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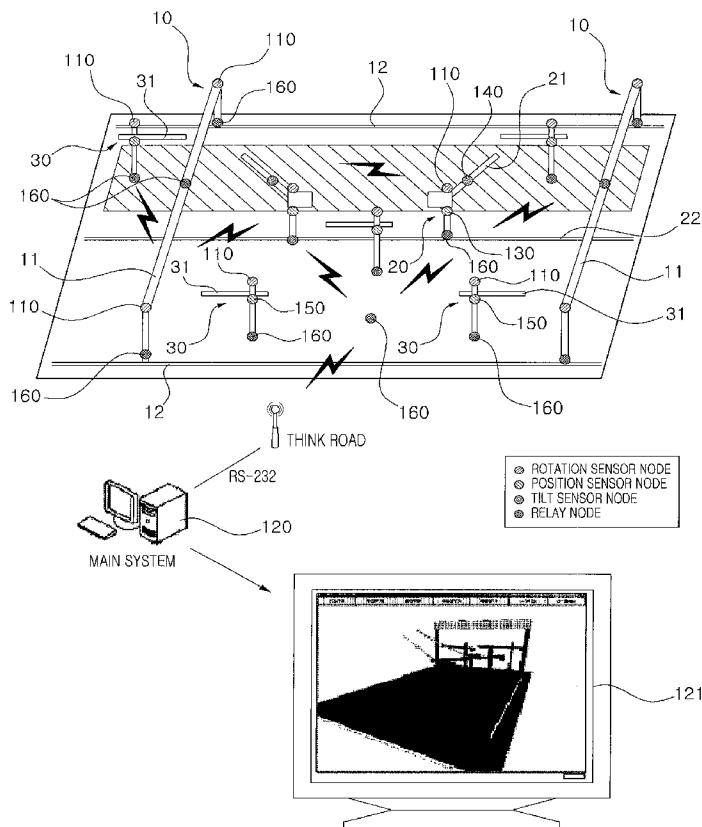
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(54) Title: SYSTEM FOR PREVENTING COLLISION OF CRANES AND MONITORING CRANE WORK

Fig. 3



(57) Abstract: A system for preventing collision of cranes and monitoring a crane work, which includes a plurality of GPS receivers installed in a plurality of cranes to acquire and transmit GPS coordinates for the respective cranes; and a main management unit for predicting collision between the respective cranes using the GPS coordinates of the cranes transmitted from the GPS receivers, rotation angle and tilt information of a jib crane boom transmitted from a first rotation sensor and a tilt sensor installed in the jib crane boom, and rotation angle information of a tower crane boom transmitted from a second rotation sensor installed in the tower crane boom. According to the system, collision between the cranes is predicted more accurately by monitoring in real time even the rotation angle and the tilt of the crane boom in addition to the positions of the respective cranes, and a danger of collision is reported in real time.

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**TITLE : SYSTEM FOR PREVENTING COLLISION OF CRANES AND  
MONITORING CRANE WORK**

**TECHNICAL FIELD**

5           The present invention relates to a system for preventing collision of cranes and monitoring a crane work, and more particularly, to a system for preventing collision of cranes and monitoring a crane work, which can monitor in real time movement of diverse kinds of large-scale cranes working in a ship construction dock and, if collision between cranes is predicted, report danger of  
10 such collision.

**BACKGROUND ART**

          At present, in a ship construction dock, various kinds of large-scale cranes for use in ship construction, such as Goliath cranes, jib cranes, tower cranes, and the like, perform their work as they move independently.

15           The Goliath crane moves along a Goliath rail. The jib crane performs upward/downward movement and left/right rotation and movement of a jib crane boom as it moves along respective jib rails. Also, the tower crane performs left/right rotation and movement of a tower crane boom as it is in its fixed position. The tower crane may remain in its fixed position for several or several  
20 tens of days, and may be moved to another position as needed.

          Although the above-described cranes move slowly at speed of 0.6m/s at maximum and follow instructions of a ground operator, danger still exists in operating the cranes, e.g. collision may occur between cranes or crane booms due to a careless operator.

25           If collision occurs between the cranes, the cranes may be damaged to

cause material loss, long-time interception of a ship construction process, and delay of goods delivery. In addition, the collision between the cranes may cause a loss of lives of crane operators or ground workers.

#### **DISCLOSURE TECHNICAL PROBLEM**

5 It is, therefore, an object of the present invention to provide a system for preventing collision of cranes and monitoring a crane work, which can monitor movement of respective cranes in real time, predict collision between the cranes, and report danger of accident in real time.

Additional aspects and/or advantages of the invention will be set forth in  
10 part in the description which follows and, in part, will be obvious from the description, or may be learned by practice of the invention.

#### **TECHNICAL SOLUTION**

In accordance with an aspect of the present invention, there is provided a system for preventing collision of cranes and monitoring a crane work, which  
15 includes a plurality of GPS receivers installed in a plurality of cranes to acquire and transmit GPS coordinates for the respective cranes; and a main management unit for predicting collision between the respective cranes based on the GPS coordinates of the cranes transmitted from the GPS receivers.

Here, the main management unit may predict collision between the  
20 respective cranes by substituting the GPS coordinates of the respective cranes in three-dimensional (3D) models for the corresponding cranes pre-stored.

The main management unit may further include an alarm unit for making it possible to aurally confirm the collision of the cranes in real time through an alarm or alert message when a difference between GPS coordinates of  
25 specified cranes becomes smaller than a threshold value and collision between

the specified cranes is predicted.

The main management unit may further include a display unit for displaying in real time shapes and positions of the respective cranes using the 3D models for the corresponding cranes in which the GPS coordinates are substituted.

Here, if the difference between the GPS coordinates of the specified cranes becomes smaller than the threshold value, and collision between the specified cranes is predicted, the display unit displays the cranes subject to collision with a specified flickering color or with a color that is different from the color of the cranes that are not subject to collision, so that the cranes subject to collision can be visually confirmed in real time.

The cranes may include one or more of Goliath cranes, jib cranes, and tower cranes.

Here, in the Goliath crane, GPS receivers may be provided at both ends of a horizontal support block installed in a length direction of the crane.

Also, in a jib crane boom that is a crane boom of the jib crane, a first rotation sensor and a tilt sensor for sensing a rotation angle and a tilt of the jib crane boom and transmitting resultant sensor values to the main management unit are provided, and in a tower crane boom that is a crane boom of the tower crane, a second rotation sensor for sensing a rotation angle of the tower crane boom and transmitting a resultant sensor value to the main management unit is provided. In this case, the main management unit can predict the collision between the respective cranes using the GPS coordinates of the respective cranes transmitted from the GPS receivers, information on the rotation angle and the tilt of the jib crane boom transmitted from the first rotation sensor and

the tilt sensor, and information on the rotation angle of the tower crane boom transmitted from the second rotation sensor.

Unlike this, in a jib crane boom that is a crane boom of the jib crane, one or more first GPS units, which are installed in the jib crane boom to receive  
5 GPS values for calculating the rotation angle and the tilt of the jib crane boom and to transmit the received coordinate values to the main management unit, are provided.

In a tower crane boom that is a crane boom of the tower crane, one or more second GPS units, which are installed in the tower crane boom to receive  
10 GPS values for calculating the rotation angle of the tower crane boom and to transmit the received coordinate values to the main management unit, are provided.

The main management unit can predict the collision between the respective cranes using the GPS coordinates of the respective cranes  
15 transmitted from the GPS receivers, information on the rotation angle and the tilt of the jib crane boom calculated through the GPS values transmitted from the first GPS units, and information on the rotation angle of the tower crane boom calculated through the GPS values transmitted from the second GPS units.

Here, the main management unit can predict the collision between the  
20 cranes by substituting the GPS coordinates of the Goliath crane, the jib crane, and the tower crane, information on the rotation angle and the tilt of the jib crane boom, and information on the rotation angle of the tower crane boom for the 3D models of the corresponding cranes pre-stored, and then calculating minimum neighboring distances among a horizontal support block part installed  
25 in a length direction of the Goliath crane, a jib crane boom part of the jib crane,

and a tower crane boom part of the tower crane.

