



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
01.11.2023 Bulletin 2023/44

(51) International Patent Classification (IPC):
E02F 3/43^(2006.01) E02F 9/20^(2006.01)

(21) Application number: **20967103.1**

(52) Cooperative Patent Classification (CPC):
E02F 3/43; E02F 9/20

(22) Date of filing: **23.12.2020**

(86) International application number:
PCT/KR2020/019037

(87) International publication number:
WO 2022/139032 (30.06.2022 Gazette 2022/26)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Volvo Construction Equipment AB**
631 85 Eskilstuna (SE)

(72) Inventor: **KIM, Jiyun**
Seongsan-gu,
Gyeongangnam-do 51564 (KR)

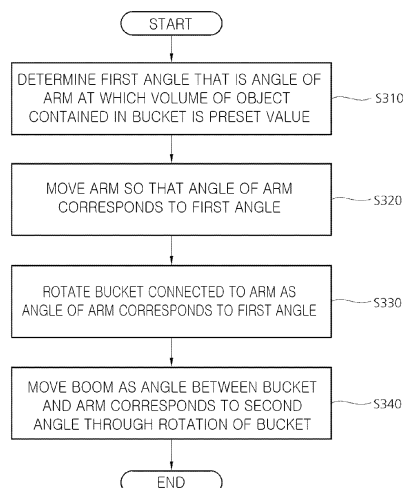
(74) Representative: **Kransell & Wennborg KB**
P.O. Box 2096
403 12 Göteborg (SE)

(54) **EXCAVATOR AND METHOD AND DEVICE FOR CONTROLLING EXCAVATOR**

(57) According to an embodiment, a method for controlling an excavator is provided, the method comprising: determining a first angle which is an angle of an arm, at which a volume of an object contained in a bucket is a preset value; moving the arm such that the angle of the

arm corresponds to the first angle; rotating the bucket connected to the arm, according to the angle of the arm corresponding to the first angle; and moving a boom, as an angle of the bucket corresponds to a second angle according to the rotation of the bucket.

FIG.3



Description

[Technical Field]

[0001] The present disclosure relates to a method and device for controlling an excavator, and more particularly, to a method and device which can effectively control movement of an arm, a bucket, and a boom based on an angle of the arm at which a volume of an object contained in the bucket is a preset value.

[Background Art]

[0002] In general, in excavators, excavation works are controlled by operator's manual operations, operations are complicated, operations skills of operators are different, and thus excavation results are differently achieved according to the operators.

[0003] Accordingly, demands for autonomous excavation technologies that may solve the above problem and accurately determine an excavation trajectory are increasing.

[Disclosure]

[Technical Problem]

[0004] The present disclosure is directed to providing a method and device which may effectively control movement of an arm, a bucket, and a boom based on an angle of the arm at which a volume of an object contained in the bucket is a preset value.

[0005] The present disclosure is directed to also providing a method and device which may effectively control the movement of the arm, the bucket, and the boom based on a point at which a projection area of the bucket and a trend line overlap each other.

[0006] The purpose of the present disclosure is not limited to the purpose described above, and other purposes which are not described may be understood from the following description.

[Technical Solution]

[0007] One aspect of the present disclosure provides a method of controlling an excavator, the method including determining a first angle that is an angle of an arm at which a volume of an object contained in a bucket is a preset value, moving the arm so that the angle of the arm corresponds to the first angle, rotating a bucket connected to the arm in response to the angle of the arm corresponding to the first angle, and moving a boom in response to an angle of the bucket corresponding to a second angle through the rotation of the bucket.

[0008] The determining of the first angle may include determining the first angle based on a trend line determined according to a slope of a terrain including the object.

[0009] The moving of the arm may include rotating the arm so that an angle between the arm and a direction of gravity corresponds to the first angle.

[0010] The rotating of the bucket may include rotating the bucket in a direction in which an angle between the arm and the bucket decreases.

[0011] The moving of the boom may include rotating the boom until a difference value between a lowermost height that the bucket reaches and an uppermost height of a load carrier (e.g., a dump truck, a hopper, and a crusher) adjacent to the excavator corresponds to a preset value.

[0012] The rotating of the bucket may include sensing a pressure applied to the arm, and rotating the boom in a direction in which the bucket raises in a state in which a hydraulic pressure applied to the arm and the bucket is maintained when the pressure applied to the arm corresponds to a first pressure.

[0013] The rotating of the boom in the direction in which the bucket raises may include stopping the rotation of the boom when the pressure applied to the arm corresponds to a second pressure, and the second pressure may be smaller than the first pressure.

[0014] The moving of the arm may include rotating the arm in a direction in which the arm approaches a body of the excavator in a state in which the bucket and the boom are stopped.

[0015] The rotating of the bucket may include simultaneously rotating the arm and the bucket in a state in which the boom is stopped.

[0016] The moving of the boom may include simultaneously rotating the arm, the bucket, and the boom.

[0017] The first angle may be determined based on a point at which a projection area of the bucket and the trend line overlap each other.

[0018] Another aspect of the present disclosure provides a device for controlling an excavator, the device including a reception unit that acquires information on a terrain including an object, and a processor that determines a first angle, which is an angle of an arm at which a volume of the object contained in a bucket is a preset value, based on the information on the terrain, moves the arm so that the angle of the arm corresponds to the first angle, rotates the bucket connected to the arm in response to the angle of the arm corresponding to the first angle, and moves a boom in response to an angle of the bucket corresponding to a second angle through the rotation of the bucket.

[0019] The processor may determine the first angle based on a trend line determined according to a slope of the terrain including the object.

[0020] The processor may rotate the arm so that an angle between the arm and a direction of gravity corresponds to the first angle.

[0021] The processor may rotate the bucket in a direction in which an angle between the arm and the bucket decreases.

[0022] The processor may rotate the boom until a dif-

ference value between a lowermost height that the bucket reaches and an uppermost height of a load carrier adjacent to the excavator corresponds to a preset value.

[0023] The processor may sense a pressure applied to the arm and rotate the boom in a direction in which the bucket raises in a state in which a hydraulic pressure applied to the arm and the bucket is maintained when the pressure applied to the arm corresponds to a first pressure.

[0024] The processor may stop the rotation of the boom when the pressure applied to the arm corresponds to a second pressure, and the second pressure may be smaller than the first pressure.

[0025] The processor may rotate the arm in a direction in which the arm approaches a body of the excavator in a state in which the bucket and the boom are stopped.

[0026] The first angle may be determined based on a point at which a projection area of the bucket and the trend line overlap each other.

[0027] Still another aspect of the present disclosure provides an excavator including a boom, an arm connected to the boom, a bucket connected to the arm, and a controller that determines a first angle which is an angle of the arm at which a volume of an object contained in the bucket is a preset value, controls the arm so that the angle of the arm corresponds to the first angle, controls the bucket so that the bucket connected to the arm rotates in response to the angle of the arm corresponding to the first angle, and controls the boom so that the boom moves in response to an angle between the arm and the bucket corresponding to a second angle through the rotation of the bucket.

[0028] Yet another aspect of the present disclosure provides a computer-readable recording medium on which a program for executing the method according to any one of the first aspect and the second aspect in a computer is recorded. Yet another aspect of the present disclosure provides a computer program stored in a recording medium to implement the method according to any one of the first aspect and the second aspect.

[Advantageous Effects]

[0029] According to an embodiment of the present disclosure, movement of an arm, a bucket, and a boom can be effectively controlled based on an angle of the arm at which a volume of an object contained in the bucket is a preset value.

[0030] Alternatively, according to an embodiment of the present disclosure, the movement of the arm, the bucket, and the boom can be effectively controlled based on a point at which a projection area of the bucket and a trend line overlap each other.

[0031] The effects of the present disclosure are not limited to the above effects and should be understood to include all effects that may be deduced from the detailed description of the present disclosure or the configuration of the present disclosure described in the appended

claims.

[Description of Drawings]

[0032]

FIG. 1 is a schematic block diagram illustrating a configuration of a device according to an embodiment.

FIG. 2 is a schematic block diagram illustrating a configuration of an excavator according to the embodiment.

FIG. 3 is a flowchart illustrating a method of controlling the excavator according to the embodiment.

FIGS. 4 to 6 are views illustrating operations of moving an arm, a bucket, and a boom in a first time segment, a second time segment, and a third time segment according to the embodiment.

FIGS. 7 and 8 are views for describing an operation in which the device controls rotation of the boom according to the embodiment.

FIG. 9 is a view for describing a projection area of the bucket according to the embodiment.

FIG. 10 is a view for describing an example in which the device controls movement of the arm, the bucket, and the boom based on a point at which the projection area of the bucket and a trend line overlap each other, according to the embodiment.

[Modes of the Invention]

[0033] Hereinafter, the present disclosure will be described with reference to the accompanying drawings. However, the present disclosure may be implemented in various different forms and thus is not limited to embodiment described herein. Further, in the drawings, parts irrelevant to the description are omitted in order to clearly describe the present disclosure, and throughout the specification, similar numerals reference numerals are assigned to similar parts.

[0034] Terms used herein have been selected as currently widely used general terms as much as possible while considering functions in the present disclosure but may be changed according to the intention or precedent of an engineer in the field, the emergence of a new technology, and the like. Further, in a specific case, a term is arbitrarily selected by the applicant, and in this case, the meaning thereof will be described in detail in the corresponding description of the disclosure. Thus, the terms used herein should be defined based on meaning of the terms and the entire contents of the present disclosure not simple names of the terms.

