a section that is nearest to a location of the crane immediately before executing the mixing work from among sections whose index values are not lower than a

predetermined level. Further, from among the sections whose index values are not lower than the predetermined level, a section that is nearest to the waste grabbing location thus determined can be determined as a waste releasing location. A waste grabbing location and a waste releasing location for restacking work are determined in a manner similar to this.

[0095] In a case where a waste grabbing location for putting-in work is to be determined, the waste grabbing location can be, from among sections whose index values are not lower than a predetermined level, a section that is on or nearest to a straight line connecting the hopper 12 and a location of the crane immediately before executing the putting-in work. This makes it possible to minimize a path length of the crane 14 when the crane 14 grabs waste and puts the waste into the hopper 12.

[0096] Note that it is possible to determine a waste grabbing location and a waste releasing location while reducing a moving distance of the crane 14 by adding a term relating to a path length of the crane 14 to the formula for calculating an index value. In this case, a term can be added with which an index value increases as a path length of the crane 14 until work finishes becomes shorter. For example, it is possible to add, to the mathematical formula (1), a term that indicates a reciprocal number of a distance between a corresponding section and a location at which the crane 14 has been present immediately before. Further, it is possible that a waste grabbing location is determined based on index values calculated based on the mathematical formula (1) to which the term has been added, and a term that indicates a reciprocal number of a distance from the waste grabbing location thus determined to a corresponding section is added to the mathematical formula (2). Then, a waste releasing location is determined based on index values calculated by the mathematical formula (2) to which the term has been added, and this makes it possible to shorten a path length of the crane 14. In putting-in work, it is possible to add, to the mathematical formula (3), a term that indicates a reciprocal number of a distance between a corresponding section and a location at which the crane 14 has been present immediately before.

[0097] In the above embodiment, the example has been described in which the crane 14 is operated in accordance with the operation schedule 71 stored in the storage section 52. Note, however, that it is possible that the crane control device 50 prepares an operation schedule and the crane 14 is operated in accordance with the operation schedule thus prepared. In this case, a method for preparing an operation schedule is not particularly limited, and an operation schedule can be prepared with use of, for example, a genetic algorithm. Specifically, first, a plurality of "individuals" are generated each of which expresses, as a gene, waste grabbing areas, waste releasing areas, and how switching between a waste grabbing area and a waste releasing area is carried out in areas which have been set (see Fig. 5). Then, an optimal gene is searched by repeating a sequential processes of (i) preferentially selecting individuals having high fitness which is calculated based on an evaluation function $f(x)$ of fitness, (ii) generating next-generation individuals by applying crossover, mutation, and the like to the selected individuals, and (iii) evaluating fitness of each of the generated individuals. Note that, as the evaluation function, a function is used with which fitness increases as a state of waste in the waste storing section 11 becomes closer to an ideal state after an action of the crane 14 is carried out in accordance with setting and shifting of a waste grabbing area and a waste releasing area which are indicated by the gene. Note that the ideal state can be a state that corresponds to a purpose of a schedule or the like. For example, the ideal state can be a state in which the numbers of mixing actions and heights are homogeneous among sections or a state in which a height of waste in an acceptance area is low. By thus carrying out the search, it is possible to prepare an operation schedule with which waste in the waste storing section 11 can be brought closest to an ideal mixed state. Of course, the operation schedule which has been thus prepared in advance can be stored as an operation schedule 71.

[0098] It is possible to achieve functions similar to those of the crane control device 50 by a client server system in which a part of a process section included in the control section 51 is provided in a server that can communicate with the crane control device 50. Alternatively, for example, it is possible to operate the crane 14 by providing the agents in a terminal device such as a notebook PC or a tablet PC, and notifying the crane control device including the crane control section 66 of details of an action of the crane 14 which have been determined in the terminal device.

[Example of Configuration Achieved by Software]

[0099] The control blocks (in particular, the control section 51) of the crane control device 50 can be realized by a logic circuit (hardware) provided in an integrated circuit (IC chip) or the like or can be alternatively realized by software with use of a central processing unit (CPU).

[0100] In the latter case, the crane control device 50 includes a CPU that executes instructions of a program that is software realizing the foregoing functions; a read only memory (ROM) or a storage device (each referred to as "recording medium") in which the program and various kinds of data are stored so as to be readable by a computer (or a CPU); a random access memory (RAM) in which the program is loaded; and the like. In a case where the computer (or CPU) reads out the program from the recording medium and executes the program, the object of the present invention is achieved. The recording medium can be a "non-transitory tangible medium" such as, for example, a tape, a disk, a card, a semiconductor memory, a programmable logic circuit, or the like. The program can be supplied to the computer via any transmission medium (such as a communication network or a broadcast wave) that can transmit the program. The

present invention can also be achieved in the form of a computer data signal in which the various programs are embodied via electronic transmission and which is embedded in a carrier wave.

[0101] The present invention is not limited to the embodiments, but can be altered by a skilled person in the art within the scope of the claims. The present invention also encompasses, in its technical scope, any embodiment derived by combining technical means disclosed in differing embodiments.

[Recap]

[0102] In order to attain the object, the crane control device in accordance with an aspect of the present invention is a crane control device that controls an action of a crane for transferring waste in a waste pit, the crane control device including: a location determining section that determines, based on a height and a degree of mixing of waste in each of a plurality of sections into which a waste storing section in the waste pit is divided, a section to be set as a waste grabbing location when the crane is controlled to execute predetermined work including a waste grabbing action; and a crane control section that controls the crane to execute the waste grabbing action at the section which has been determined by the location determining section when the crane is controlled to execute the predetermined work.

[0103] According to the configuration, the waste grabbing location is determined based not only on the height of waste in each of the sections but also on the degree of mixing. From this, it is possible to control the crane to execute predetermined work at an appropriate waste grabbing location (i.e., an appropriate section) which corresponds to both a height of waste and a degree of mixing waste in each section.

[0104] It is possible that the location determining section further determines, based on the height and the degree of mixing of waste in each of the plurality of sections, a section to be set as a waste releasing location when the crane is controlled to execute the predetermined work.

[0105] According to the configuration, it is possible to control the crane to execute predetermined work at an appropriate waste releasing location (i.e., an appropriate section) which corresponds to both a height of waste and a degree of mixing waste in each section.

[0106] It is possible that the crane control device further includes: section managing parts that are provided for the respective plurality of sections and manage the respective plurality of sections, the section managing parts calculating respective index values each of which corresponds to a height and a degree of mixing of waste in a managed section and indicates a degree of necessity for a waste grabbing action at the managed section, and the location determining section determining a section to be set as the waste grabbing location with use of the index values.