The alarm unit of the main management unit makes it possible to aurally confirm the collision of the cranes in real time through an alarm or alert message when the minimum neighboring distance becomes smaller than a threshold distance and collision between specified cranes is predicted.

Also, the alarm unit classifies the corresponding distance that is smaller than the threshold distance into a plurality of distance steps, and a different alarm or alert message is provided for a corresponding distance step that is smaller than the minimum neighboring distance.

The display unit of the main management unit can display in real time shapes and positions of the respective cranes using the 3D models for the corresponding cranes, in which the transmitted GPS coordinates of the cranes, information on the rotation angle and the tilt of the jib crane, and information on the rotation angle of the tower crane have been substituted.

Also, if collision between the specified cranes is predicted, the display unit displays the cranes subject to collision with a specified flickering color or with a color that is different from the color of the cranes that are not subject to collision, so that the cranes subject to collision can be visually confirmed in real time.

Also, the display unit classifies the corresponding distance that is smaller than the threshold distance into a plurality of distance steps, and the display color of the cranes subject to collision may differ for the corresponding distance step that is smaller than the minimum neighboring distance, or the display unit may display which distance step among the plurality of distance steps that are smaller than the threshold distance includes the cranes subject to collision in

the form of one or a combination of an image, a text, graphics, and a table.

On the other hand, it is preferable that if the GPS coordinate values are not changed in a specified time, the GPS receiver does not transmit the GPS coordinates to the main management unit, and if the sensor values are not  
5 changed in a specified time, the first rotation sensor, the second rotation sensor, and the tilt sensor do not transmit the sensor values to the main management unit.

In addition, it is preferable that if the GPS values are not changed in a specified time, the first GPS unit and the second GPS unit do not transmit the  
10 GPS values to the main management unit.

The system for preventing collision of cranes and monitoring a crane work according to an embodiment of the present invention may further include one or more relay means installed between the cranes and the main management unit to relay between the respective cranes and the main  
15 management unit.

The system for preventing collision of cranes and monitoring a crane work according to an embodiment of the present invention may further include operator terminals owned by operators of the respective cranes or a manager terminal owned by a safety manager who manages a work spot where the  
20 crane work is performed. In this case, the operator terminal or the manager terminal may include a display unit for displaying in real time information on the cranes subject to collision transmitted from the main management unit, and an alarm unit for notifying the operator or the manager of the information on the cranes subject to collision in the form of an alarm or alert message.

25 **ADVANTAGEOUS EFFECTS**

According to the system for preventing collision of cranes and monitoring a crane work according to an embodiment of the present invention, the collision between the cranes is accurately predicted by monitoring not only the position of a respective crane but also the rotation angle and the tilt of the crane boom in real time, and the danger of collision is reported to the managers or operators in real time, so that the danger of various kinds of accidents and the resultant damage of manpower and material properties can be greatly reduced.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is a view illustrating the construction of a system for preventing collision of cranes and monitoring a crane work in accordance with an embodiment of the present invention.

FIG. 2 is a view illustrating the detailed construction of a system for preventing collision of cranes and monitoring a crane work of FIG. 1;

FIG. 3 is an exemplary view illustrating a ship construction dock to which the system in accordance with the present invention is applied;

FIG. 4 is an exemplary view illustrating the construction of a test bed for verifying the reliability of the system in accordance with an embodiment of the present invention; and

FIGS. 5 to 7 are exemplary views explaining calculation of the minimum neighboring distance between cranes.

### **BEST MODE FOR THE INVENTION**

Hereinafter, a preferred embodiment of the present invention will be explained in detail with reference to accompanying drawings. Before the present method is disclosed and described, one should notice that the terminology used in the specification and any of the claims are not to be

interpreted by general meaning commonly known to an ordinary skilled person in the art or definitions in dictionary only, but should be understood as meaning and concept suitable for technical idea of the present invention, on the basis of the principle that an inventor is able to define the concept of a certain term for the purpose of describing his invention in the best way.

Therefore, the embodiments described herein and the construction illustrated in the drawings are for the purpose of describing a particular embodiment only, and are not intended to be limiting or representing all the technical ideas the present invention try to convey. Therefore, one should notice that there are many alternatives, modifications, and variations that can act as a substitute for them at the time of filing.

The following will now explain a system for preventing collision of cranes and monitoring a crane work in accordance with one embodiment of the present invention.

FIG. 1 is a view illustrating the construction of a system for preventing collision of cranes and monitoring a crane work in accordance with an embodiment of the present invention, and FIG. 2 is a view illustrating the detailed construction of a system for preventing collision of cranes and monitoring a crane work of FIG. 1. FIG. 3 is an exemplary view illustrating a ship construction dock to which the system in accordance with the present invention is applied, and FIG. 4 is an exemplary view illustrating test bed construction for verifying the reliability of the system in accordance with an embodiment of the present invention.

As illustrated in FIG. 1 or 2, the system 100 for preventing collision of cranes and monitoring a crane work in accordance with an embodiment of the

present invention briefly includes GPS receivers 110 and a main management unit 120.

The GPS receiver 110, as illustrated in FIGS. 1 to 3, is a part installed for each crane to obtain and transmit GPS coordinates for the crane.

5 Here, as illustrated in FIG. 2 or FIG. 3, the cranes may include one or more of Goliath cranes 10, jib cranes 20, and tower cranes 30.

Specifically, in a ship construction dock, only several Goliath cranes 10 may be arranged, several Goliath cranes 10 and jib cranes 20 may be arranged, or several Goliath cranes 10, jib cranes 20, and tower cranes 30 may be  
10 arranged. In addition, diverse arrangements of the above-described cranes may be provided. Generally, the number of the cranes 10, 20, and 30 arranged in the ship construction dock may be properly determined depending on the ship construction process.

The main management unit 120 is a part that predicts the collision  
15 between the cranes 10, 20, and 30 based on the GPS coordinates of the respective cranes transmitted from the GPS receivers 110.

More specifically, a prediction unit 123 of the main management unit 120 predicts the collision between the respective cranes 10, 20, and 30 by substituting the GPS coordinates of the respective cranes 10, 20, and 30 in the  
20 pre-stored 3D models of the corresponding cranes 10, 20, and 30.

For example, the height of a pair of pillars that support both sides of the horizontal support block 11 of the Goliath crane 10 and the length of the horizontal support blocks 11 installed on such pillars are pre-stored, and by substituting the GPS coordinates for a specified reference point of the Goliath  
25 crane 10, the actual position of the Goliath crane 100 having the specified size,

structure, and shape as described above can be presented together with the corresponding 3D model. Such positional data may be used as reference data for predicting the collision of the crane.

That is, the main management unit 120 stores therein the sizes, shapes,  
5 and structures of the respective cranes in the form of a 3D model, and through the substitution of the reference GPS coordinates of the corresponding cranes in the reference points of the 3D models, the present positions of the respective cranes 10, 20, and 30 and distances among the cranes can be obtained.

Here, if the difference between the GPS coordinates of the specified  
10 cranes becomes smaller than the threshold value and the collision between the specified cranes is predicted, the alarm unit 122 included in the main management unit 120 produces an alarm or alert message, so that the collision of the cranes can be aurally confirmed in real time through the alarm or alert message.

15 By using the GPS coordinates substituted in the 3D model that includes information on sizes, shapes, and structures of cranes pre-stored in the main management unit 120, the alarm unit 122 aurally notifies the manager of the danger of collision between the cranes if the difference between the GPS coordinates becomes smaller than the threshold value, and thus the manager  
20 can immediately recognize the danger of collision.

As illustrated in FIG. 3, the display unit 121 included in the main management unit 120 displays in real time the shapes and positions of the respective cranes using the 3D models of the respective cranes in which the GPS coordinates have been substituted, so that the current positions of the  
25 cranes and the 3D models existing in such positions are visible to the naked

eye in real time.

Also, if the difference in GPS coordinates between the cranes becomes smaller than the threshold value and thus the collision between the specified cranes is predicted, the display unit 121 displays the cranes subject to collision with a specified flickering color or with a color that is different from the color of the cranes that are not subject to collision, so that the cranes subject to collision can be visually confirmed in real time.

For example, if the collision between the Goliath crane 10 and the jib crane 20 is predicted, the 3D models of the Goliath crane 10 and the jib crane 20 among the 3D models of the cranes being displayed are displayed with a red color flickering in a specified period, or with a color different from that of the 3D models of other cranes, so that the cranes subject to collision can be easily discriminated and confirmed.