[0035] Throughout the specification, when a part "includes" a component, this means that another component is not excluded but may be further included unless otherwise stated. Further, terms "unit", "module", and the like described in the specification refer to a unit that processes at least one function or operation and may be im-

plemented as hardware or software or a combination of the hardware and the software.

[0036] Throughout the specification, when a first part is connected to a second part, this includes not only a case in which the first part is "directly connected" to the second part but also a case in which the first part is "indirectly connected" to the second part with a third part interposed therebetween. Further, when a part "includes" a component, this means that another component is not excluded but may be further included unless otherwise stated.

[0037] Hereinafter, embodiments of the present disclosure will be described in detail with reference to the accompanying drawings so that those of the skilled in the art to which the present disclosure pertains may easily carry out the present disclosure. However, the present disclosure may be implemented in various different forms, and is not limited to the embodiments described herein.

[0038] Hereinafter, the embodiments of the present disclosure will be described in detail with reference to the accompanying drawings.

[0039] FIG. 1 is a schematic block diagram illustrating a configuration of a device 100 according to an embodiment.

[0040] Referring to FIG. 1, the device 100 may control an excavator 200, and in the embodiment, may be implemented as a computing device that operates through a computer program for implementing a function described in the specification. For example, the device 100 may be implemented to control the overall operation of the excavator 200 while mounted on the excavator 200, to transmit a control signal to a controller 240 while electrically connected to the controller 240 that controls the excavator 200, or to be included in the controller 240.

[0041] The device 100 may include a reception unit 110 and a processor 120.

[0042] The reception unit 110 may acquire information on a terrain including an object. Here, the object is an excavation target of the excavator 200 and may include all types of **target** materials that may be loaded or transported by the excavator 200, for example, soil during a soil moving work, building debris during a building demolition work, and ground debris during a ground clearing work.

[0043] In the embodiment, the reception unit 110 may receive information on the terrain including the object from another device (e.g., a server) or another component (e.g., a memory, a sensor, or the like) and may include, for example, a wired/wireless communication device that may transmit or receive various pieces of information described throughout the specification while connected to the other device through a network.

[0044] In another embodiment, the reception unit 110 may generate the information on the terrain through sensing the terrain including the object, may include, for example, one or more terrain detection sensor modules such as a camera, a radar, and a lidar, and may sense,

in real time, the information on the terrain including a position, a size, a type of surrounding terrain, an angle between the object and the surrounding terrain, and the like of the object (e.g., soil) within a target area which changes in real time as an arm 210, a bucket 220, or a boom 230 of the excavator 200 moves.

[0045] The processor 120 may determine a first angle, which is an angle of the arm 210, at which a volume of the object contained in the bucket 220 is a preset value, based on the information on the terrain, may move the arm 210 so that the angle of the arm 210 corresponds to the first angle, may rotate the bucket 220 connected to the arm 210 as the angle of the arm 210 corresponds to the first angle, and may move the boom 230 as an angle between the arm 210 and the bucket 220 corresponds to a second angle through the rotation of the bucket 220. However, there may be various methods for determining the first angle, and the volume of the object contained in the bucket 220, a point (which will be described below in FIGS. 9 and 10) at which a projection area of the bucket 220 and a trend line overlap each other, and the like may be used to determine the first angle.

[0046] The series of operations described above will be described in detail below with reference to FIGS. 3 to 8.

[0047] In the embodiment, the processor 120 may perform a series of operations for controlling the excavator 200, may be implemented as a central processing unit (CPU) or the controller 240 for controlling the overall operations of the device 100, and may be electrically connected to the reception unit 110 and other components to control data flow therebetween.

[0048] FIG. 2 is a schematic block diagram illustrating a configuration of the excavator 200 according to the embodiment.

[0049] Referring to FIG. 2, the excavator 200 is a device that excavates the object, and may include various types of excavators that may perform the excavation operation in various manners in the soil moving work, the building demolition work, and the ground clearing work.

[0050] In the embodiment, the excavator 200 may be implemented to include the computing device that operates through a computer program for implementing a function described in the present specification, and in another embodiment, the excavator 200 may be connected to the device 100 and controlled according to a control signal of the device 100.

[0051] The excavator 200 may include the arm 210, the bucket 220, the boom 230, and the controller 240.

[0052] The arm 210 may be connected to each of the bucket 220 and the boom 230, and in the embodiment, the boom 230, the arm 210, and the bucket 220 may be connected through joints in this order, and the joints may move by hydraulic cylinders. For example, the arm 210 may be connected to the boom 230 connected to an upper vehicle body of the excavator 200 at one end thereof and connected to the bucket 220 at the other end, the arm 210, the bucket 220, and the boom 230 may rotate about one or more axes by an arm cylinder, a bucket

cylinder, and a boom cylinder, the bucket 220 may contain the object (e.g., the soil) on the ground according to the rotation, and the controller 240 may control the overall operation.

[0053] The controller 240 according to the embodiment may determine the first angle that is the angle of the arm 210 at which the volume of the object contained in the bucket 220 is a preset value, may control the arm 210 so that the angle of the arm 210 corresponds to the first angle, may control the bucket 220 so that the bucket 220 connected to the arm 210 rotates as the angle of the arm 210 corresponds to the first angle, and may control the boom 230 so that the boom 230 moves as the angle between the arm 210 and the bucket 220 corresponds to the second angle through the rotation of the bucket 220.

[0054] The series of operations described above will be described in detail below with reference to FIGS. 3 to 8.

[0055] Throughout the specification, the controller 240 and the processor 120 are distinct concepts, the controller 240 may be implemented to include a function of the processor 120 in the embodiment and controlled by the processor 120 in another embodiment.

[0056] Further, those skilled in the art can understand that other general-purpose components other than the components illustrated in FIGS. 1 and 2 may be further included in the device 100 or the excavator 200. For example, the device 100 or the excavator 200 may further include various types of drivers for the movement of the arm 210, the bucket 220, and the boom 230, a drive control module for controlling the drivers in detail, a pipe, a lower body, a memory for storing data used in the overall operation, an input/output interface for receiving user input or outputting information, and the like.

[0057] FIG. 3 is a flowchart illustrating a method of controlling the excavator 200 according to the embodiment, and FIGS. 4 to 6 are views illustrating operations of moving an arm 210, a bucket 220, and a boom 230 in a first time segment, a second time segment, and a third time segment, respectively, according to the embodiment. Hereinafter, embodiments in which the device 100 controls the excavator 200 will be mainly described, but embodiments in which the controller 240 controls the excavator 200 in the same or similar manner may be included.

[0058] Referring to FIGS. 3 to 6, the device 100 may control movement of (a) the arm 210, (b) the arm 210 and the bucket 220, and (c) the arm 210, the bucket 220, and the boom 230 in this order over time. In detail, as a digging operation starts, only the arm 210 may be controlled to move during the first time segment, the arm 210 and the bucket 220 may be controlled to move together during the second time segment after the first time segment, and all the arm 210, the bucket 220, and the boom 230 may be controlled to move during the third time segment after the second time segment.

[0059] In operation S310, the device 100 may determine the first angle that is the angle of the arm 210 at which the volume of the object contained in the bucket

220 is a preset value. In the embodiment, the device 100 may obtain the information on the terrain including the object, may determine the first angle based on the information on the terrain, and for example, may calculate the first angle, which is the angle of the arm 210 at which the object (e.g., the soil) having a predetermined volume or more is contained in the bucket 220, using information on a position, a size, a type of the terrain, a height, a slope, angle between the object and the surrounding terrain, and the like of the object (e.g., the soil) included in the information on the terrain.

[0060] In the embodiment, the first angle includes an angle between the arm 210 and a horizontal surface, but the present disclosure is not limited thereto, and the first angle may be, for example, angles with respect to various reference surfaces, such as an angle between the arm 210 and the boom 230, an angle with respect to the ground, an angle with respect to a vertical surface, and an angle with respect to gravity. For another example, the first angle may be the amount of change in the moved angle as compared to an angle at which the arm 210 firstly starts to move and the amount of change in the angle of the arm 210 per unit time. The above-described various manners may be applied.

[0061] In the embodiment, the device 100 may determine the first angle based on a trend line 710 determined according to a slope of the terrain including the object. Here, the trend line 710 indicates an inclination line between the excavator 200 and the slope of the terrain, and in the embodiment, may mean an average inclination line with respect to the slope of the land viewed from the excavator 200. For example, the device 100 may determine the first angle by calculating a total rotation angle (the first angle), a rotation angle per unit time, a rotation duration time (the first time segment), and a rotation path of the arm 210 so that the soil having a preset volume may move into the bucket 220 in consideration of a height of the terrain, an inclination between slopes of the terrain with respect to the horizontal surface, and a type of the object (e.g., the soil) included in the pre-obtained information on the terrain.

[0062] In the embodiment, the present volume may be updated based on the trend line 710. For example, when an average angle between the excavator 200 and the slope of the land is greater than or equal to a preset value, a reference value of the volume of the object contained in the bucket 220 may be adjusted by reducing the preset volume by a preset ratio or by reflecting an adjustment factor that is inverse proportional to the average angle.