[0107] According to the configuration, it is possible to control the crane to execute predetermined work at an appropriate waste grabbing location (i.e., an appropriate section) which (i) has been obtained by an arithmetical operation using an index value corresponding to a height of waste and a degree of mixing waste and (ii) corresponds to both the height of waste and the degree of mixing waste in each section.

[0108] It is possible that the crane control device further includes: an area setting section that sets a waste grabbing area and a waste releasing area, the waste grabbing area being an area in which a waste grabbing action is to be executed in the predetermined work, and the waste releasing area being an area in which a waste releasing action is to be executed in the predetermined work, the location determining section determining, from among sections included in the waste grabbing area, a section to be set as the waste grabbing location and determines, from among sections included in the waste releasing area, a section to be set as the waste releasing location.

[0109] According to the configuration, a waste grabbing area and a waste releasing area are set, a section to be set as the waste grabbing location is determined from among sections included in the waste grabbing area, and a section to be set as the waste releasing location is determined from among sections included in the waste releasing area. This makes it possible to surely transfer waste from the waste grabbing area to the waste releasing area.

[0110] It is possible that the area setting section sets a waste grabbing area and a waste releasing area each of which differs, for each time zone, in at least one of location and range.

[0111] According to the configuration, the waste grabbing area and the waste releasing area are set each of which differs, for each time zone, in at least one of location and range. This makes it possible to appropriately transfer waste depending on the time zone.

[0112] It is possible that the area setting section sets, for a time zone in which waste is to be brought into the waste pit, a waste releasing area from among areas which are in the waste storing section and are not an acceptance area for accepting waste which has been brought in; and the area setting section sets, for a time zone in which no waste is to be brought into the waste pit, a waste releasing area from among areas which include the acceptance area.

[0113] According to the configuration, the acceptance area is not set to be a waste releasing area during the time zone in which waste is to be brought in. It is therefore possible to prevent a problem from occurring in bringing waste in due to excessively highly stacked waste in the acceptance area. Meanwhile, the acceptance area can be set to be a waste releasing area during the time zone in which no waste is to be brought in. From this, it is possible to carry out restacking work and mixing work with respect to waste while effectively utilizing the acceptance area.

[0114] It is possible that the crane control device further includes a putting-in managing section as the location determining section, and the putting-in managing section determines a section to be set as a waste grabbing location for putting-in work to put waste by the crane into a hopper through which waste in the waste storing section is fed to an incinerator.

[0115] According to the configuration, it is possible to automatically determine a waste grabbing location for putting-in work. As above described, the waste grabbing location is determined based on the height and the degree of mixing of waste in each section, and it is therefore possible to put, into the hopper, waste which is stacked high in the section and has been sufficiently mixed.

[0116] It is possible that the crane control device further includes: a mixing managing section that manages mixing work to grab and release waste in a mixing area which is set in the waste storing section, the mixing managing section serving as the location determining section and determining a section to be set as a waste grabbing location and a section to be set as a waste releasing location in the mixing work; an acceptance managing section that manages restacking work to transfer waste from an acceptance area to the mixing area, the acceptance area being an area for accepting waste which has been brought in, and the acceptance managing section serving as the location determining section and determining a section to be set as a waste grabbing location and a section to be set as a waste releasing location in the restacking work; and a conflict adjusting section that cancels mixing work and controls restacking work to be executed in a case where the mixing managing section has determined a waste grabbing location and a waste releasing location and then the acceptance managing section has determined a waste grabbing location and a waste releasing location before the mixing work is executed.

[0117] According to the configuration, it is possible to automatically determine the waste grabbing location and the waste releasing location for each of mixing work and restacking work. Moreover, as above described, the waste grabbing location and the waste releasing location are determined based on the height of waste and the degree of mixing waste in each section. It is therefore possible to (i) mix waste such that the degrees of mixing becomes homogeneous and non-uniformity in height becomes smaller among the sections and also (ii) carry out restacking while preventing a problem from occurring in accepting waste and preventing waste which has been insufficiently mixed from being put into the hopper.

[0118] According to the configuration, in a case where the mixing managing section has determined a waste grabbing location and a waste releasing location and then the acceptance managing section has determined a waste grabbing location and a waste releasing location before the mixing work is carried out, execution of the mixing work is cancelled and restacking work is executed. From this, even in a case where a conflict state has occurred between mixing work and restacking work, such a conflict state can be solved and the restacking work is preferentially executed. Therefore, it is possible to prevent a problem from occurring in bringing waste in. Note that the mixing work which has been cancelled can be carried out after the restacking work has finished.

[0119] In order to attain the object, the method for controlling a crane control device in accordance with an aspect of the present invention is a method for controlling a crane control device that controls an action of a crane for transferring waste in a waste pit, the method including the steps of: determining, based on a height and a degree of mixing of waste in each of a plurality of sections into which a waste storing section in the waste pit is divided, a section to be set as a waste grabbing location when the crane is controlled to execute predetermined work including a waste grabbing action; and controlling the crane to execute the waste grabbing action at the section which has been determined in the determining step when the crane is controlled to execute the predetermined work. Therefore, it is possible to bring about an effect similar to that of the crane control device.

[0120] The crane control device in accordance with each of the aspects of the present invention can be realized by a computer. In such a case, the present invention encompasses (i) a control program of the crane control device which control program causes the computer to serve as the sections (software elements) included in the crane control device for realizing the calculation device and (ii) a computer-readable recording medium storing the control program.

Reference Signs List

[0121]

- 1: Waste pit
- 11: Waste storing section
- 14: Crane
- 50: Crane control device
- 61: Crane agent (area setting section/conflict adjusting section)
- 62: Putting-in agent (location determining section/putting-in managing section)
- 63: Accepting agent (location determining section/acceptance managing section)
- 64: Mixing agent (location determining section/mixing managing section)
- 65: Cell agent (section managing part)

66: Crane control section

Claims

- 5
1. A crane control device that controls an action of a crane for transferring waste in a waste pit, said crane control device comprising:

10 a location determining section that determines, based on a height and a degree of mixing of waste in each of a plurality of sections into which a waste storing section in the waste pit is divided, a section to be set as a waste grabbing location when the crane is controlled to execute predetermined work including a waste grabbing action; and

15 a crane control section that controls the crane to execute the waste grabbing action at the section which has been determined by the location determining section when the crane is controlled to execute the predetermined work.