On the other hand, in the case of the Goliath crane 10, GPS receivers 110 may be installed at both ends of the horizontal support block 11 installed in a length direction of the crane. In this case, both the length and the height of the horizontal support block 11 can be acquired using only longitude, latitude, and altitude information received in the GPS receivers 110, and it is not required to pre-store information on the length and the height of the horizontal support block 11 in the 3D model of the Goliath crane 10.

In the case of predicting the collision using only the GPS coordinate information of the cranes as in the embodiment of FIG. 1, a rough collision prediction is possible, but it is defective to judge the collision based on only the GPS coordinates. For example, in the case where the collision between the cranes occurs due to the movement of the crane booms, although the

difference between the GPS coordinates of the specified cranes is larger than the threshold value, it is impossible to accurately predict the collision.

Here, in order to acquire the rotation angle or tilt information due to the movement of the respective crane booms 21 and 31 according to an embodiment of the present invention, corresponding sensors are installed on  
5 the respective crane booms 21 and 31, or GPS units are installed to receive the GPS coordinates.

First, in the case of using the sensors, as shown in FIG. 2, a first rotation sensor 130 and a tilt sensor 140, which are installed on the jib crane boom that  
10 is the crane boom of the jib crane 20, and a second rotation sensor 150, which is installed on the tower crane boom 31 that is the crane boom of the tower crane 30, may be further provided in addition to the GPS receivers 110 and the main management unit 120.

Here, as shown in FIG. 3, since the Goliath crane 10 is moved along a  
15 Goliath rail 12, but no separate crane boom exists, only the GPS coordinate information is required, while since the jib crane boom 21 performs upward/downward movement and left/right rotation and movement as the jib crane 20 is moved along the jib rail 22, the first rotation sensor 130 and the tilt sensor 140 are further required in addition to the GPS coordinates. Although the  
20 position of the tower crane 30 is fixed without any separate rail, the tower crane boom 31 performs left/right rotation and movement, and thus the second rotation sensor 150 is further required in addition to the GPS coordinates.

That is, the first rotation sensor 130 and the tilt sensor 140 sense the rotation angle and the tilt of the jib crane boom 21, and transmit resultant sensor  
25 values to the main management unit 120.

Also, the second rotation sensor 150 senses the rotation angle of the tower crane boom 31, and transmits a resultant sensor value to the main management unit 120.

In this case, the prediction unit 123 of the main management unit 120  
5 predicts the collision between the respective cranes 10, 20, and 30 using the GPS coordinates of the respective cranes 10, 20, and 30 transmitted from the GPS receiver 110, rotation angle and tilt information of the jib crane boom 21 transmitted from the first rotation sensor 130 and the tilt sensor 140, and the rotation angle information of the tower crane boom 31 transmitted from the  
10 second rotation sensor 150.

Instead of the sensors as described above, GPS units for receiving the GPS coordinates may be installed on the respective crane booms 21 and 31 to obtain rotation angles or tilt information. In this case, the installation cost and the repair and maintenance cost may be somewhat greater than those in the  
15 communication system using the sensor network as described above, but the GPS units can be effectively used in the system according to the present invention.

In the case of using the GPS, one or more first GPS units (not illustrated), which are installed on the jib crane boom 21 that is a crane boom of the jib  
20 crane 20 to receive the GPS values for calculating the rotation angle and the tilt of the jib crane boom 21 and to transmit the received coordinate values to the main management unit 120, may be provided on the jib crane boom 21.

one or more second GPS units (not illustrated), which are installed on the tower crane boom 31 that is a crane boom of the tower crane 30 to receive the  
25 GPS values for calculating the rotation angle of the tower crane boom 31 and to

transmit the received coordinate values to the main management unit 120, may be provided on the tower crane boom 31.

For example, 3D model information on the length, shape, and structure of vertical pillars of the jib crane 20, and the length, shape, and structure of the jib crane boom 21 installed at a specified height of the vertical pillars is pre-stored in the main management unit 120, and the computation of the tilt and the rotation angle can be performed through comparison of reference coordinates obtained from the GPS receiver 110 positioned on the shaft of the tower crane boom 21 that meets the vertical pillars as shown in FIG. 2 with reference coordinates obtained from the GPS unit (not illustrated) installed on one side of the tower crane boom 21.

In addition, it is also possible that a pair of GPS units (not illustrated) may be installed on both ends of the respective crane booms 21 and 31, or on a shaft part of the crane boom 21 and one end of the crane boom 21, to compute the tilt and the rotation angle. The positions and the number of GPS units (not illustrated) installed in the respective crane booms 21 and 31 can be changed at any time as a design change.

In this case, the main management unit 120 substitute the GPS coordinates of the Goliath crane 10, the jib crane 10, and the tower crane 30, information on the rotation angle and the tilt of the jib crane boom 21, and the rotation angle information of the tower crane boom 31 in the 3D models of the corresponding cranes pre-stored, and predicts the possibilities of collision among the respective parts of the cranes 10, 20, and 30 by calculating the minimum neighboring distances among a horizontal support block part 11 installed in a length direction of the Goliath crane 10, a jib crane boom part 21

of the jib crane 20, and a tower crane boom part 31 of the tower crane 30.

In the case of the jib crane boom 21, the 3D model information on not only the length, shape and structure of vertical pillars of the jib crane but also the length, shape, and structure of the jib crane boom 21 installed at a specified  
5 height of the vertical pillars is pre-stored in the main management unit 120.

In this case, the main management unit 120 substitutes not only the basic GPS coordinates acquired by the GPS receiver 110 installed on the pillars of the jib crane but also the rotation angle and tilt information of the jib crane boom 21 in the 3D model.

10 Accordingly, as the rotation angle and tilt information is substituted in not only the position of the current jib crane 20 but also the position coordinates of the current jib crane boom 21, even the coordinates of both ends in a length direction of the jib crane boom 21 and the coordinates of all points that connect the coordinates of the both ends can be known on the basis of the above-  
15 described tilt and angle information.

The prediction of collision becomes possible in diverse cases, for example, when the minimum neighboring distance between the jib crane boom 21 and the tower crane boom 31 becomes smaller than a threshold distance value, or when the minimum neighboring distance between the horizontal  
20 support block of the Goliath crane 10 and the tower crane 31 becomes smaller than the threshold distance value.

In addition, the danger of collision exists when a distance between one end of the jib crane boom 21, which is extended in a length direction of the jib crane boom, and one point in a length direction of the tower crane boom 31  
25 corresponds to the maximum neighboring distance between the jib crane boom

21 and the tower crane boom 31, but the minimum neighboring distance is smaller than the threshold value (See FIG. 6). Also, the collision is predicted when a distance between one point in a length direction of the tower crane boom 31 and one point of the horizontal support block 11 of the Goliath crane 10 corresponds to the maximum neighboring distance between the tower crane boom 31 and the Goliath crane 10, but the minimum neighboring distance is smaller than the threshold value (See FIG. 5). FIGS. 5 to 7 illustrate modeling of the crane booms 21 and 31 or horizontal support block 11 as straight lines. Specifically, in FIGS. 5 to 7, respective line segments Line1 and Line2 may correspond to parts of the horizontal support block 11, the jib crane boom 21, and tower crane boom 31. For example, both ends of a line segment (a1, b1, c1) and (a2, b2, c2) may correspond to both ends of the horizontal support block 11 of the Goliath crane 10, both ends of the jib crane boom 21, or both ends of the tower crane boom 31.

In FIG. 5, in the case where Line1 is the jib crane boom 21, and Line2 is the tower crane boom 31, a length D, which is connected between one point of the jib crane boom 21 and one point of the tower crane boom 31, and which corresponds to a line segment Line3 of which inner products with respect to Line1 and Line2 are all "0" (i.e. a distance between coordinates (a0, b0, c0) on the jib crane boom 21 and coordinates (x0, y0, z0) on the tower crane boom 31), corresponds to the minimum neighboring distance between the jib crane boom 21 and the tower crane boom 31.