[0063] In operation S320, the device 100 may move the arm 210 such that the angle of the arm 210 corresponds to the first angle, and for example, may rotate the arm 210 until the angle between the arm 210 and the boom 230 is equal to the first angle or approaches the first angle by a preset difference value.

[0064] In the embodiment, the movement includes the rotation, but the present disclosure is not limited thereto, and according to a typical embodiment, the movement

may be controlled in a rotational manner but may also include movement in a manner other than the rotation.

[0065] In the embodiment, the device 100 may rotate the arm 210 such that an angle between the arm 210 and the direction of gravity corresponds to the first angle, and for example, may rotate the arm 210 until an angle between the arm 210 and the vertical surface is the first angle.

[0066] In the embodiment, the device 100 may rotate the arm 210 in a direction in which the bucket 220 approaches a body of the excavator 200 in a state in which the bucket 220 and the boom 230 are stopped, and for example, may perform a control such that the bucket 220 and the boom 230 do not rotate, only the arm 210 rotates toward the body of the excavator 200, the bucket 220 connected to the arm 210 moves together, and thus the soil is contained in the bucket 220, as illustrated in FIG. 4.

[0067] Referring to FIG. 4, the arm 210 may move from a (1-1)th point 410 at which the arm 210 firstly starts to move to a (1-2)th point 430 along a (1-1)th movement path 420 during the first time segment indicating a time until the angle of the arm 210 corresponds to the first angle. In this case, the bucket 220 and the boom 230 do not rotate, and only the arm 210 may rotate. In the embodiment, an angle between the (1-1)th point 410 and the (1-2)th point 420 with respect to a rotary shaft of the arm 210 may correspond to the first angle. In this case, the arm 210 rotates at a first rotational speed during the first time segment, so that the amount of change in the angle, which is equal to the first angle, and the amount of positional movement, which is equal to the (1-1)th movement path 420, may be generated.

[0068] In operation S330, the device 100 may rotate the bucket 220 connected to the arm 210 as the angle of the arm 210 corresponds to the first angle. For example, the arm cylinder connected to the arm 210 is rotationally driven to rotate only the arm 210 until the angle of the arm 210 reaches the first angle. From a time point at which the angle of the arm 210 reaches the first angle, the arm cylinder and the bucket cylinder connected to the bucket 220 may be rotationally driven to rotate the arm 210 and the bucket 220 together.

[0069] In the embodiment, the device 100 may rotate the bucket 220 in a direction in which the angle between the arm 210 and the bucket 220 decreases. That is, the arm 210 and the bucket 220 may rotate together so that the bucket 220 rotates in an inward direction. In the embodiment, the device 100 may move the arm 210 at a (2-1)th rotational speed and move the bucket 220 at a (2-2)th rotational speed greater than the (2-1)th rotational speed. As an example, a rotational speed of the bucket 220 may be controlled such that an initial movement speed may be determined as the (2-2)th rotational speed greater than the (2-1)th rotational speed by a preset ratio or more and the movement speed becomes equal to the (2-1)th rotational speed over time.

[0070] In the embodiment, the device 100 may rotate the arm 210 and the bucket 220 in a state in which the

boom 230 is stopped. For example, as illustrated in FIG. 5, the device 100 may perform a control such that, as the boom 230 does not rotate and only the arm 210 and the bucket 220 rotate toward the body of the excavator 200, the soil having a predetermined volume or more is contained in the bucket 220.

[0071] Referring to FIG. 5, during the second time segment indicating a time from when the angle of the arm 210 corresponds to the first angle until the angle between the arm 210 and the bucket 220 corresponds to the second angle, the bucket 220 may move from a (2-1)th point 510 at which the bucket 220 firstly starts to move to a (2-2)th point 530 along a (2-1)th movement path 520. In the embodiment, during the same time segment, the arm 210 may move from the (1-2)th point 430, at which the angle of the arm 210 corresponds to the first angle, along a (1-2)th movement path 440 to a (1-3)th point 450 or may move toward the (1-3)th point 450. In this case, the boom 230 does not rotate and only the arm 210 and the bucket 220 rotate, and thus the angle between the arm 210 and the bucket 220 may decrease over time. In another embodiment, during the same time segment, only the bucket 220 may rotate, and the arm 210 and the boom 230 may not rotate.

[0072] In the embodiment, an inclination between the arm 210 and the bucket 220 with respect to a rotary shaft of the bucket 220 may correspond to the second angle. For example, a time point at which the angle of the arm 210 is the first angle indicates a boundary time point between the first time segment and the second time segment. During the second time segment, the arm 210 rotates at the (2-1)th rotational speed to generate the amount of change in the angle, which is equal to a (2-1)th angle and the amount of positional movement, which is equal to the (1-2)th movement path 440. The bucket 220 rotates at the (2-2)th rotational speed to generate the amount of change in the angle, which is equal to a (2-2)th angle and the amount of positional movement, which is equal to the (2-1)th movement path 520. The arm 210 and the bucket 220 may rotate until a difference between the (2-2)th angle and the (2-1)th angle corresponds to the preset second angle.

[0073] In this way, the device 100 may determine the first angle through calculation in advance, and then sequentially control the rotation of the arm 210 and the bucket 220 according to the first angle in a state in which the first angle is determined. Accordingly, while the arm 210 moves, the device 100 may operate without measuring the volume of the soil contained in the bucket 220 in real time. Thus, considerable resource consumption required in a process of measuring the volume of the soil in real time can be reduced, thereby achieving efficient operation, and at the same time, the first angle may be calculated based on the information on the terrain so that control of an excavation operation of the excavator 200 is accurately performed.

[0074] In the embodiment, the second angle may be determined based on at least one of the first angle, the

preset volume, and the trend line 710. For example, in operation S310, when the first angle is determined, the second angle may be calculated by applying a preset ratio from the first angle, a set value by a user may be applied to the second angle, or the second angle may be adjusted by reflecting, on the set value, an average angle of the slope of the land viewed from the excavator 200.

[0075] In the embodiment, the device 100 may sense a pressure applied to the arm 210, may stop the movement of the arm 210 and the bucket 220 when the pressure applied to the arm 210 corresponds to a first pressure, and may rotate the boom 230 in a direction in which the bucket 220 raises in a state in which a hydraulic pressure applied to the arm 210 and the bucket 220 is maintained. However, in this case, even though the hydraulic pressure is maintained in the arm 210 and the bucket 220, in some cases, the arm 210 and the bucket 220 may seem to be stopped due to a pressure applied from the outside. During the digging operation, in particular, in the second time segment, a stuck state indicating a state in which a load is too large and thus the arm 210 and the bucket 220 cannot move may be detected. In this case, the arm 210 and the bucket 220 may be released from the stuck state through a boom-up operation of moving the boom 230. For example, the device 100 may sense the pressure applied to the arm 210 in real time through a built-in pressure sensor and perform the boom-up operation of rotating and moving the boom 230 upward when it is detected that the pressure of the arm 210 is greater than or equal to the first pressure (e.g., 280 bar) while the arm 210 and the bucket 220 rotate.

[0076] In the embodiment, when the pressure applied to the arm 210 corresponds to the second pressure, the device 100 may stop the rotation of the boom 230, and the second pressure may be smaller than the first pressure. For example, when it is detected that the pressure of the arm 210 is lower than or equal to a second value (e.g., 250 bar) while the boom-up operation is performed so that the arm 210 and the bucket 220 are released from the stuck state, the boom-up operation is released, and the remaining operation of rotating only the arm 210 and the bucket 220 may be subsequently performed until the angle between the arm 210 and the bucket 220 becomes the second angle. That is, only when the pressure is low enough, the boom-up operation may be stopped.

[0077] In the embodiment, the second value may be smaller than the first value by a predetermined value or ratio, and the second value may be determined to a value that is two times smaller than the first value or a value that is smaller than the first value by a predetermined ratio or more based on statistical data causing the stuck state. That is, the second value may be set to be smaller than the first value with a sufficient margin to some extent to prevent the movement from stopping unnecessarily frequently.

[0078] In the embodiment, the second value may be adjusted based on the trend line 710. For example, when an average angle between the excavator 200 and the

ground is very large more than a preset value, the second value is updated to a value smaller than a preset ratio, and thus in a very sloping area, more sufficient margins may be set.

[0079] In the embodiment, the device 100 may determine a speed of the boom 230 based on the first pressure in a process of performing the boom-up operation as the pressure applied to the arm 210 corresponds to the first pressure. For example, the device 100 may adjust a rotational speed of the boom 230 within a set level by reflecting an adjustment factor inversely proportional to the first pressure. The boom 230 may move slowly when a very large pressure is detected on the arm 210 and may move quickly when a relatively small pressure is detected and thus the boom-up operation is performed.

[0080] In operation S340, the device 100 may move the boom 230 as the angle between the arm 210 and the bucket 220 corresponds to the second angle due to the rotation of the bucket 220. For example, the arm 210 and the bucket 220 rotate together until the angle between the arm 210 and the bucket 220 reaches the second angle. As the arm 210 and the bucket 220 rotate, the angle between the arm 210 and the bucket 220 decreases, and when the angle between the arm 210 and the bucket 220 reaches the second angle, the boom 230 may rotate. Alternatively, according to another embodiment, the movement of the bucket 220 reaches a preset ratio (e.g., 0.8 times) or more of a preset target angle and then the boom 230 may be moved so that the movement amount of the arm 210 becomes a preset value (e.g., the first angle * 1.5).

