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(54) OPERATION SYSTEM

(57) Loading and unloading operation system (10) adapted for use in a forestry vehicle (100), comprising a crane control unit (20) and crane sensors (30), adapted to measure the turn angle of the crane (35), and the extension position of each hydraulic actuator (36) of the crane (35), so that the crane tip location (40) and a maximum crane outreach state is detected, an engine control unit (50) and engine sensors (60), adapted to measure the RPM speed of the engine and the fuel consumption, an operator interface (70), the operation system (10) adapted to display the location of logs and various adjectives of the logs and the locations and a calculated optimum position of the vehicle (100) for loading and unloading operation, an operation CPU (80) with CPU

software (90), adapted to correlate the measurements and establish a fuel matrix, depending on measured values of the crane (35), and on the fuel consumption, calculating an estimated fuel consumption depending on the established fuel matrix (110) and a theoretical crane reach as well as the number of logs, size and position in relation to an estimated vehicle position, displaying a calculated optimum stopping position of the vehicle (100) for loading or unloading the logs based on the calculation and a minimal fuel consumption or a minimal operation time, adapted to assist the operator to find the optimum stopping position by displaying the vehicle (100) on a map display, and/or stopping the vehicle automatically at the optimum stopping position.

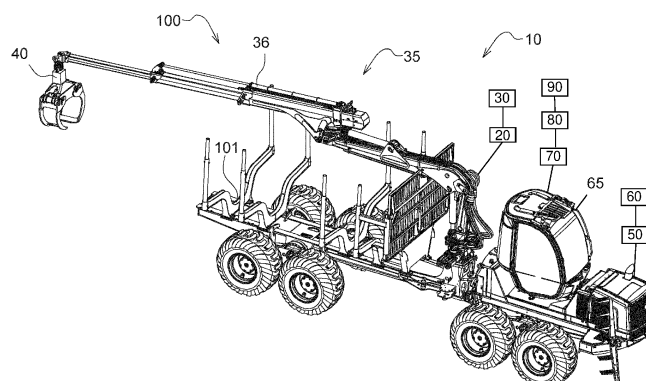


FIG. 1

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Description

[0001] Forestry machines, especially vehicles must operate efficiently to address the workload and working costs. During the operation most of the work tasks is load and unloading of logs from the forestry area to a roadside area to be available for further transport. The process of loading and unloading involves a crane with a grapple tool reaching outwards to a log pile and repeatedly undergo the loading procedure to transfer a log pile to the vehicle or in a reverse manner to unload the log pile to a target area. The different tasks result in a certain fuel consumption or in a certain work time that depend on e.g., an outreach of the crane, the position of the vehicle, the load of the logs in the grapple tool, the speed of movement of the crane. As these parameters are subject to the local conditions, the efficiency of the vehicle is difficult to predict.

[0002] The present invention aims to remedy those problems and to define a system and method which solves the above problems.

[0003] The invention is a loading and unloading operation system adapted for use in a forestry vehicle, comprising a crane control unit and crane sensors, adapted to measure the turn angle of the crane, and the extension position of each hydraulic actuator of the crane, so that the crane tip location and a maximum crane outreach state is detected, an engine control unit and engine sensors, adapted to measure the RPM speed of the engine and the fuel consumption, an operator interface, the operation system adapted to display the location of logs and various adjectives of the logs and the locations and a calculated optimum position of the vehicle for loading and unloading operation, an operation CPU with CPU software, adapted to correlate the measurements and establish a fuel matrix, depending on measured values of the crane, and on the fuel consumption, calculating an estimated fuel consumption depending on the established fuel matrix and a theoretical crane reach as well as the number of logs, size and position in relation to an estimated vehicle position, displaying a calculated optimum stopping position of the vehicle for loading or unloading the logs based on the calculation and a minimal fuel consumption or a minimal operation time, adapted to assist the operator to find the optimum stopping position by displaying the vehicle on a map display, and/or stopping the vehicle automatically at the optimum stopping position.

[0004] The operation system can be part of a vehicle or can be afterwards installed in the vehicle as an add-on feature. The operation system ensures that the forest machine is on a location that provides an optimum fuel consumption derived from a fuel-outreach matrix or a time matrix resulting a fuel map or similar. This could also be extended to comprehend and determine an optimum unloading position or an optimum unloading distance with respect to a possible log unloading area and resulting pile properties and a log pile height. The operation

system could also help with optimal loading/unloading crane trajectories, giving guidance of best loading/unloading trajectories derived from a fuel matrix. In addition to an optimum location, the operator could also rely on or automatically make use of these optimal crane movement trajectories, by moving the crane in a statistically determined most economical way which could be time based or fuel based.

[0005] The crane comprises a control unit and sensors to be able to control the crane movements and detect the accuracy and correctness of the movements. The control unit can be integrated in the operator control unit in the cabin to be manually or automatically adjusted either by the operator or by an integrated CPU and software acting on the crane control unit. The sensors detect a horizontal turning angle of the crane in relation to the crane base and/or the vehicle where the crane is mounted on. The sensors can measure the extension of the crane hydraulic actuators and are thus enabled to detect the individual positions of the booms of the crane wherein multiple booms are connected to each other to form a crane structure.

[0006] The control unit can detect the location of the crane tip, being the end of the last boom and an outreach state, being the elongation of the crane including the extension of the individual booms so that the geometric form of the crane is detected and displayed on the operator interface.

[0007] The engine control unit together with the RPM sensor can measure the engine speed at any moment in time and the fuel consumption. The measurement is overlaid with the crane movement and the crane position at that time so that a relation between the crane status and the engine status is created.