Referring to FIG. 6, since inner products formed between Line3 and Line1 and between Line3 and Line2 are all "0", the length D of Line3 corresponds to the minimum neighboring distance between the jib crane boom

21 and the tower crane boom 31. In this case, however, the crossing point of Line3 and the tower crane boom 31 is not positioned on Line2 that is the tower crane boom 31 as shown in FIG. 1, but is positioned at one end ( $x_0, y_0, z_0$ ) of Line2.

5        FIG. 7 shows a case where inner products formed between Line3 and Line1 and between Line3 and Line2 are all "0", and a line segment connected between Line1 and Line2 does not exist. In this case, the length D of the line segment Line3 connected between the coordinates ( $a_1, b_1, c_1$ ) and the coordinates ( $x_1, y_1, z_1$ ), which is the shortest distance connected between both  
10 ends of Line1 and both ends of Line2, corresponds to the minimum neighboring distance.

On the other hand, if it is assumed that the movement or moving speed of the crane (e.g. body or boom) is about 0.6m/s, it is preferable that the error of judgment of the possibility of collision of the cranes is set to 3m (maximum  
15 distance) and one second (maximum time). However, this is merely exemplary, and may be changed to another error judgment basis.

The alarm unit 122, if the minimum neighboring distance becomes smaller than the threshold distance and collision between specified cranes is predicted, makes it possible to aurally confirm the collision of the cranes in real  
20 time through an alarm or alert message.

Also, the alarm unit 122 classifies the distance that is smaller than the threshold distance into a plurality of distance steps, and a different alarm or alert message is provided for a corresponding distance step that is smaller than the minimum neighboring distance.

25        For example, the threshold distance (which may be set to 3m) may be

classified into a collision emerging area (which may be set to 1.5m), a collision warning area (which may be set to 2m), and a collision feasible area (which may be set to 3m). As the calculated minimum neighboring distance is changed from 3m to 1.5m, the information output period may become fast, or a different  
5 cautionary message may be provided. For example, in the case where the cranes approach within 3m, a cautionary message "Cranes are entering into a collision feasible area", and in the case where the cranes approach within 2m, a cautionary message "Cranes are entering into a collision warning area". Also, in the case where the cranes approach within 1.5m, a cautionary message  
10 "Cranes are entering into a collision emerging area."

On the other hand, in the case of acquiring even information on the crane booms 21 and 31, the display unit 121 displays in real time the shapes and positions of the respective cranes using the 3D models for corresponding cranes in which the GPS coordinates of the respective cranes, rotation angle  
15 and tilt information of the jib crane 20, and the rotation angle information of the tower crane 30 have been substituted.

Also, in the case where the collision between the respective cranes is predicted as described above, the display unit 121 displays the cranes subject to collision with a specified flickering color or with a color that is different from  
20 the color of the cranes that are not subject to collision, so that the cranes subject to collision can be visually confirmed in real time.

Also, the display unit 121 classifies the corresponding distance that is smaller than the threshold distance into a plurality of distance steps, and the display color of the cranes subject to collision may differ for the corresponding  
25 distance step that is smaller than the minimum neighboring distance, or the

display unit may display which distance step among the plurality of distance steps that are smaller than the threshold distance includes the cranes subject to collision in the form of one or a combination of an image, a text, graphics, and a table.

5           For example, in the case where the corresponding cranes enter into the collision feasible area, the collision warning area, and the collision emerging area, the 3D models of the corresponding cranes may be displayed with different colors.

          Also, it may be displayed in the form of one selected among an image,  
10   graphics, and a table, which area among the collision feasible area, the collision warning area, and the collision emerging area the cranes subject to collision are positioned in.

          On the other hand, it is preferable that if the GPS coordinate values are not changed in a specified time, the GPS receiver 110 does not transmit the  
15   corresponding GPS coordinates to the main management unit 120. In this case, the power consumption and the frequency of signal transmission can be reduced, and thus the signal congestion in the wireless environment and the corresponding signal interference can be reduced.

          Of course, it is preferable that if the sensor values are not changed in a  
20   specified time, the first rotation sensor 130, the second rotation sensor 150, and the tilt sensor 140 do not transmit the sensor values to the main management unit 120. Also, it is preferable that if the GPS values obtained in a specified time are not changed, the first GPS unit (not illustrated) installed in the jib crane boom 20 and the second GPS unit (not illustrated) installed in the tower crane  
25   30 do not transmit the corresponding GPS values to the main management unit

120. This is to obtain the same effect as the GPS receiver 110 as described above.

On the other hand, as illustrated in FIG. 2 or 3,

The system for preventing collision of cranes and monitoring a crane  
5 work according to an embodiment of the present invention may further include  
one or more relay means 160 installed between the cranes 10, 20, and 30 and  
the main management unit 120 to relay between the respective cranes 10, 20,  
and 30 and the main management unit 120.

By installing the relay means 160 in some parts of the system 100  
10 according to the present invention, signal attenuation, signal loss, and the like,  
can be effectively prevented, and thus the reliability of prediction of crane  
collision can be increased.

On the other hand, as illustrated in FIG. 2, the system for preventing  
collision of cranes and monitoring a crane work according to an embodiment of  
15 the present invention may further include operator terminals 170 owned by  
operators of the respective cranes or a manager terminal 180 owned by a  
safety manager who manages a work spot where the crane work is performed.

Here, the operator terminal 170 and the manager terminal 180 may  
include display units 171 and 181 for displaying in real time information on the  
20 cranes subject to collision (e.g. names and positions of the corresponding  
cranes, operator information of the corresponding cranes, and the like)  
transmitted from the main management unit 120, and alarm units 172 and 182  
for notifying the operator or the manager of the information on the cranes  
subject to collision in the form of an alarm or alert message. If collision between  
25 specified cranes is predicted, the operators of the cranes or the safety manager

of the work spot can immediately recognize such collision and thus can promptly take action to prevent the collision.

FIG. 4 is an exemplary view illustrating a test bed temporarily constructed to test the system 100 as illustrated in FIG. 2 or 3 according to an  
5 embodiment of the present invention.

There exist several problems in directly constructing and developing a system in a dock spot.

Since spot work progresses according to tight plans, it is difficult to request a work interception in order to construct an unverified system, and  
10 diverse construction change of a sensor network is required to secure the reliability of the sensor network. In this case, it is difficult to immediately perform the construction change, and diverse crane arrangements and movement scenarios should be realized in order to verify the accuracy of an algorithm. To make such requests from the operator who performs the spot work is actually  
15 impossible.

Accordingly, by constructing a test bed for mini model simulations in an environment similar to the spot, the performance and the security of the system can be examined.

A manager console of FIG. 4 is a part that corresponds to the main  
20 management unit 120, and monitoring of the spot crane work and the prediction of possible collision can be performed through the manager console.

The manager console optionally generates scenario data for simulations of crane prediction (i.e. scenario data, such as how many coordinates specified cranes move for a specified time, how many coordinates a specified crane  
25 boom is rotated for, and the like), and this is to verify how much reliability and

accuracy, the monitoring of the corresponding cranes and the prediction of crane collision in accordance with a desired scenario can be performed with.

The control box is a part for individually controlling movement of cranes in the unit of 0.1 second in accordance with the scenario data (e.g. movement  
5 coordinates of cranes, rotation coordinates of crane booms, tilt coordinates, and the like) transmitted from the manager console, and transmits a crane movement signal for such scenario data to a crane work simulator.

The crane work simulator is a part in which cranes having a reduced form corresponding to the actual cranes are installed and actually moved, and  
10 the actual cranes can perform the movement through the coordinate information transmitted from the control box.

In the jib crane, a tilt sensor and a rotation sensor are installed, and in the tower crane, only a rotation sensor is attached. On the spot, the GPS receiver is used in computing the position coordinates. In the case of a test bed,  
15 the distance is too short and an error may occur in receiving the information using the GPS, and thus a position tracking method using supersonic waves has been used. That is, four transmitters (corresponding to four GPS satellites) are installed at corners of the whole dock in which the cranes are positioned, and three receivers are installed in the respective cranes to recognize the  
20 positions.

On the other hand, the crane work simulator transmits in real time movement information of the actually moving cranes (e.g. rotation angles of crane booms, the tilt of the crane booms, and the current positions of the cranes) to the manager console through a wireless sensor network (USN). For  
25 example, whenever the position of the crane is changed along a rail, a receiver

attached to the crane calculates the position of the crane using a time difference of signals, and transmits the changed position to the manager console using the real time USN.