[0081] In the embodiment, the device 100 may simultaneously rotate the arm 210, the bucket 220, and the boom 230. For example, the rotation of the arm 210, the bucket 220, and the boom 230 may be sequentially triggered in a manner in which the bucket 220 additionally rotates when the angle of the arm 210 reaches a preset ratio (e.g., 70%) of the first angle, and the boom 230 additionally rotates when the angle between the arm 210 and the bucket 220 reaches a preset ratio (e.g., 80%) of the second angle.

[0082] Referring to FIG. 6, during the third time segment indicating a time from when the angle between the arm 210 and the bucket 220 corresponds to the second angle until the height of an end of the bucket 220 corresponds to a preset height, the boom 230 may move from a (3-1)th point 610, at which the boom 230 firstly starts to move, along a third movement path 620 to a third point 630. In the embodiment, during the same time segment, the arm 210 may move from the (1-2)th point 430, at which the angle between the arm 210 and the bucket 220 corresponds to the second angle, along the (1-2)th movement path 440 to the (1-3)th point 450. The bucket 220 may move from the (2-2)th point 530, at which the angle between the arm 210 and the bucket 220 corresponds to the second angle, along a (2-2)th movement path 540 to a (2-3)th point 550. In this case, all the arm 210, the bucket 220, and the boom 230 rotate, and thus the angle

between the arm 210 and the bucket 220 may further decrease over time. In another embodiment, during the same time segment, only the boom 230 may rotate, and at least one of the arm 210 and the bucket 220 may not rotate.

[0083] For example, a time point at which the angle between the arm 210 and the bucket 220 is the second angle indicates a boundary time point between the second time segment and the third time segment. The device 100 may perform the boom-up operation of moving the boom 230 upward until a lowermost height of the bucket 220 reaches a determined target height based on a highest height of a load carrier (e.g., a dump truck, a hopper, and a crusher) adjacent to the excavator 200 through a built-in height sensor.

[0084] The built-in height sensor may include the excavator 200, may be included in the load carrier, or may be included in another third device (e.g., an adjacent device). The type and operation method (e.g., an ultraviolet method, an infrared method, ultrasonic method) of the sensor is not limited.

[0085] In this way, the device 100 rotates the arm 210 and starts to rotate the bucket 220 at a trigger time point at which the angle of the arm 210 corresponds to the first angle. The device 100 rotates the arm 210 and the bucket 220 together and starts to rotate the boom 230 at a trigger time point at which the angle between the arm 210 and the bucket 220 corresponds to the second angle. The device 100 may efficiently control to rotate the arm 210, the bucket 220, and the boom 230 together and terminate the rotation of the boom 230 through the digging operation at a trigger time point at which the height of the bucket 220 corresponds to the preset height so that the soil having a targeted volume is contained in the bucket 220.

[0086] FIGS. 7 and 8 are views for describing an operation in which the device 100 controls rotation of the boom 230 according to the embodiment.

[0087] Referring to FIG. 7, the device 100 may determine the trend line 710 according to the slope of the terrain based on the information on the terrain including the object, may analyze the movement of the bucket 220 required to contain the object (e.g., the soil) having a preset volume or more in the bucket 220 based on a pile shape trend line of a pre-stored environment recognition algorithm (see identification number 720), may determine the first angle of the arm 210 and the second angle of the arm 210 and the bucket 220 for containing the object (e.g., the soil) having a preset volume or more in the bucket 220 according to the analysis result, and may calculate a target angle of the boom 230 by sensing information on a height between a bottom point of the bucket 220 and a dump bed disposed at an upper end of the load carrier through the built-in height sensor.

[0088] In the embodiment, the device 100 may analyze the amount of movement of the arm 210 and the amount of movement of the bucket 220 for containing the object (e.g., the soil) having a preset volume or more in the bucket 220 of the arm 210, may calculate the first angle

and the second angle from the analysis, and may rotate only the arm 210 until the angle of the arm 210 reaches the first angle (see identification number 730). Further, when the angle of the arm 210 reaches the first angle, until a total angle change amount of the arm 210 reaches a preset value (e.g., the analyzed amount of the arm 210 * 1.5) and the angle of the bucket 220 reaches a certain level (e.g., 80%) of the second angle, the arm 210 and the bucket 220 may rotate together at different rotational speeds (see identification number 740 and 750). When the angle between the arm 210 and the bucket 220 reaches a target value, the boom 230 starts to rotate, and the boom-up operation may be performed until a height difference between the bottom point of the bucket 220 and the uppermost end of the load carrier corresponds to a preset value (see identification number 860).

[0089] Further, as described above, in a process of rotating the arm 210 and the bucket 220 together, when the pressure applied to at least one of the arm 210 and the bucket 220 is sensed in real time, a chamber pressure having a preset value or more or a mutually equivalent pressure is detected, and thus the arm 210 and the bucket 220 are determined as the stuck state (or a stall state), the device 100 may perform the boom-up operation of activating the boom 230 so that the arm 210 and the bucket 220 are released from the corresponding state.

[0090] Referring to FIG. 8, the device 100 may rotate the boom 230 until a difference value between a lowermost height that the bucket 220 may reach and an uppermost height of the load carrier adjacent to the excavator 200 corresponds to a preset value. Here, the lowermost end of the bucket 220 indicates a lowermost height that an end point of the bucket 220 may reach when the rotation of the bucket 220 is considered. FIG. 8 illustrates a dump bed 810 which is disposed at an upper end of the load carrier adjacent to the excavator 200 and on which the object contained in the bucket 220 may be loaded. The device 100 may sense a first height 820 that is a distance between the ground and an uppermost position of the dump bed 810, may set a target value of a second height 830 that is a lowermost height that the bucket 220 may reach such that the second height 830 has a margin greater than the first height 820 by a preset value (e.g., 50 cm) or more, and may sense the second height 830 in real time in a process of rotating the boom 230 and perform the boom-up operation until a difference value 840 between the second height 830 and the first height 820 reaches a preset value (e.g., 50 cm).

[0091] In the embodiment, the device 100 may determine an arrival point 860 of the bucket 220 based on at least one of the difference value 840 between the first height 820 and the second height 830, a width 850 of the bucket 220, and a central position of the dump bed 810. For example, as illustrated in FIG. 8, the lowermost height that the bucket 220 is to reach is determined so that the difference value 840 between the second height 830 and the first height 820 reaches a preset value (e.g., 50 cm),

and a height Z_r of the arrival point 860 may be determined by adding the width 850 of the bucket 220 to the determined lowermost height so that the bucket 220 may sufficiently rotate by a preset angle (e.g., 90 degrees) or more in a process of loading the object on the load carrier. Further, a center position (X_d and Y_d) of the dump bed 810 is detected in an X axis direction and an Y axis direction, a horizontal width X_r and a vertical width Y_r of the arrival point 860 are determined according to the center position (X_d and Y_d) of the dump bed 810 or determined such that the arrival point 860 is positioned within a preset distance margin therefrom, and thus positional coordinates X_r , Y_r , and Z_r of the arrival point 860, which correspond to a target position that the rotary shaft of the bucket 220 finally reaches, may be determined.

[0092] In the embodiment, the positional coordinates X_r , Y_r , and Z_r of the arrival point 860 may be determined based on at least one of Equation 1 and Equation 2, but the present disclosure is not limited thereto.

[Equation 1]

$$X_1 = W_b + X_m$$

$$X_r = (X_d / 2) - X_1$$

$$Z_1 = W_b + Z_m$$

$$Z_r = Z_d + Z_1$$

[Equation 2]

$$Y_r = Y_d + Y_m$$

[0093] (Here, X_m , Y_m , and Z_m denote a preset first margin in the X axis direction, a preset second margin in the Y axis direction, and a preset third margin in a Z axis direction, W_b denote the width 850 of the bucket 220, and X_d and Y_d denote the center position of the dump bed 810 in the X axis direction and the Y axis direction).

[0094] In this way, the device 100 may set, as a target angle, the angle of the boom 230 when a difference between the lowermost end of the bucket 220 and the uppermost end of the dump bed 810 is a certain margin (e.g., 50 cm) or more, may perform a control so as not to perform the boom-up operation after the boom-up operation is performed only up to the target angle, and thus may perform a control so that an efficient movement that is as large as necessary is achieved.

[0095] In the embodiment, the device 100 may differently determine at least one of the speed of the arm 210 and the speed of the bucket 220 in operations S310, S320, and S330. For example, the rotational speed of the arm 210 is determined such that the speed decreases in the order of operations S310, S320, and S330. In an

initial stage in which rough work is performed, the arm 210 may move quickly, and in a late stage in which delicate work is required, the arm 210 may move slowly. As another example, in respective operations, the speed of the arm 210 may be controlled to be continuously changed in order of a first speed, a second speed (faster than the first speed), and the first speed over time and may be determined such that the speed is smaller in the late stage than in the initial stage.