- 20 2. The crane control device as set forth in claim 1, wherein the location determining section further determines, based on the height and the degree of mixing of waste in each of the plurality of sections, a section to be set as a waste releasing location when the crane is controlled to execute the predetermined work.

3. The crane control device as set forth in claim 1 or 2, further comprising:

25 section managing parts that are provided for the respective plurality of sections and manage the respective plurality of sections,

the section managing parts calculating respective index values each of which corresponds to a height and a degree of mixing of waste in a managed section and indicates a degree of necessity for a waste grabbing action at the managed section, and

30 the location determining section determining a section to be set as the waste grabbing location with use of the index values.

4. The crane control device as set forth in claim 2, further comprising:

35 an area setting section that sets a waste grabbing area and a waste releasing area, the waste grabbing area being an area in which a waste grabbing action is to be executed in the predetermined work, and the waste releasing area being an area in which a waste releasing action is to be executed in the predetermined work, the location determining section determining, from among sections included in the waste grabbing area, a section to be set as the waste grabbing location and determines, from among sections included in the waste releasing area, a section to be set as the waste releasing location.

- 40 5. The crane control device as set forth in claim 4, wherein the area setting section sets a waste grabbing area and a waste releasing area each of which differs, for each time zone, in at least one of location and range.

6. The crane control device as set forth in claim 4 or 5, wherein:

45 the area setting section sets, for a time zone in which waste is to be brought into the waste pit, a waste releasing area from among areas which are in the waste storing section and are not an acceptance area for accepting waste which has been brought in; and

50 the area setting section sets, for a time zone in which no waste is to be brought into the waste pit, a waste releasing area from among areas which include the acceptance area.

7. The crane control device as set forth in any one of claims 1 through 6, further comprising:

55 a putting-in managing section that manages putting-in work to put waste by the crane into a hopper through which waste in the waste storing section is fed to an incinerator,

the putting-in managing section serving as the location determining section and determining a section to be set as a waste grabbing location for the putting-in work.

8. The crane control device as set forth in claim 2, further comprising:

a mixing managing section that manages mixing work to grab and release waste in a mixing area which is set in the waste storing section, the mixing managing section serving as the location determining section and determining a section to be set as a waste grabbing location and a section to be set as a waste releasing location in the mixing work;

an acceptance managing section that manages restacking work to transfer waste from an acceptance area to the mixing area, the acceptance area being an area for accepting waste which has been brought in, and the acceptance managing section serving as the location determining section and determining a section to be set as a waste grabbing location and a section to be set as a waste releasing location in the restacking work; and a conflict adjusting section that cancels mixing work and controls restacking work to be executed in a case where the mixing managing section has determined a waste grabbing location and a waste releasing location and then the acceptance managing section has determined a waste grabbing location and a waste releasing location before the mixing work is executed.

9. A method for controlling a crane control device that controls an action of a crane for transferring waste in a waste pit, said method comprising the steps of:

determining, based on a height and a degree of mixing of waste in each of a plurality of sections into which a waste storing section in the waste pit is divided, a section to be set as a waste grabbing location when the crane is controlled to execute predetermined work including a waste grabbing action; and controlling the crane to execute the waste grabbing action at the section which has been determined in the determining step when the crane is controlled to execute the predetermined work.

10. A control program for causing a computer to function as a crane control device recited in claim 1, said control program causing the computer to function as the location determining section and the crane control section.