The manager console receives a feedback of movement data of the  
5 actual crane from the control box having a crane control error of 0.1mm on the basis of the scenario data.

In this case, the manager console can verify the accuracy and reliability of the system, such as the obtained movement information, by comparing an error between the fed crane movement data and crane coordinates transmitted  
10 through the sensors (the error of the coordinates is determined in accordance with a delay due to a transmission interval of sensor data, a delay of network transmission, a transmission error, and the like). Accordingly, when the system according to the present invention is applied to the actual spot, it can be judged in advance and calculated with how much reliability the system is operated, or  
15 to what extent an allowable error range is determined on the actual spot.

As described above, it is apparent that the system for preventing collision of cranes and monitoring a crane work according to an embodiment of the present invention includes the above-described wireless sensor network (WSN) system and other wireless communication systems, such as a wireless LAN  
20 (WLAN), RF system, and the like. The communication network system can be changed at any time to correspond to the optimum conditions for the safety of the system, installation and maintenance cost, the accuracy of the system, time delay, and the like.

While the invention has been shown and described with reference to  
25 certain preferred embodiments thereof, it will be understood by those skilled in

the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention as defined by the appended claims.

**Claims:**

1. A system for preventing collision of cranes and monitoring a crane work, comprising:

5 a plurality of GPS receivers installed in a plurality of cranes to acquire and transmit GPS coordinates for the respective cranes; and

a main management unit for predicting collision between the respective cranes based on the GPS coordinates of the cranes transmitted from the GPS receivers.

10 2. The system of claim 1, wherein the main management unit predicts collision between the respective cranes by substituting the GPS coordinates of the respective cranes in three-dimensional (3D) models for the corresponding cranes pre-stored.

15 3. The system of claim 2, wherein the main management unit further comprises an alarm unit for making it possible to aurally confirm the collision of the cranes in real time through an alarm or alert message when a difference between GPS coordinates of specified cranes becomes smaller than a threshold value and collision between the specified cranes is predicted.

20 4. The system of claim 2, wherein the main management unit further comprises a display unit for displaying in real time shapes and positions of the respective cranes using the 3D models for the corresponding cranes in which the GPS coordinates are substituted.

25

5. The system of claim 4, wherein, if the difference between the GPS coordinates of the specified cranes becomes smaller than the threshold value, and collision between the specified cranes is predicted, the display unit displays the cranes subject to collision with a specified flickering color or with a color that is different from the color of the cranes that are not subject to collision, so that the cranes subject to collision can be visually confirmed in real time.

6. The system of claim 1, wherein the cranes include one or more of Goliath cranes, jib cranes, and tower cranes.

7. The system of claim 6, wherein in the Goliath crane, GPS receivers are provided at both ends of a horizontal support block installed in a length direction of the crane.

8. The system of claim 6, wherein in a jib crane boom that is a crane boom of the jib crane, a first rotation sensor and a tilt sensor for sensing a rotation angle and a tilt of the jib crane boom and transmitting resultant sensor values to the main management unit are provided; and

in a tower crane boom that is a crane boom of the tower crane, a second rotation sensor for sensing a rotation angle of the tower crane boom and transmitting a resultant sensor value to the main management unit is provided;

wherein the main management unit predicts the collision between the respective cranes using the GPS coordinates of the respective cranes transmitted from the GPS receivers, information on the rotation angle and the tilt

of the jib crane boom transmitted from the first rotation sensor and the tilt sensor, and information on the rotation angle of the tower crane boom transmitted from the second rotation sensor.

5           9. The system of claim 6, wherein in a jib crane boom that is a crane boom of the jib crane, one or more first GPS units, which are installed in the jib crane boom to receive GPS values for calculating the rotation angle and the tilt of the jib crane boom and to transmit the received coordinate values to the main management unit, are provided; and

10           in a tower crane boom that is a crane boom of the tower crane, one or more second GPS units, which are installed in the tower crane boom to receive GPS values for calculating the rotation angle of the tower crane boom and to transmit the received coordinate values to the main management unit, are provided;

15           wherein the main management unit predicts the collision between the respective cranes using the GPS coordinates of the respective cranes transmitted from the GPS receivers, information on the rotation angle and the tilt of the jib crane boom calculated through the GPS values transmitted from the first GPS units, and information on the rotation angle of the tower crane boom  
20           calculated through the GPS values transmitted from the second GPS units.

          10. The system of claim 8 or 9, wherein the main management unit predicts the collision between the cranes by substituting the GPS coordinates of the Goliath crane, the jib crane, and the tower crane, information on the rotation  
25           angle and the tilt of the jib crane boom, and information on the rotation angle of

the tower crane boom for the 3D models of the corresponding cranes pre-stored, and then calculating minimum neighboring distances among a horizontal support block part installed in a length direction of the Goliath crane, a jib crane boom part of the jib crane, and a tower crane boom part of the tower crane.

5

11. The system of claim 10, wherein the main management further comprises an alarm unit for making it possible to aurally confirm the collision of the cranes in real time through an alarm or alert message when the minimum neighboring distance becomes smaller than a threshold distance and collision  
10 between specified cranes is predicted.

12. The system of claim 11, wherein the alarm unit classifies the corresponding distance that is smaller than the threshold distance into a plurality of distance steps, and a different alarm or alert message is provided for  
15 a corresponding distance step that is smaller than the minimum neighboring distance.

13. The system of claim 10, wherein the main management unit further comprises a display unit for displaying in real time shapes and positions  
20 of the respective cranes using the 3D models for the corresponding cranes, in which the transmitted GPS coordinates of the cranes, information on the rotation angle and the tilt of the jib crane, and information on the rotation angle of the tower crane have been substituted.

25 14. The system of claim 13, wherein if collision between the specified

cranes is predicted, the display unit displays the cranes subject to collision with a specified flickering color or with a color that is different from the color of the cranes that are not subject to collision, so that the cranes subject to collision can be visually confirmed in real time.

5

15. The system of claim 13, wherein the display unit classifies the corresponding distance that is smaller than the threshold distance into a plurality of distance steps, and the display color of the cranes subject to collision differs for the corresponding distance step that is smaller than the minimum  
10 neighboring distance, or the display unit displays which distance step among the plurality of distance steps that are smaller than the threshold distance includes the cranes subject to collision in the form of one or a combination of an image, a text, graphics, and a table.

15

16. The system of claim 8, wherein if the GPS coordinate values are not changed in a specified time, the GPS receiver does not transmit the GPS coordinates to the main management unit, and if the sensor values are not changed in a specified time, the first rotation sensor, the second rotation sensor, and the tilt sensor do not transmit the sensor values to the main management  
20 unit.

17. The system of claim 9, wherein if the GPS values are not changed in a specified time, the GPS receiver does not transmit the GPS coordinates to the main management unit, and the first GPS unit and the second GPS unit do  
25 not transmit the GPS values to the main management unit.

18. The system of claim 8 or 9, further comprising one or more relay means installed between the crane and the main management unit to relay between the respective cranes and the main management unit.

5

19. The system of claim 8 or 9, further comprising operator terminals owned by operators of the respective cranes or a manager terminal owned by a safety manager who manages a work spot where the crane work is performed;

wherein the operator terminal or the manager terminal comprises a  
10 display unit for displaying in real time information on the cranes subject to collision that is transmitted from the main management unit, and an alarm unit for notifying the operator or the manager of the information on the cranes subject to collision in the form of an alarm or alert message.