[0096] In the embodiment, in the device 100, at least one of the speed of the arm 210 and the speed of the bucket 220 may be updated based on the type of object, the importance of work, and the trend line 710. For example, when the excavator 200 is gently inclined at a preset level or more with respect to the ground, the importance of work received through user input is normal, or the type of object is general soil, the speed may be set to be quick or the degree of difference between speeds in step by step may increase. Further, when the excavator 200 is sharply inclined, the importance of work is high, or the type of object is a hazardous material, the speed may be set to be slow or the degree of difference between speeds in step by step may decrease. Further, different weights may be assigned to respective elements, and for example, high weights may be assigned in the order of the type of object, the importance of work, and the trend line 710. In this way, the digging operation may be performed quickly and precisely according to situations in consideration of a stage in which the digging operation is performed, the slope situation, the type of object, and the like.

[0097] FIG. 9 is a view for describing a projection area 910 of the bucket 220 according to the embodiment. Referring to FIG. 9, the virtual projection area 910 for the bucket 220 may be identified according to the shape of the bucket 220. When the device 100 controls the movement of the arm 210, the bucket 220, and the boom 230, the projection area 910 may be used.

[0098] In detail, FIG. 10 illustrates an example in which the device 100 according to the embodiment controls the movement of the arm 210, the bucket 220, and the boom 230 based on a point 1110 at which the projection area 910 of the bucket 220 and the trend line 710 overlap each other.

[0099] Referring to FIG. 10, the device 100 may determine the first angle based on the point 1110 at which the projection area 910 and the trend line 710 overlap each other, may move the arm 210 so that the angle of the arm 210 corresponds to the first angle, may rotate the bucket 220 connected to the arm 210 as the angle of the arm 210 corresponds to the first angle, and may move the boom 230 as the angle between the arm 210 and the bucket 220 corresponds to the second angle through the rotation of the bucket 220.

[0100] For example, the device 100 may determine the first angle based on a ratio of a first height 1130 and a second height 1120, which is determined according to the overlapping point 1110. As an example, the device

100 may control the rotation of the arm 210 by previously determining the first angle when "the first height 1 130/the second height 1 120 = 0.9". Here, 0.9 is an arbitrary number, and the number may be determined as an arbitrary number of 1 or less in advance.

[0101] According to the embodiment, the device 100 may determine the angle of the arm 210, at which the volume of the object contained in the bucket 220 is a preset value, according to the overlapping point 1 110. In detail, the device 100 may determine the volume of the object contained in the bucket 220 based on the ratio of the first height 1 130 and the second height 1 120 and may determine the first angle accordingly.

[0102] The device operation according to the determination of the first angle may refer to the details described above with reference to FIGS. 1 to 8.

[0103] According to an embodiment of the present disclosure, movement of an arm, a bucket, and a boom can be effectively controlled based on an angle of the arm at which a volume of an object contained in the bucket is a preset value.

[0104] The order and combination of the operations described above is an embodiment, and it can be seen that an order, a combination, a branch, a function, and a subject of performance thereof may be variously implemented in an added form, an omitted form, or a modified form without departing from the essential characteristics of respective components described in the specification.

[0105] Meanwhile, the above-described method may be written as a computer-executable program and may be implemented in a general-purpose digital computer that operates the program using a computer-readable recording medium. Further, a structure of data used in the above-described method may be recorded on the computer-readable recording medium through various means. The computer-readable recording medium includes storage media such as magnetic storage media (e.g., a read-only memory (ROM), a random access memory (RAM), a universal serial bus (USB), a floppy disc, a hard disc, and the like) and optical reading media (e.g., a compact disc read-only memory (CD-ROM), a digital versatile disc (DVD), and the like).

[0106] The above description of the present disclosure is merely illustrative, and those skilled in the art to which the present disclosure pertains can understand that the present disclosure can be easily modified in other specific forms without changing the technical spirit or essential features of the present disclosure. Therefore, it should be understood that the embodiments described above are illustrative but not limiting in all aspects. For example, components described as a single type may be implemented in a distributed manner, and likewise, components described as a distributed manner may also be implemented in a coupled form.

[0107] The scope of the present disclosure is indicated by the appended claims, and all changes or modifications derived from the meaning and scope of the appended claims and equivalent concepts thereof should be con-

strued as being included in the scope of the present disclosure.

5 Claims

1. A method of controlling an excavator, the method comprising:

10 determining a first angle that is an angle of an arm at which a volume of an object contained in a bucket is a preset value;
moving the arm so that the angle of the arm corresponds to the first angle;
15 rotating a bucket connected to the arm in response to the angle of the arm corresponding to the first angle; and
moving a boom in response to an angle of the bucket corresponding to a second angle through the rotation of the bucket.

2. The method of claim 1, wherein the determining of the first angle includes determining the first angle based on a trend line determined according to a slope of a terrain including the object.

3. The method of claim 1, wherein the moving of the arm includes rotating the arm so that an angle between the arm and a direction of gravity corresponds to the first angle.

4. The method of claim 1, wherein the rotating of the bucket includes rotating the bucket in a direction in which an angle between the arm and the bucket decreases.

5. The method of claim 1, wherein the moving of the boom includes rotating the boom until a difference value between a lowermost height that the bucket reaches and an uppermost height of a load carrier adjacent to the excavator corresponds to a preset value.

6. The method of claim 1, wherein the rotating of the bucket includes:

sensing a pressure applied to the arm; and
rotating the boom in a direction in which the bucket raises in a state in which a hydraulic pressure applied to the arm and the bucket is maintained when the pressure applied to the arm corresponds to a first pressure.

7. The method of claim 6, wherein the rotating of the boom in the direction in which the bucket raises includes stopping the rotation of the boom when the pressure applied to the arm corresponds to a second pressure, and

the second pressure is smaller than the first pressure.

8. The method of claim 1, wherein the moving of the arm includes rotating the arm in a direction in which the arm approaches a body of the excavator in a state in which the bucket and the boom are stopped. 5
9. The method of claim 1, wherein the rotating of the bucket includes simultaneously rotating the arm and the bucket in a state in which the boom is stopped. 10
10. The method of claim 1, wherein the moving of the boom includes simultaneously rotating the arm, the bucket, and the boom. 15
11. The method of claim 2, wherein the first angle is determined based on a point at which a projection area of the bucket and the trend line overlap each other. 20
12. A device for controlling an excavator, the device comprising:

a reception unit configured to acquire information on a terrain including an object; and 25
a processor configured to determine a first angle, which is an angle of an arm at which a volume of the object contained in a bucket is a preset value, based on the information on the terrain, 30
move the arm so that the angle of the arm corresponds to the first angle,
rotate the bucket connected to the arm in response to the angle of the arm corresponding to the first angle, and 35
move a boom in response to an angle of the bucket corresponding to a second angle through the rotation of the bucket.

13. The device of claim 12, wherein the processor determines the first angle based on a trend line determined according to a slope of the terrain including the object. 40
14. The device of claim 12, wherein the processor rotates the arm so that an angle between the arm and a direction of gravity corresponds to the first angle. 45
15. The device of claim 12, wherein the processor rotates the bucket in a direction in which an angle between the arm and the bucket decreases. 50
16. The device of claim 12, wherein the processor rotates the boom until a difference value between a lowermost height that the bucket reaches and an uppermost height of a load carrier adjacent to the excavator corresponds to a preset value. 55

17. The device of claim 12, wherein the processor senses a pressure applied to the arm and rotates the boom in a direction in which the bucket raises in a state in which a hydraulic pressure applied to the arm and the bucket is maintained when the pressure applied to the arm corresponds to a first pressure.
18. The device of claim 17, wherein the processor stops the rotation of the boom when the pressure applied to the arm corresponds to a second pressure, and the second pressure is smaller than the first pressure.
19. The device of claim 12, wherein the processor rotates the arm in a direction in which the arm approaches a body of the excavator in a state in which the bucket and the boom are stopped.
20. The device of claim 13, wherein the first angle is determined based on a point at which a projection area of the bucket and the trend line overlap each other.
21. An excavator comprising:

a boom;
an arm connected to the boom;
a bucket connected to the arm; and
a controller configured to determine a first angle which is an angle of the arm at which a volume of an object contained in the bucket is a preset value, control the arm so that the angle of the arm corresponds to the first angle, control the bucket so that the bucket connected to the arm rotates in response to the angle of the arm corresponding to the first angle, and control the boom so that the boom moves in response to an angle between the arm and the bucket corresponding to a second angle through the rotation of the bucket.
22. A computer-readable recording medium on which a program for executing the method of any one of claims 1 to 11 in a computer is recorded.