11. A computer-readable recording medium that stores a control program recited in claim 10.

FIG. 1

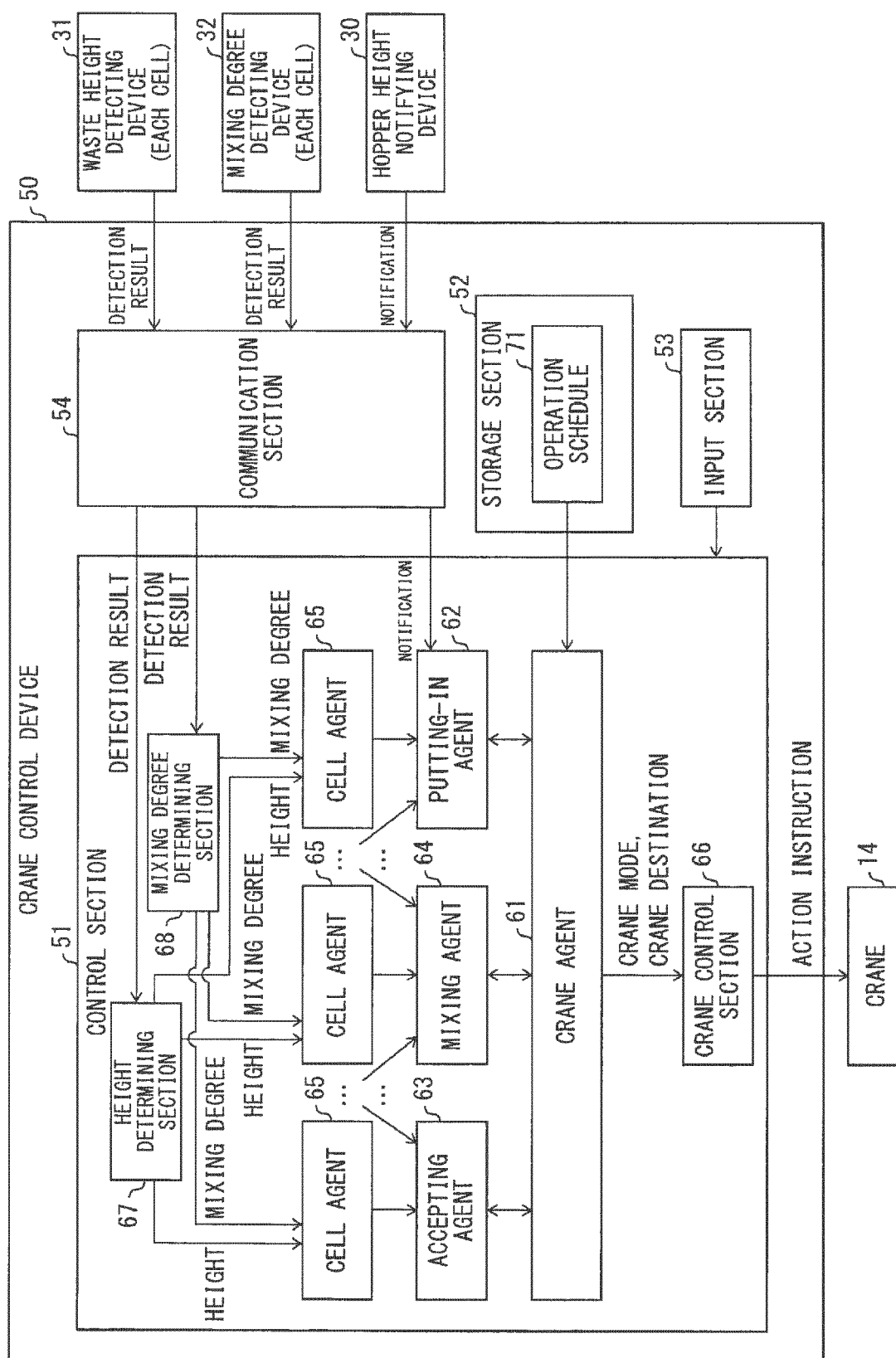


FIG. 2

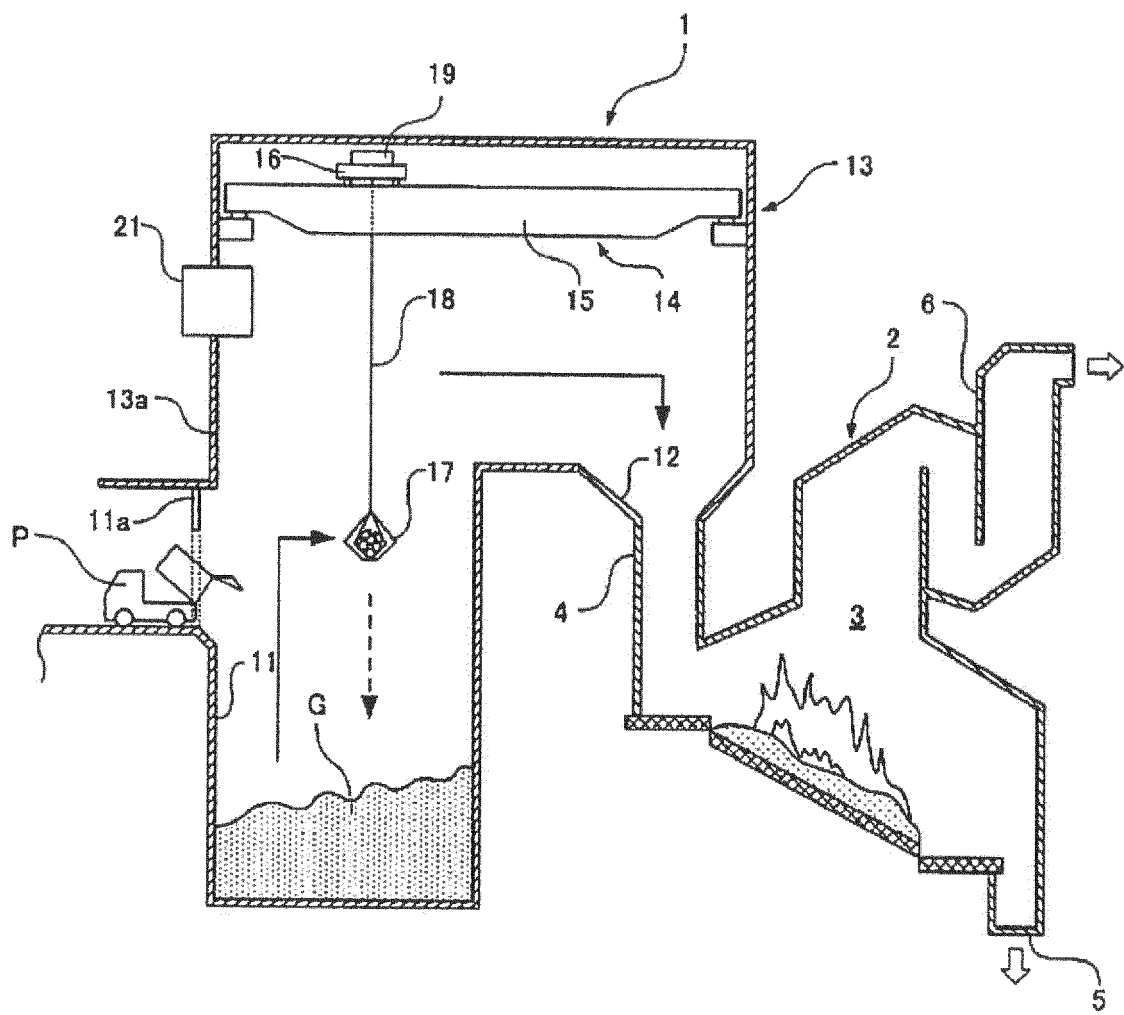


FIG. 3

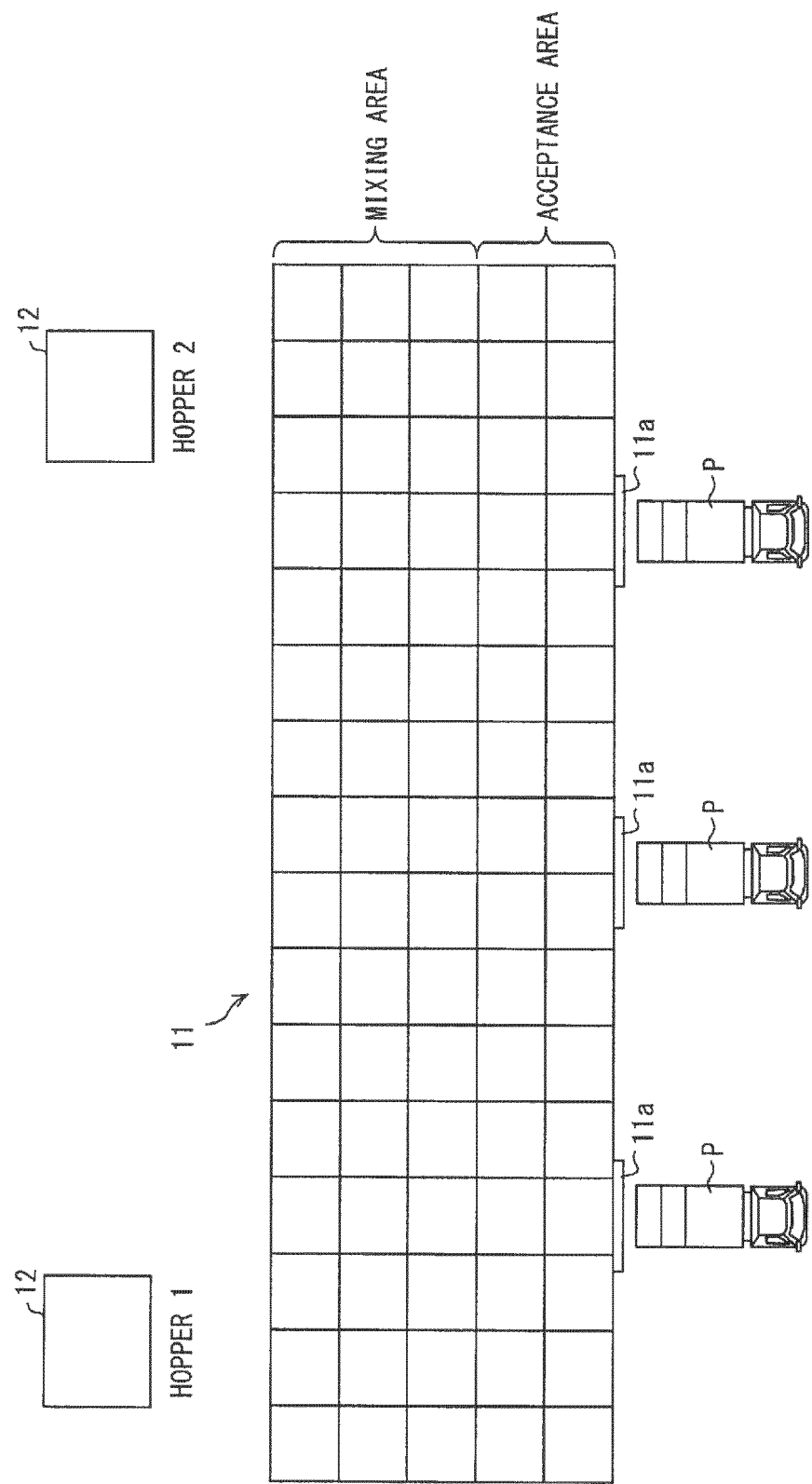


FIG. 4

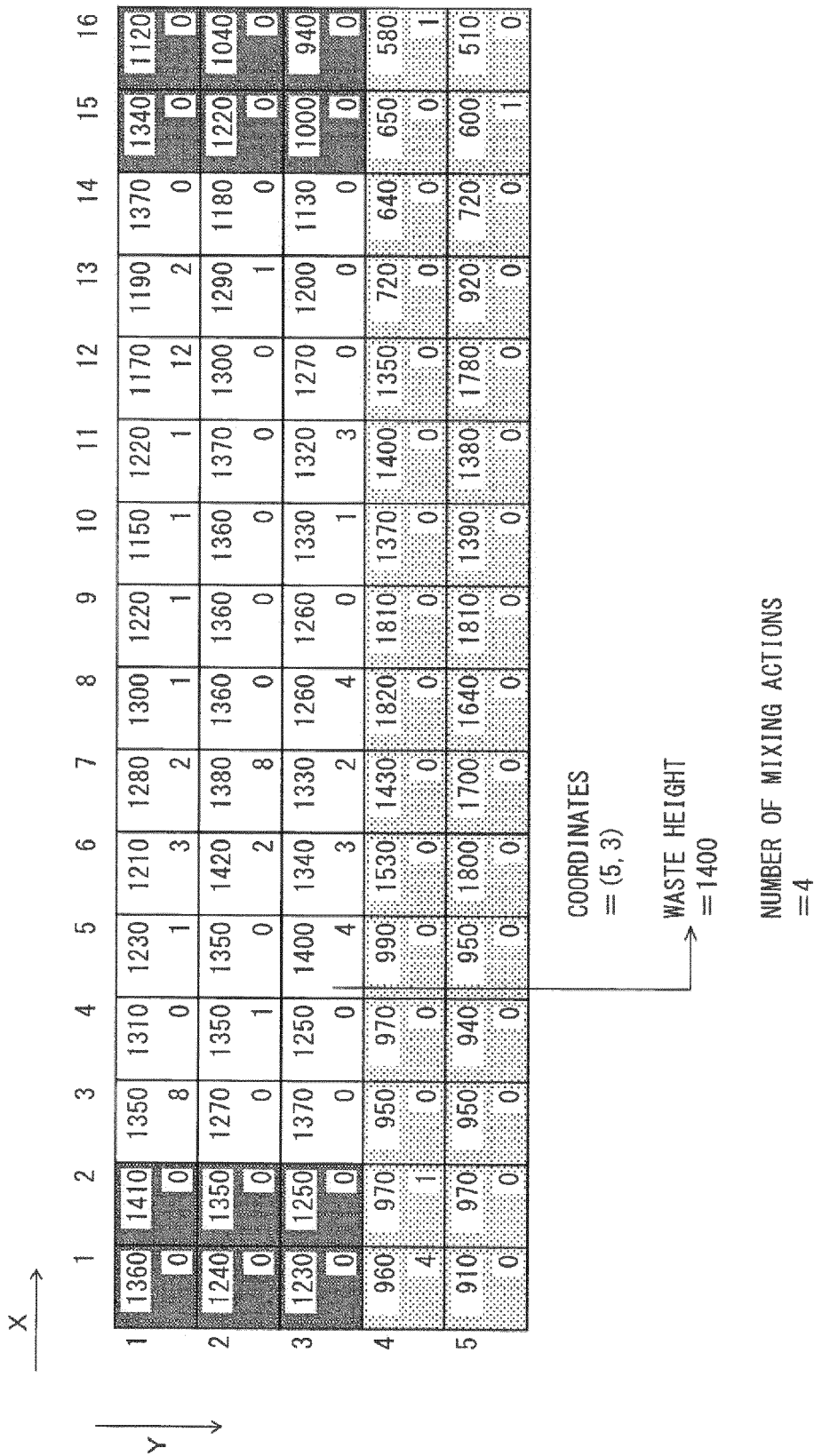


FIG. 5

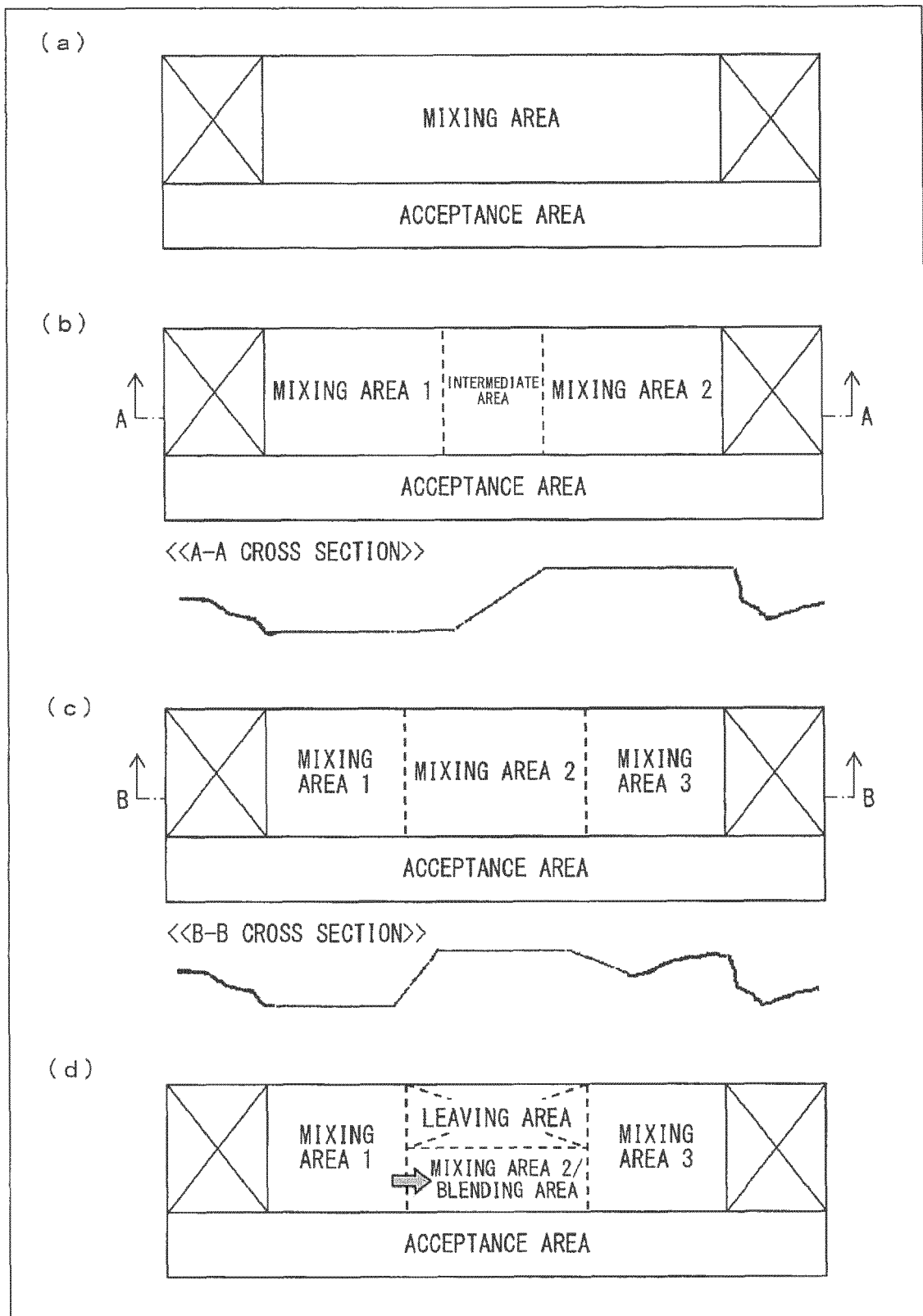


FIG. 6

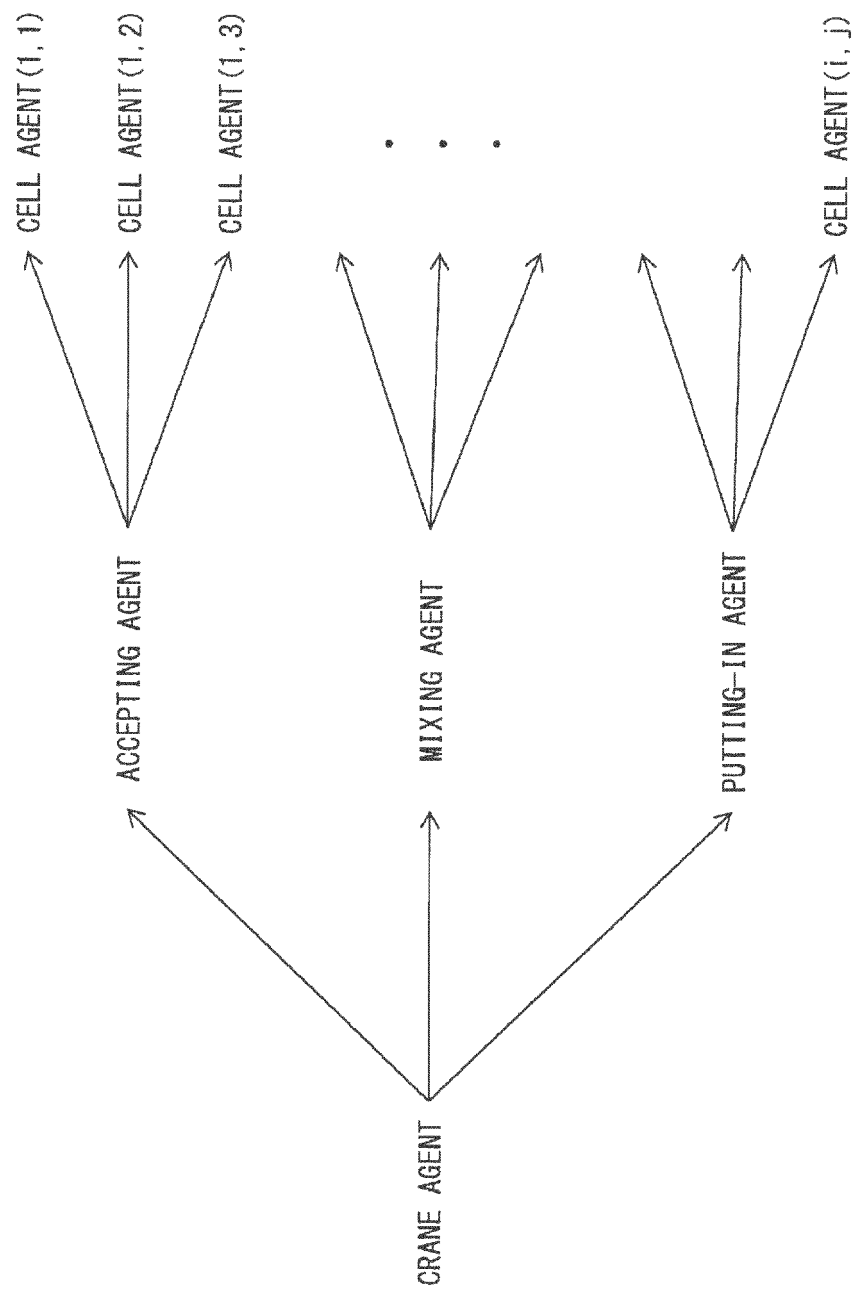


FIG. 7

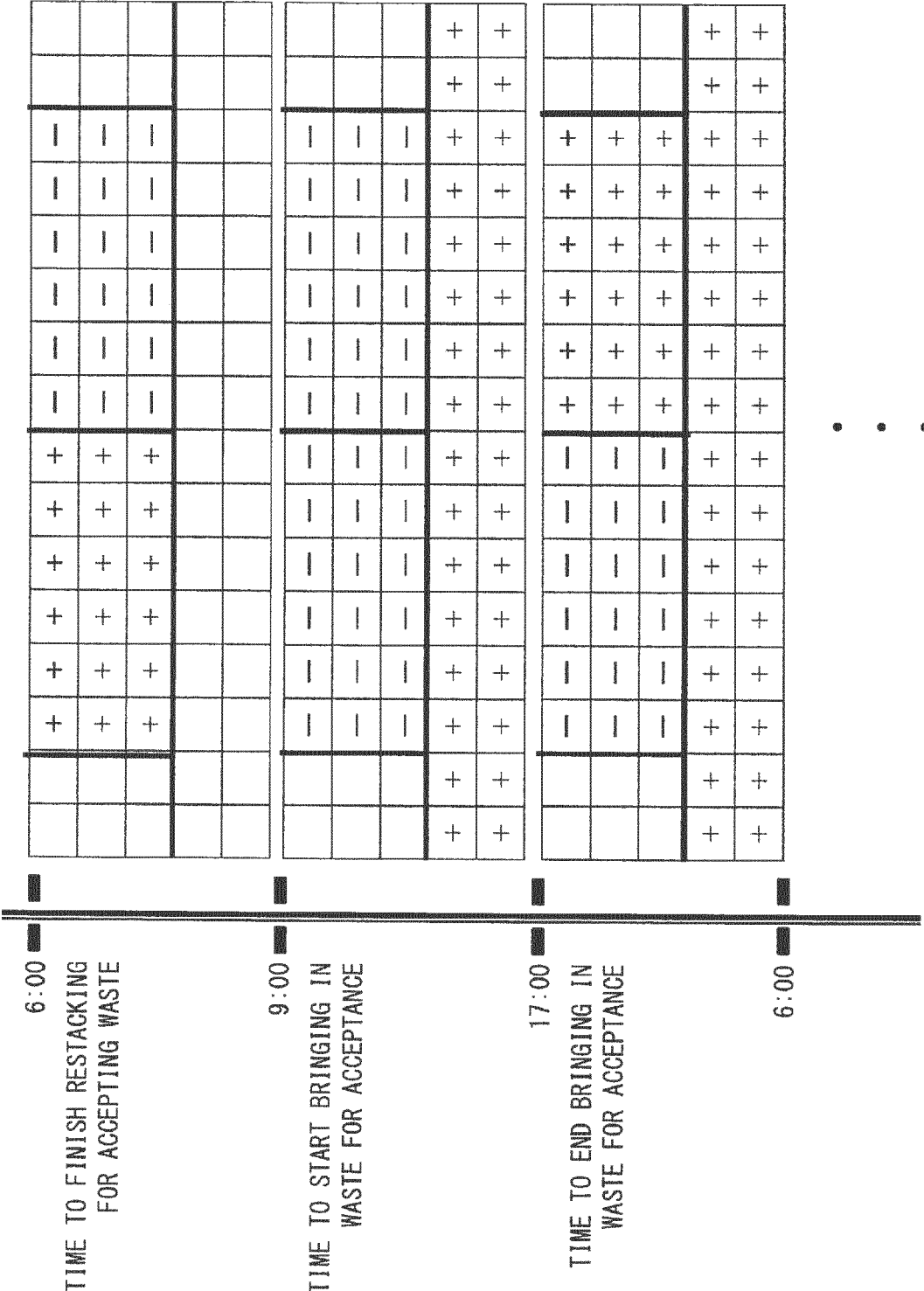


FIG. 8

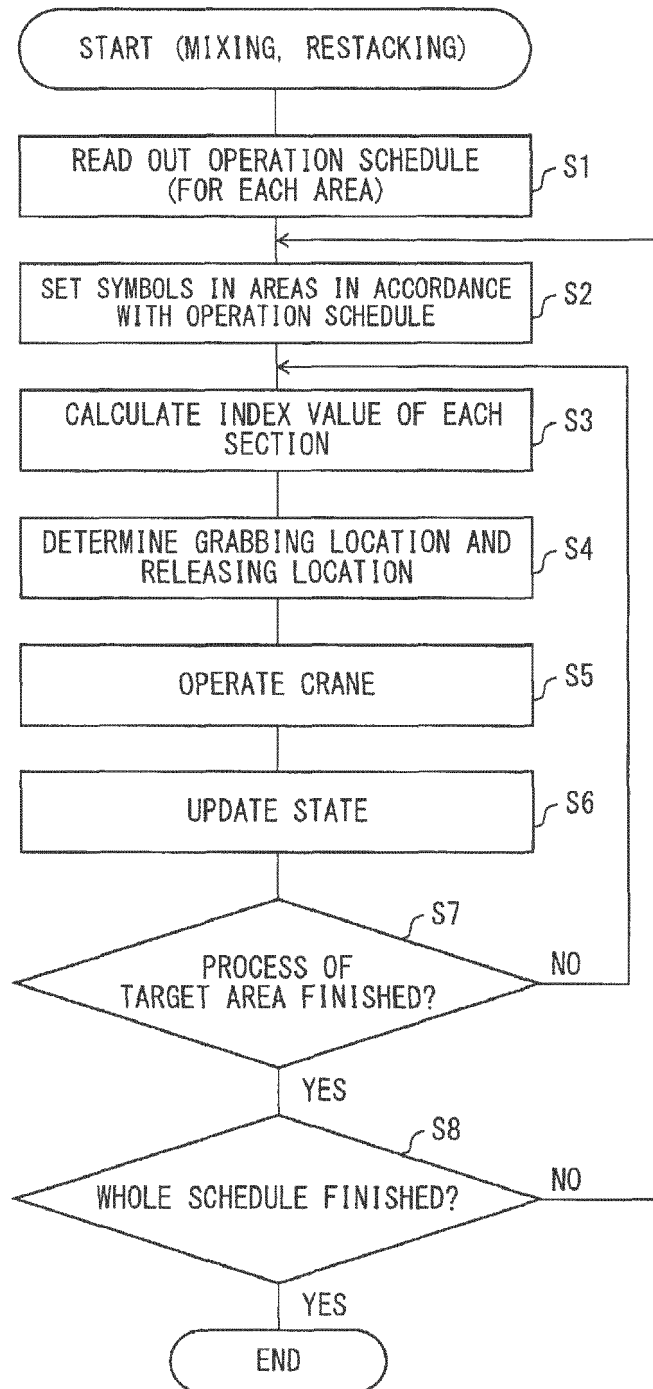
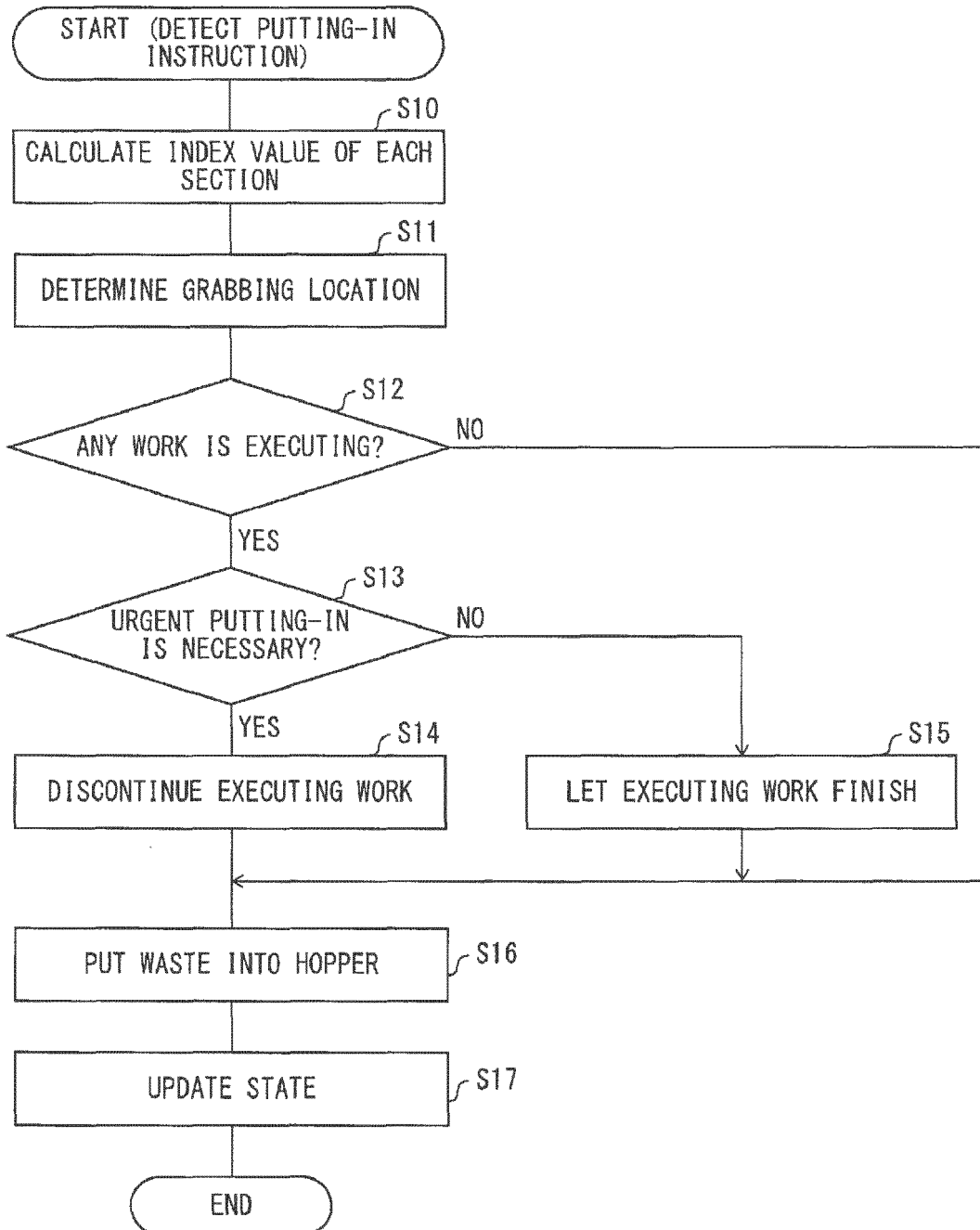