1/7

Fig. 1

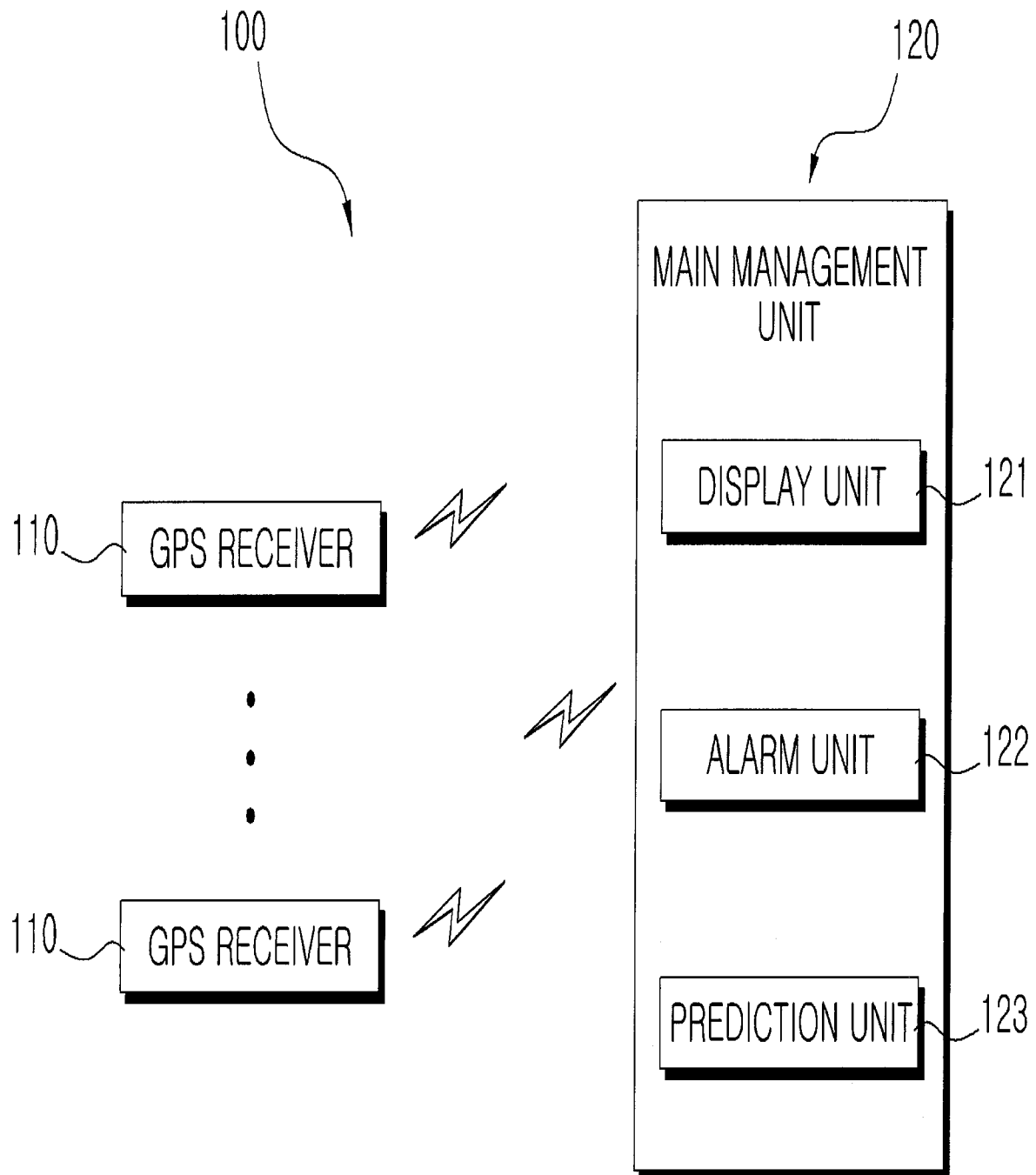
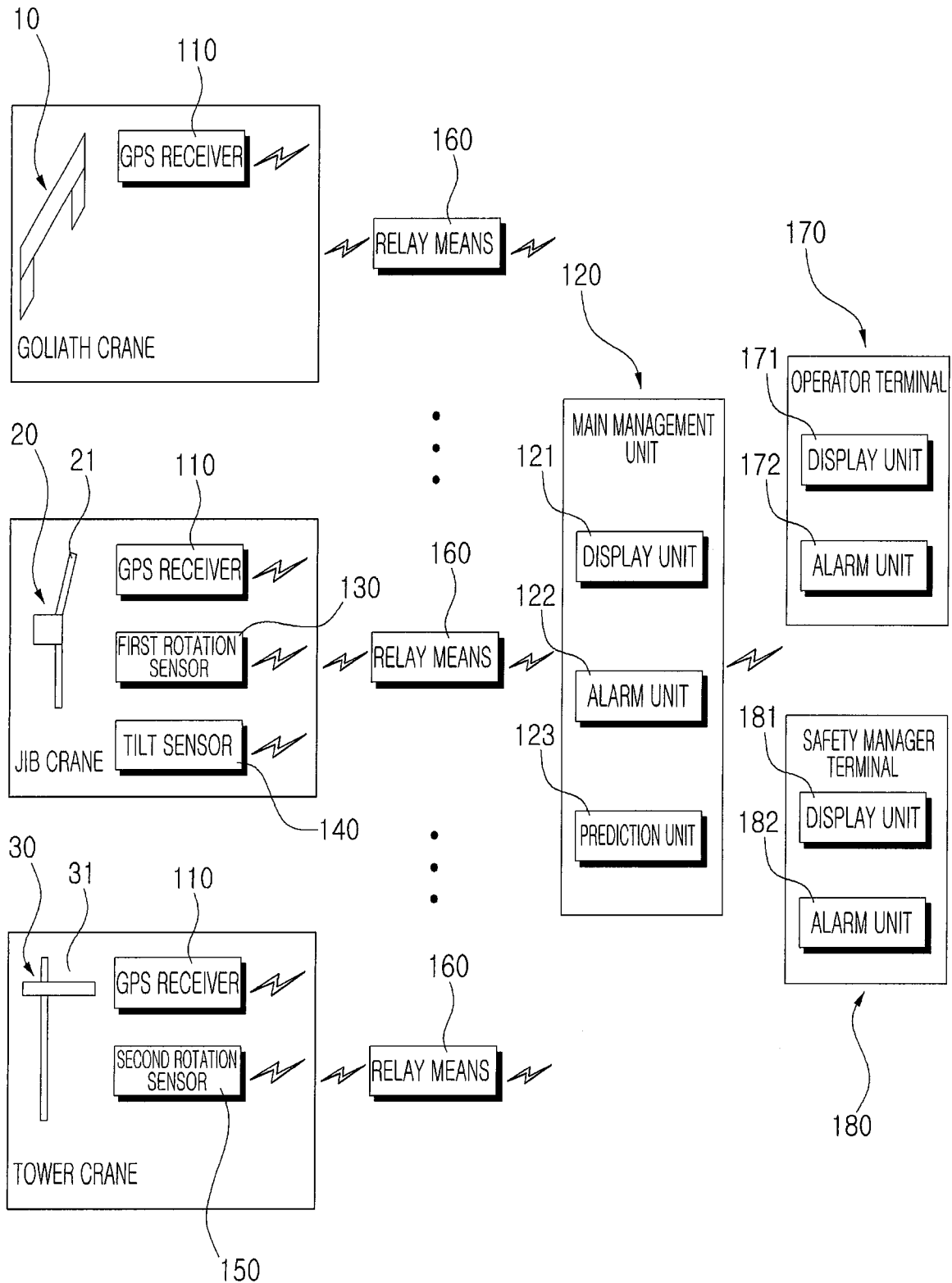
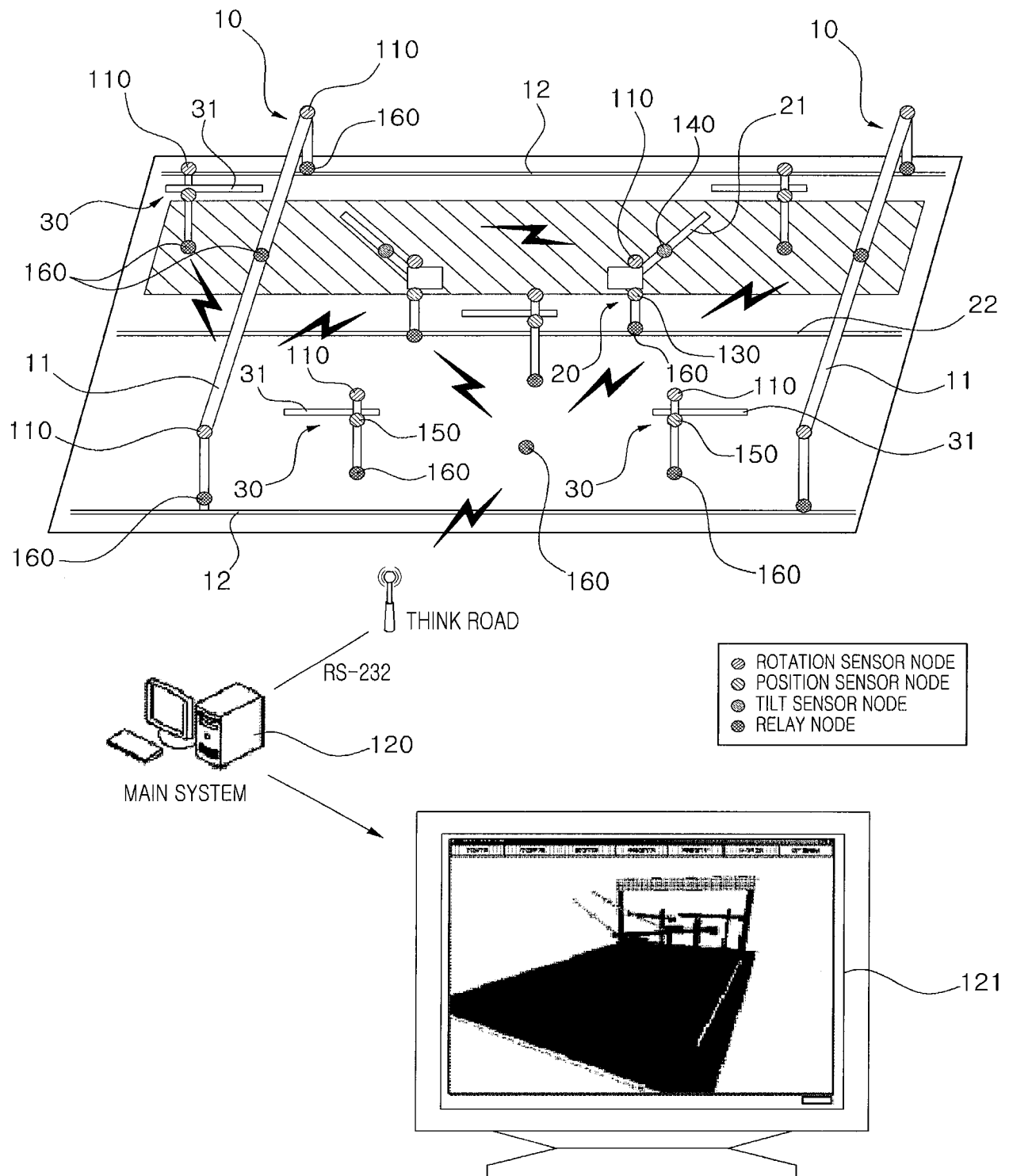