FIG.1

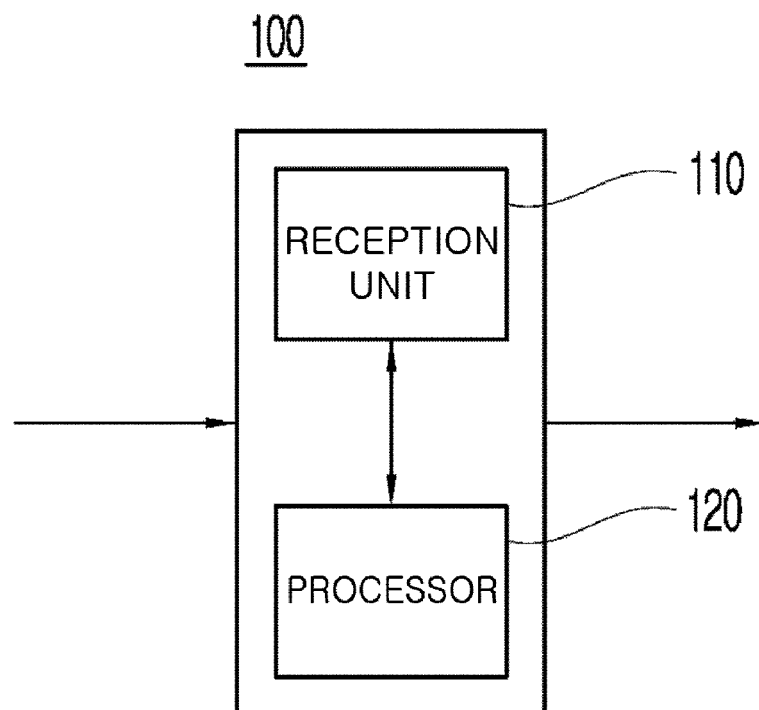


FIG.2

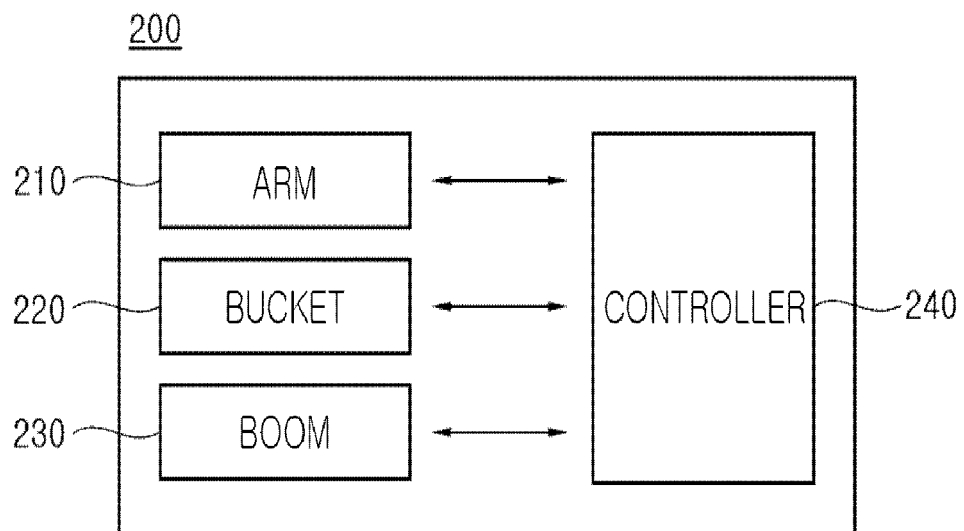


FIG.3

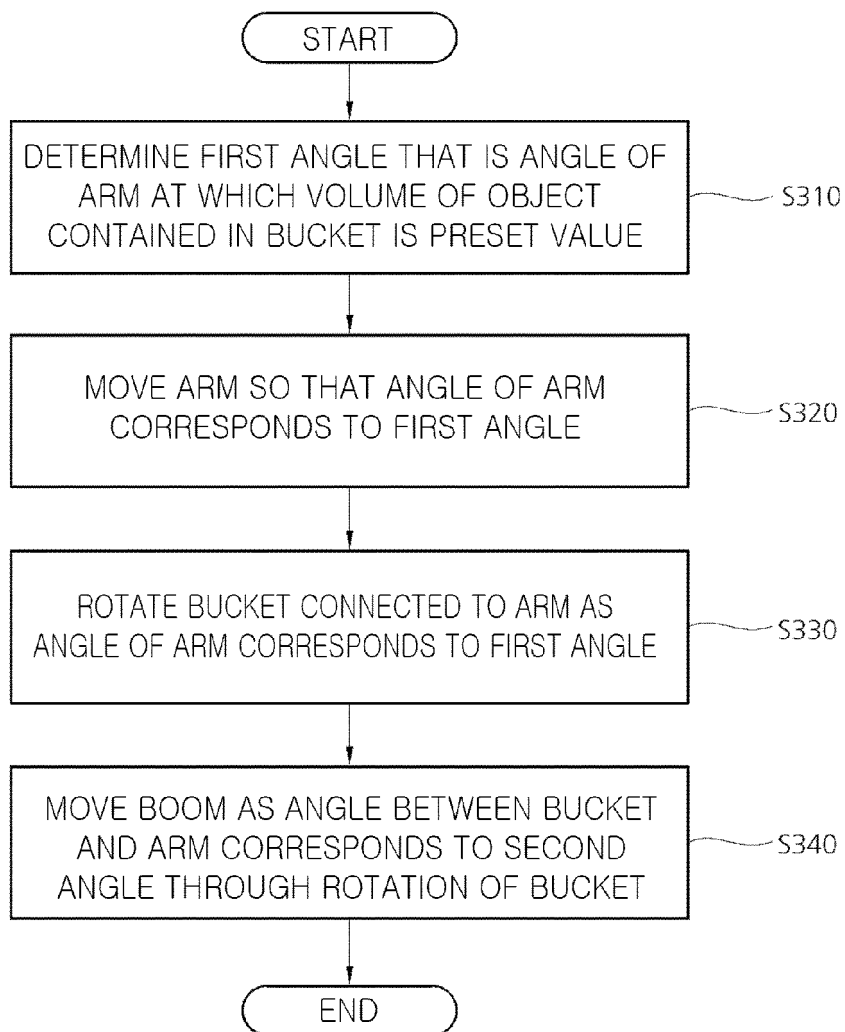


FIG.4

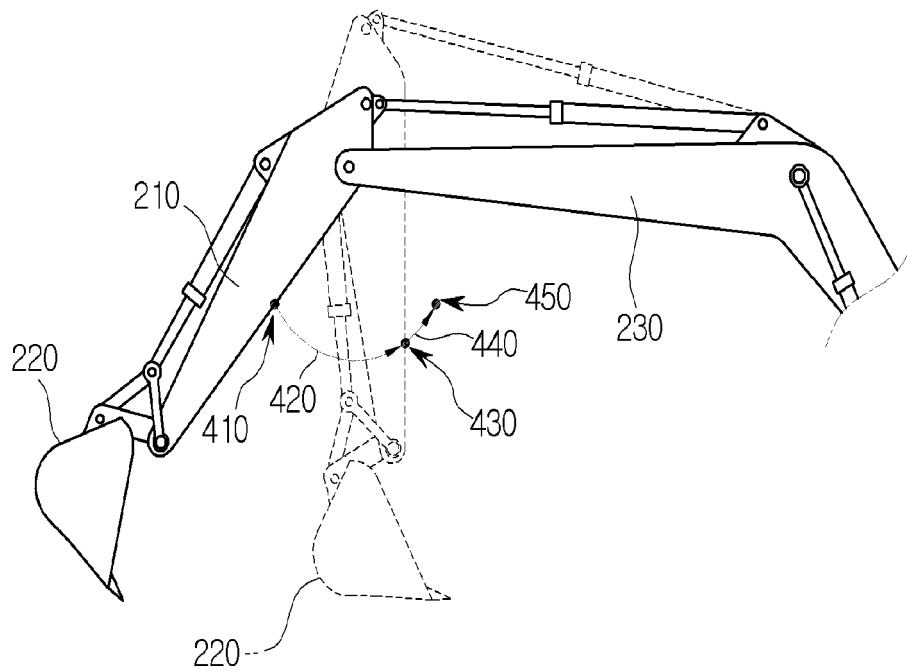


FIG.5

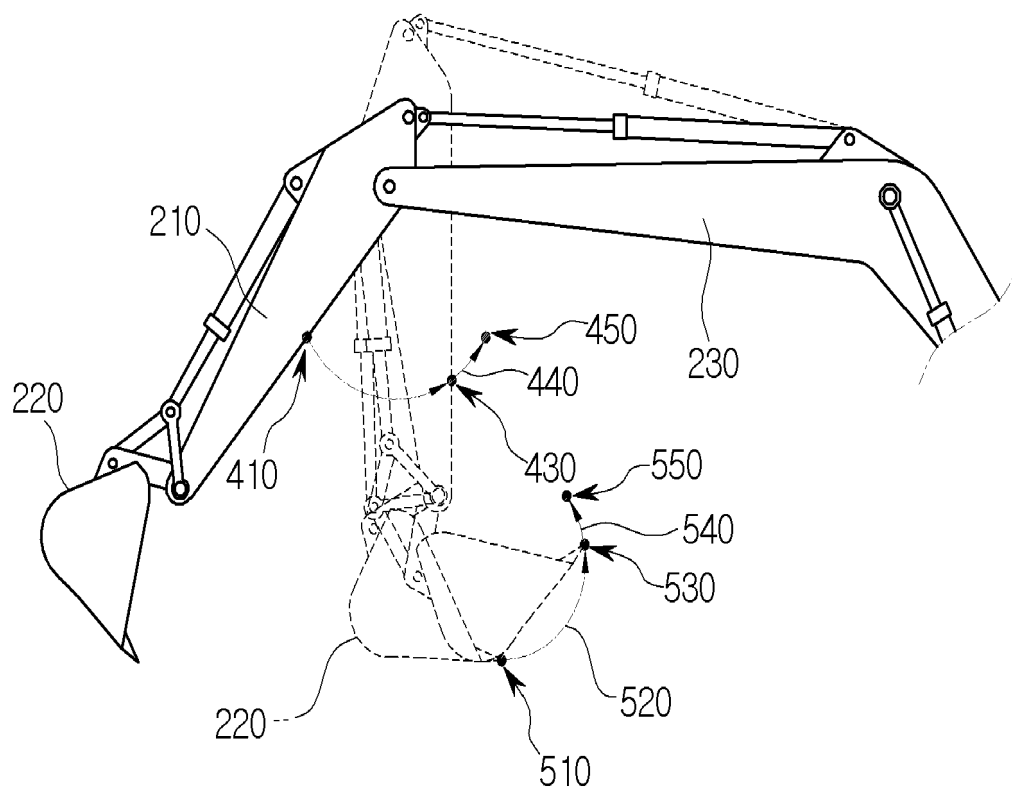


FIG.6

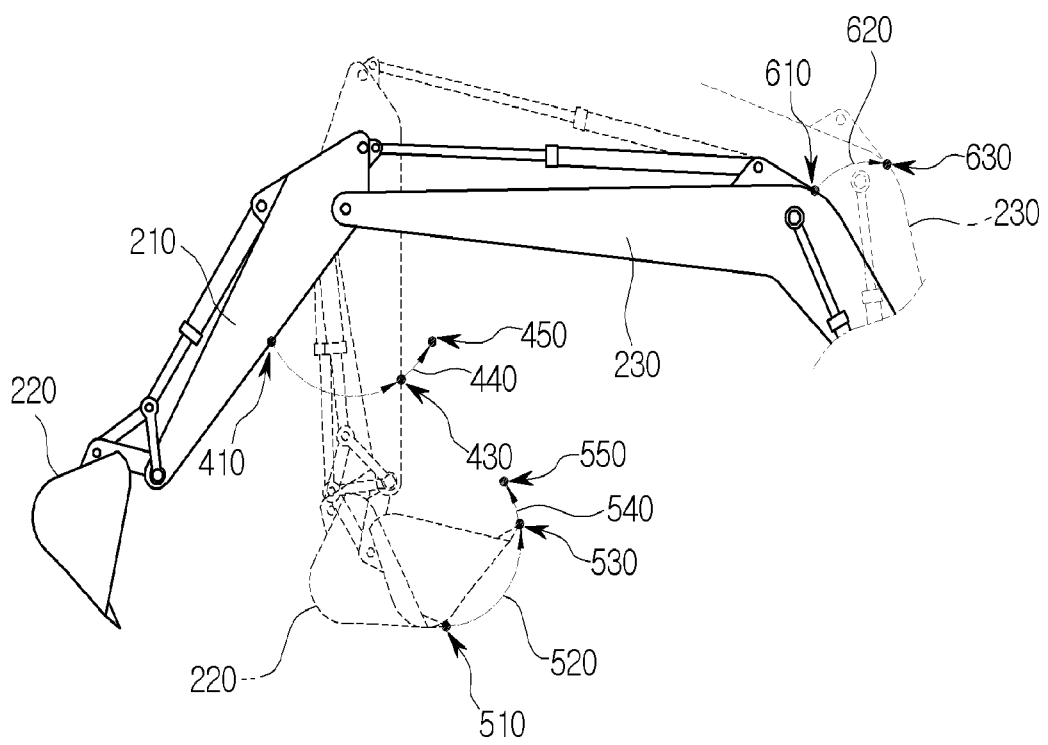


FIG.7

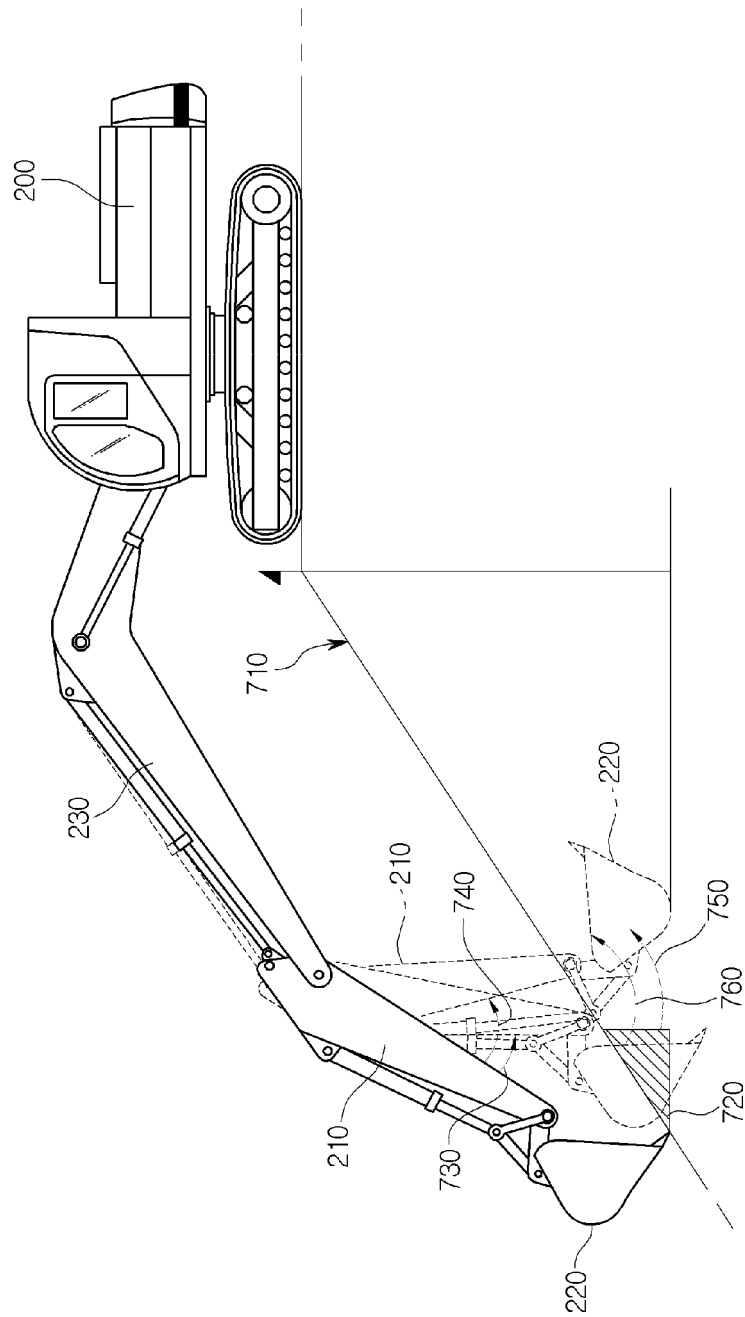


FIG.8

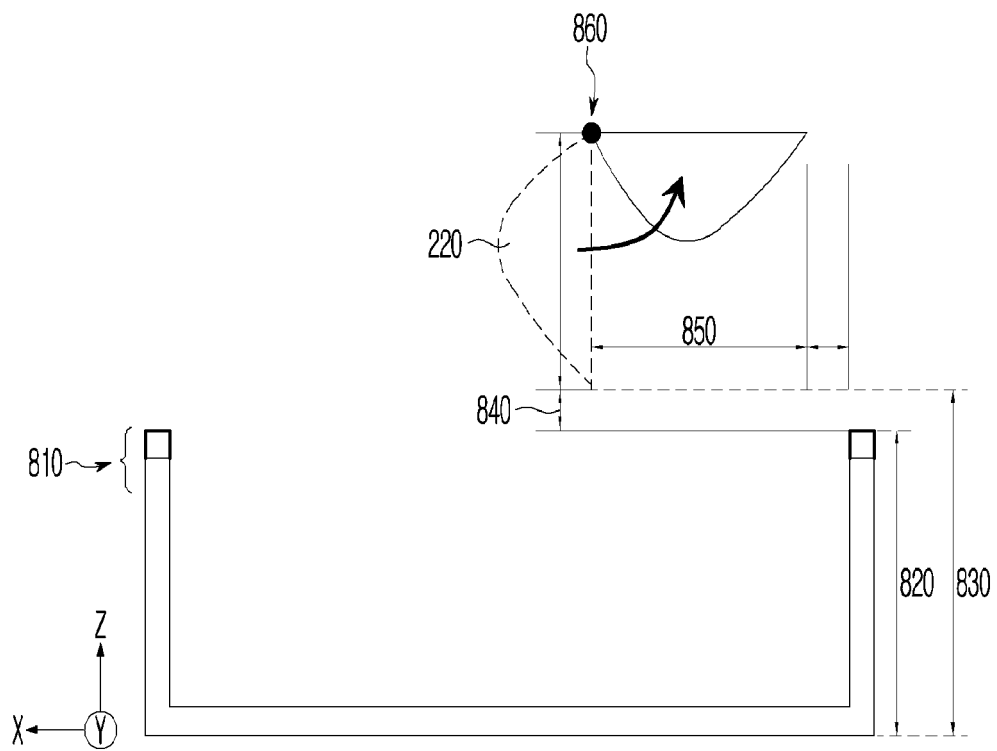


FIG.9

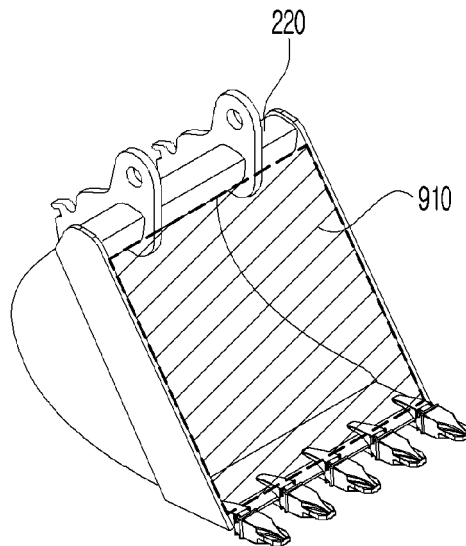
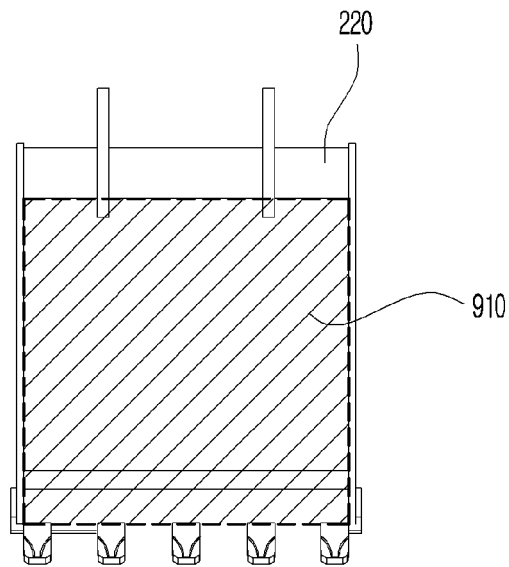
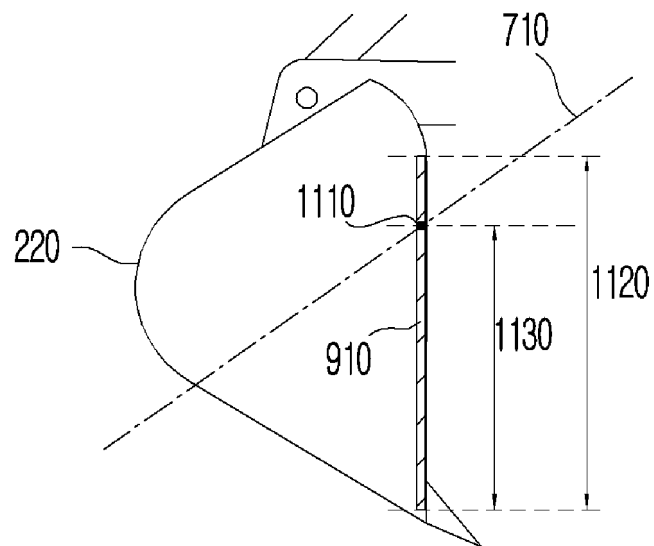


FIG.10



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2020/019037

A. CLASSIFICATION OF SUBJECT MATTER E02F 3/43(2006.01)i; E02F 9/20(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) E02F 3/43(2006.01); E02F 9/20(2006.01); E02F 9/22(2006.01); E02F 9/24(2006.01)																					
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Korean utility models and applications for utility models: IPC as above Japanese utility models and applications for utility models: IPC as above																					
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) eKOMPASS (KIPO internal) & keywords: 굴착기(excavator), 버킷(bucket), 암(arm), 붐(boom), 기설정(predetermined), 부피(volume)																					
C. DOCUMENTS CONSIDERED TO BE RELEVANT																					
<table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td>JP 2016-160718 A (HITACHI LTD.) 05 September 2016 (2016-09-05) See paragraphs [0030]-[0053] and [0058]-[0066] and figures 1-8 and 11.</td> <td>1-4,6-15,17-22</td> </tr> <tr> <td>Y</td> <td></td> <td>5,16</td> </tr> <tr> <td>Y</td> <td>EP 3412838 A1 (KOMATSU LTD.) 12 December 2018 (2018-12-12) See paragraphs [0037]-[0042] and figure 7.</td> <td>5,16</td> </tr> <tr> <td>X</td> <td>JP 2000-291076 A (TOKAI RIKI CO., LTD.) 17 October 2000 (2000-10-17) See paragraphs [0082]-[0083] and figure 11.</td> <td>1-4,8-15,19-22</td> </tr> <tr> <td>X</td> <td>KR 10-2019-0039710 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 15 April 2019 (2019-04-15) See claim 1 and figure 3.</td> <td>1-4,8-15,19-22</td> </tr> <tr> <td>A</td> <td>WO 2020-054421 A1 (KOMATSU LTD. et al.) 19 March 2020 (2020-03-19) See claim 1 and figure 3.</td> <td>1-22</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	JP 2016-160718 A (HITACHI LTD.) 05 September 2016 (2016-09-05) See paragraphs [0030]-[0053] and [0058]-[0066] and figures 1-8 and 11.	1-4,6-15,17-22	Y		5,16	Y	EP 3412838 A1 (KOMATSU LTD.) 12 December 2018 (2018-12-12) See paragraphs [0037]-[0042] and figure 7.	5,16	X	JP 2000-291076 A (TOKAI RIKI CO., LTD.) 17 October 2000 (2000-10-17) See paragraphs [0082]-[0083] and figure 11.	1-4,8-15,19-22	X	KR 10-2019-0039710 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 15 April 2019 (2019-04-15) See claim 1 and figure 3.	1-4,8-15,19-22	A	WO 2020-054421 A1 (KOMATSU LTD. et al.) 19 March 2020 (2020-03-19) See claim 1 and figure 3.	1-22