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/018692

A. CLASSIFICATION OF SUBJECT MATTER

F23G5/50(2006.01)i, B65F5/00(2006.01)i, B66C13/46(2006.01)i, B66C13/48
(2006.01)i, F23G5/02(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)
F23G5/50, B65F5/00, B66C13/46, B66C13/48, F23G5/02

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 1996-2017
Kokai Jitsuyo Shinan Koho 1971-2017 Toroku Jitsuyo Shinan Koho 1994-2017

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 2007-126246 A (Hitachi Plant Technologies, Ltd.), 24 May 2007 (24.05.2007), paragraphs [0013] to [0024]; fig. 1 to 6-2 (Family: none)	1-7, 9-11 8
Y	JP 2011-27349 A (Takuma Co., Ltd.), 10 February 2011 (10.02.2011), paragraphs [0022] to [0041]; fig. 1 to 6 (Family: none)	1-7, 9-11
Y	JP 56-28188 A (Takuma Co., Ltd.), 19 March 1981 (19.03.1981), page 5, upper left column, line 17 to upper right column, line 2; fig. 6, 7 (Family: none)	2-7

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

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"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
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"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	

Date of the actual completion of the international search
14 July 2017 (14.07.17)

Date of mailing of the international search report
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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/018692

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2015-124955 A (Hitachi Zosen Corp.), 06 July 2015 (06.07.2015), entire text; all drawings (Family: none)	1-11
A	JP 2010-275064 A (Kobe Steel, Ltd.), 09 December 2010 (09.12.2010), entire text; all drawings (Family: none)	1-11
A	JP 2006-44904 A (Hitachi Kiden Kogyo, Ltd.), 16 February 2006 (16.02.2006), entire text; all drawings (Family: none)	1-11
A	JP 2-293515 A (Babcock-Hitachi Kabushiki Kaisha), 04 December 1990 (04.12.1990), entire text; all drawings (Family: none)	1-11

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REFERENCES CITED IN THE DESCRIPTION

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- JP 6449815 B [0005]
- JP 56028188 A [0006]