Fig. 2



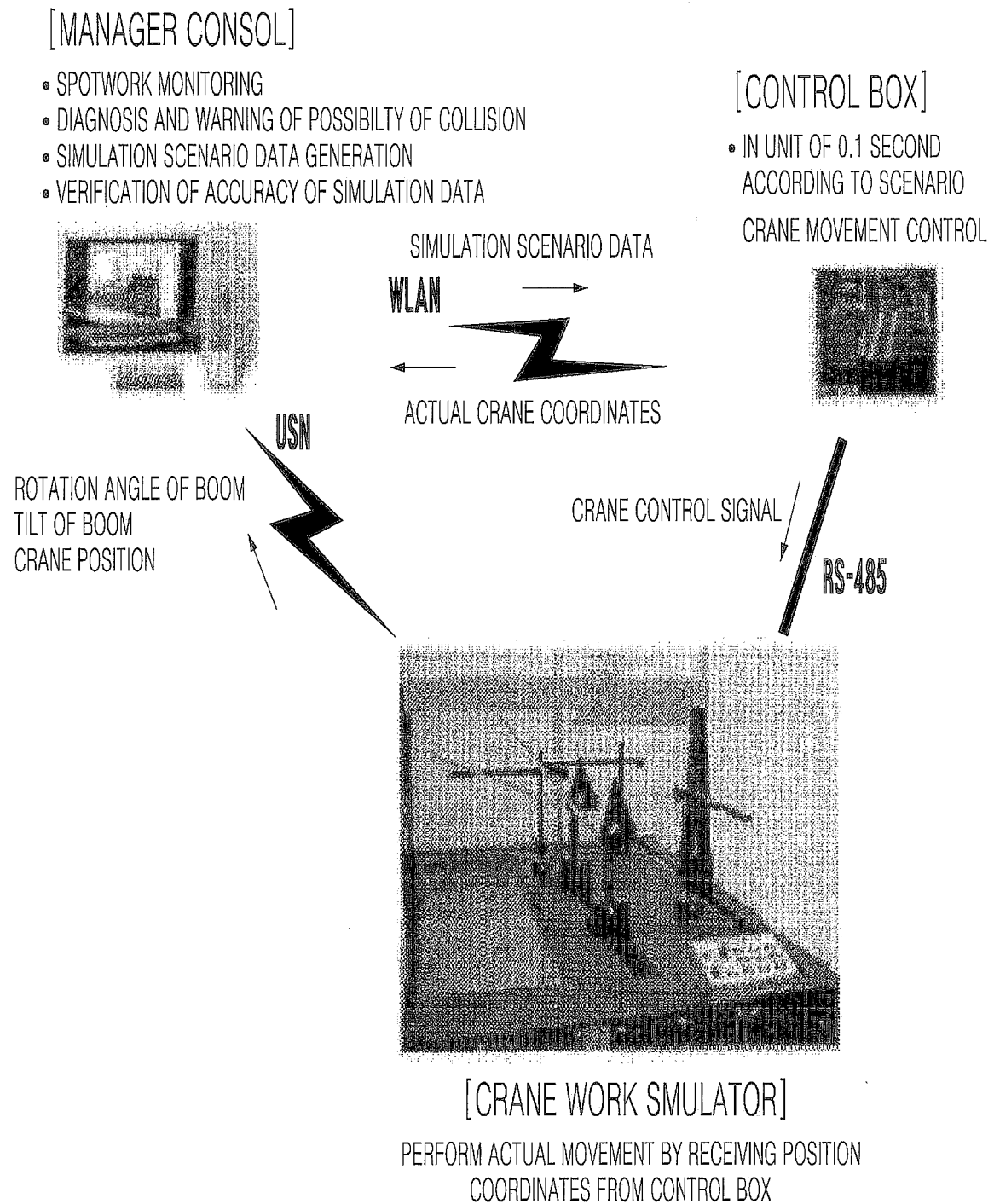
3/7

Fig. 3



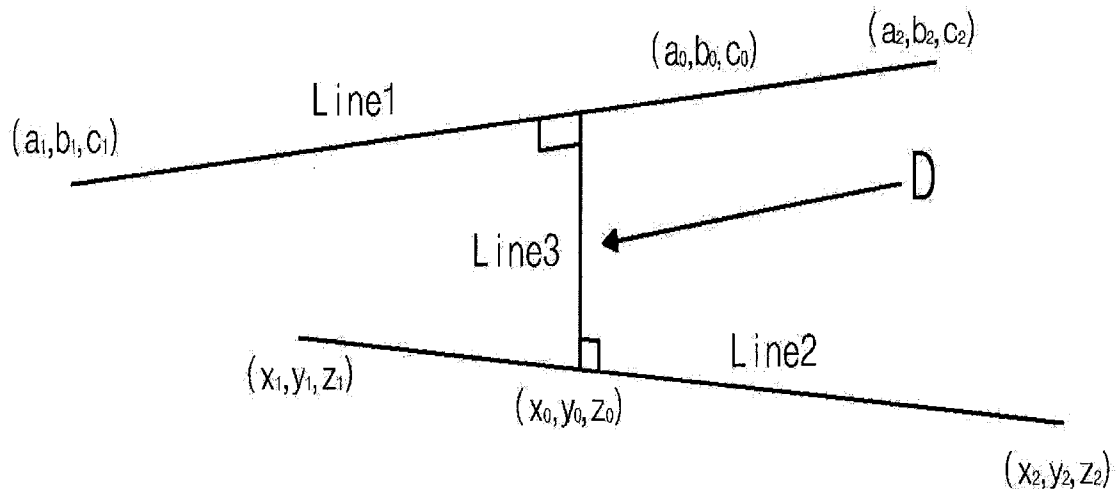
4/7

Fig. 4



5/7

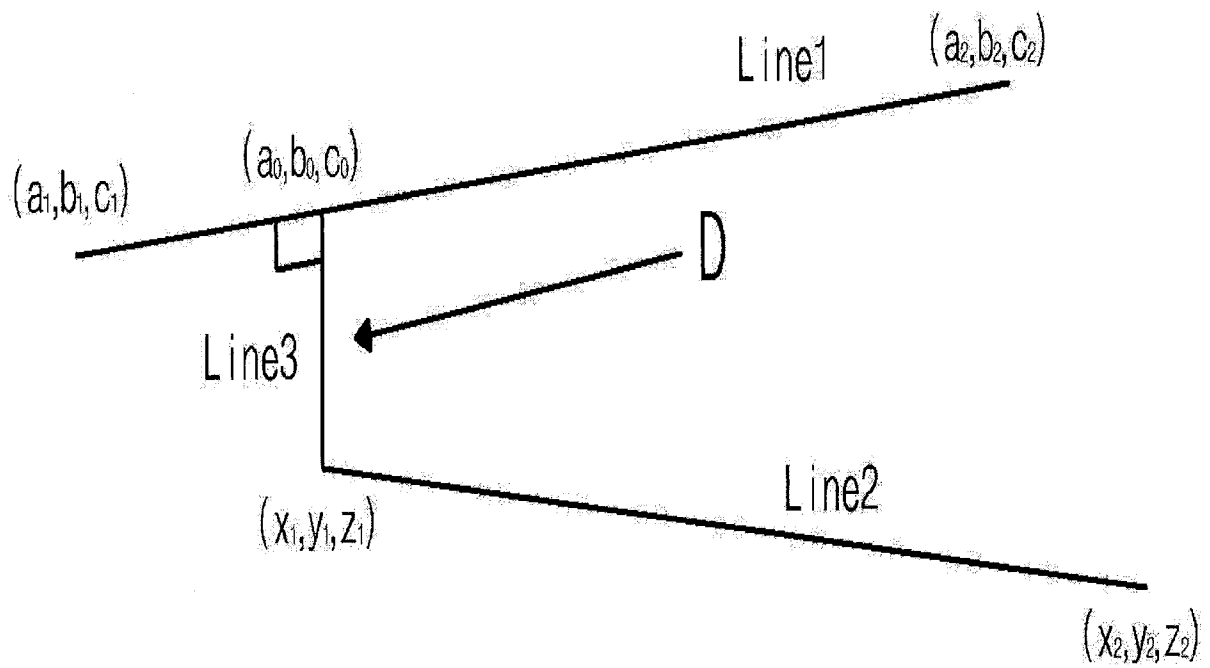
Fig. 5



$$D = \sqrt{(a_0 - x_0)^2 + (b_0 - y_0)^2 + (c_0 - z_0)^2}$$

6/7

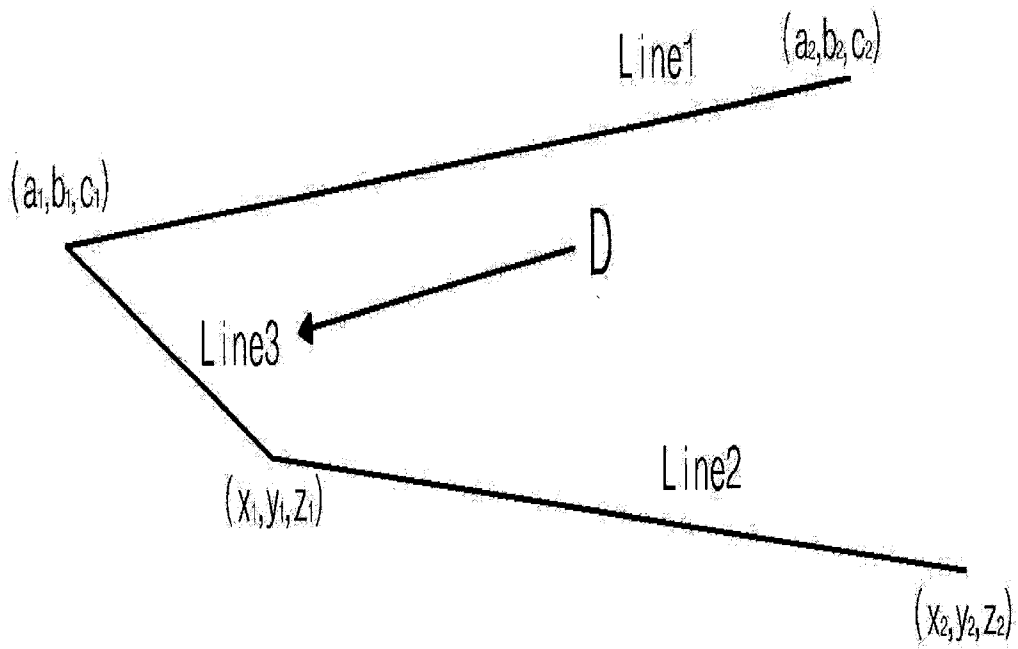
Fig. 6



$$D = \sqrt{(a_0 - x_1)^2 + (b_0 - y_1)^2 + (c_0 - z_1)^2}$$

7/7

Fig. 7



$$D = \sqrt{(a_1 - x_1)^2 + (b_1 - y_1)^2 + (c_1 - z_1)^2}$$

**A. CLASSIFICATION OF SUBJECT MATTER*****B66C 15/04(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)

IPC B66C 15/04, B66C 13/46

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 since 1975

Japanese utility models and applications for utility models since 1975

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

eKIPASS (KIPO internal) &amp; Keywords: GPS, crane, predicting collision, and 3D model

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages                              | Relevant to claim No. |
|-----------|-----------------------------------------------------------------------------------------------------------------|-----------------------|
| X         | JP 2007-276996 A (KABUSIKI KAISYA OBAYASIKUMI) 25 OCTOBER 2007<br>See abstract, figures 1-6, 9 and claims 1-10. | 1                     |
| Y         | JP 2007-276996 A (KABUSIKI KAISYA OBAYASIKUMI) 25 OCTOBER 2007<br>See abstract, figures 1-6, 9 and claims 1-10. | 2-8                   |
| Y         | JP 2005-029338 A (KABUSIKI KAISYA OBAYASIKUMI) 3 FEBRUARY 2005<br>See abstract, figures 1-7, 9 and claims 1-6.  | 2-8                   |
| A         | KR 10-2007-0088331 A (MITSUBISHI HEAVY INDUSTRIES, LTD.) 29 AUGUST 2007<br>See abstract, and figure 1.          | 1-19                  |
| A         | JP 2007-015842 A (FUKADA SALVAGE & MARINE WORKS CO., LTD.) 25 JANUARY 2007<br>See abstract, and figures 1-3.    | 1-19                  |



Further documents are listed in the continuation of Box C.



See patent family annex.

\* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"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

"&amp;" document member of the same patent family

Date of the actual completion of the international search

18 MAY 2009 (18.05.2009)

Date of mailing of the international search report

**25 MAY 2009 (25.05.2009)**

Name and mailing address of the ISA/KR

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Facsimile No. 82-42-472-7140

Authorized officer

CHUNG, Suk Hyun

Telephone No. 82-42-481-8285



**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.

**PCT/KR2008/007032**

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
|-------------------------------------------|---------------------|----------------------------|---------------------|
| JP 2007-276996 A                          | 25.10.2007          | NONE                       |                     |
| JP 2005-029338 A                          | 03.02.2005          | NONE                       |                     |
| KR 10-2007-0088331 A                      | 29.08.2007          | EP 1829810 A1              | 05.09.2007          |
|                                           |                     | JP 2006-176217 A           | 06.07.2006          |
|                                           |                     | TW 279389 B                | 21.04.2007          |
|                                           |                     | TW 279389 A                | 21.04.2007          |
|                                           |                     | WO 2006-068125 A1          | 29.06.2006          |
| JP 2007-015842 A                          | 25.01.2007          | NONE                       |                     |