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.																			
X	JP 2016-160718 A (HITACHI LTD.) 05 September 2016 (2016-09-05) See paragraphs [0030]-[0053] and [0058]-[0066] and figures 1-8 and 11.	1-4,6-15,17-22																			
Y		5,16																			
Y	EP 3412838 A1 (KOMATSU LTD.) 12 December 2018 (2018-12-12) See paragraphs [0037]-[0042] and figure 7.	5,16																			
X	JP 2000-291076 A (TOKAI RIKI CO., LTD.) 17 October 2000 (2000-10-17) See paragraphs [0082]-[0083] and figure 11.	1-4,8-15,19-22																			
X	KR 10-2019-0039710 A (HITACHI CONSTRUCTION MACHINERY CO., LTD.) 15 April 2019 (2019-04-15) See claim 1 and figure 3.	1-4,8-15,19-22																			
A	WO 2020-054421 A1 (KOMATSU LTD. et al.) 19 March 2020 (2020-03-19) See claim 1 and figure 3.	1-22																			
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex. <table border="0"> <tr> <td style="vertical-align: top;"> * Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "D" document cited by the applicant in the international application "E" earlier application or patent but published on or after the international filing date "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) "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 </td> <td style="vertical-align: top;"> "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 "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 "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family </td> </tr> </table>	* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "D" document cited by the applicant in the international application "E" earlier application or patent but published on or after the international filing date "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) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "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 "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family																			
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "D" document cited by the applicant in the international application "E" earlier application or patent but published on or after the international filing date "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) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "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 "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family																				
<table border="1"> <tr> <td>Date of the actual completion of the international search 17 September 2021</td> <td>Date of mailing of the international search report 23 September 2021</td> </tr> </table>	Date of the actual completion of the international search 17 September 2021	Date of mailing of the international search report 23 September 2021																			
Date of the actual completion of the international search 17 September 2021	Date of mailing of the international search report 23 September 2021																				
<table border="1"> <tr> <td> Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon Building 4, 189 Cheongsaro, Seo-gu, Daejeon 35208 Facsimile No. +82-42-481-8578 </td> <td> Authorized officer Telephone No. </td> </tr> </table>	Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon Building 4, 189 Cheongsaro, Seo-gu, Daejeon 35208 Facsimile No. +82-42-481-8578	Authorized officer Telephone No.																			
Name and mailing address of the ISA/KR Korean Intellectual Property Office Government Complex-Daejeon Building 4, 189 Cheongsaro, Seo-gu, Daejeon 35208 Facsimile No. +82-42-481-8578	Authorized officer Telephone No.																				

Form PCT/ISA/210 (second sheet) (July 2019)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2020/019037

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2016-160718 A	05 September 2016	JP 6314105 B2	18 April 2018
		US 2016-0258128 A1	08 September 2016
		US 9752298 B2	05 September 2017
EP 3412838 A1	12 December 2018	CN 108779628 A	09 November 2018
		CN 108779628 B	08 June 2021
		EP 3412838 A4	28 August 2019
		EP 3412838 B1	04 November 2020
		JP 6914943 B2	04 August 2021
		US 10815640 B2	27 October 2020
		US 2019-0093311 A1	28 March 2019
		US 2021-0032837 A1	04 February 2021
		WO 2018-043104 A1	08 March 2018
JP 2000-291076 A	17 October 2000	None	
KR 10-2019-0039710 A	15 April 2019	CN 109757113 A	14 May 2019
		CN 109757113 B	16 March 2021
		EP 3680395 A1	15 July 2020
		EP 3680395 A4	16 June 2021
		JP 6676825 B2	08 April 2020
		US 2020-0217050 A1	09 July 2020
		WO 2019-049248 A1	14 March 2019
WO 2020-054421 A1	19 March 2020	CN 112639211 A	09 April 2021
		DE 112019003932 T5	20 May 2021
		JP 2020-041354 A	19 March 2020

Form PCT/ISA/210 (patent family annex) (July 2019)