[0008] The operator interface displays the log location on a map like display in relation to the vehicle and crane position. The data for the log location is obtained either by import of map data or via data interface or manual input before working operation commences. The operator can manually choose the log pile to be loaded or the operator interface automatically chooses the nearest log pile for a loading operation given that the vehicle has an empty bunk space.

[0009] The operation system uses the calculated results to determine a position of the vehicle and crane to ensure a loading operation with either optimized fuel economy or with optimized loading work time.

[0010] The operation CPU correlates the measurements of the different control units and the located sensors to create a fuel matrix which provides a calculated fuel consumption that results from different movements of the crane, the load of the crane and the position of the crane and vehicle at the time of ongoing loading operation. The CPU provides a result to the operation interface that displays an optimum stopping position for the vehicle so that the fuel consumption is minimized, or the loading time is minimized. The CPU can also assist the vehicle operator to stop the vehicle when that position is reached.

[0011] The operation system allows the operator of the vehicle to find an optimized position for the forwarder vehicle to start a loading or unloading process. The fuel consumption can be reduced, limiting the use of fuel resources. The operation system can also be used to optimize the loading or unloading operation to reduce the work time for operation, reducing the outreach of the crane or a height difference.

[0012] In another embodiment the crane sensors can be adapted to measure the pressure of each hydraulic actuator of the crane, so that the weight of the load of the crane is detected.

[0013] The weight can be used to further specify the fuel matrix for effects of the weight on the fuel consumption. The log location and the number of logs can be used to calculate an estimated weight which effects the possible fuel consumption. The stopping position can thus be further calculated to minimize the crane outreach or to minimize the loading time.

[0014] In a further embodiment the crane sensors can be adapted to detect the position of each of the crane booms and the position of the crane tip.

[0015] The operation system can estimate and detect the position and movement of the crane and calculate the fuel matrix based on these measurements. The crane position can be visualized in the operator interface and the crane outreach can be calculated so that the fuel matrix application is updated depending on the crane reach.

[0016] According to another embodiment the operation system can comprise a hydraulic pump control unit and hydraulic sensors, adapted to measure the power consumption and the speed of the hydraulic pump.

[0017] The power and fuel consumption due to usage of the hydraulic pump is detectable by the operation system and can be used to increase the accuracy of the fuel matrix.

[0018] In a further embodiment the weight estimate of the logs can be calculated, and a maximum outreach of the crane is modified depending on the weight estimate.

[0019] The weight calculation can be facilitated by a sensor in the crane tip which detects a weight increase during lifting of the load, it is also possible to estimate the weight of the load due to a pressure increase in the hydraulic actuators at a time of lifting a load or by an increase of the workload of the hydraulic pump at a time of lifting a load with the crane. The outreach of the crane for an optimized fuel consumption is modified in regard to a potential weight of the load so that an estimated position of the vehicle is modified to reflect the lifting work of the crane and realize an optimization in regard to the fuel matrix or in regard to a time optimum.

[0020] In a further embodiment the operation system can comprise a camera and/or a data map system, being used to calculate an estimated weight of the logs.

[0021] The camera can be a real time camera, identifying the log piles in the vehicle or crane surrounding. From a identification of the number of logs, a diameter estima-

tion by camera software and a length identification the operation system can estimate the gross weight of the log pile. The weight estimation is compared to a possible crane reach and a resulting fuel consumption of the fuel matrix. As a result, the operation system optimized a stopping position of the vehicle for a reduced fuel consumption.

[0022] Another invention is a forestry vehicle with a loading and unloading operation system, comprising a crane and a crane control unit and crane sensors, adapted to measure the turn angle of the crane, and the extension position of each hydraulic actuator of the crane, so that the crane tip location and a maximum crane outreach state is detected, an engine control unit and engine sensors, adapted to measure the RPM speed of the engine and the fuel consumption, an operator interface, the operation system adapted to display the location of logs and various adjectives of the logs and the locations and a calculated optimum position of the vehicle for loading and unloading operation, an operation CPU with CPU software, adapted to correlate the measurements and establish a fuel matrix, depending on measured values of the crane, and on the fuel consumption, calculating an estimated fuel consumption depending on the established fuel matrix and a theoretical crane reach as well as the number of logs, size and position in relation to an estimated vehicle position, displaying a calculated optimum stopping position of the vehicle for loading or unloading the logs based on the calculation and a minimal fuel consumption or a minimal operation time, adapted to assist the operator to find the optimum stopping position by displaying the vehicle on a map display, and/or stopping the vehicle automatically at the optimum stopping position.

[0023] The operation system can be part of a vehicle or can be afterwards installed in the vehicle as an add-on feature. The operation system ensures that the forest machine is on a location that provides an optimum fuel consumption derived from a fuel-outreach matrix or a time matrix resulting a fuel map or similar. This could also be extended to comprehend and determine an optimum unloading position or an optimum unloading distance with respect to a possible log unloading area and resulting pile properties and a log pile height. The operation system could also help with optimal loading/unloading crane trajectories, giving guidance of best loading/unloading trajectories derived from a fuel matrix. In addition to an optimum location, the operator could also rely on or automatically make use of these optimal crane movement trajectories, by moving the crane in a statistically determined most economical way which could be time based or fuel based.

[0024] The crane comprises a control unit and sensors to be able to control the crane movements and detect the accuracy and correctness of the movements. The control unit can be integrated in the operator control unit in the cabin to be manually or automatically adjusted either by the operator or by an integrated CPU and software acting

on the crane control unit. The sensors detect a horizontal turning angle of the crane in relation to the crane base and/or the vehicle where the crane is mounted on. The sensors can measure the extension of the crane hydraulic actuators and are thus enabled to detect the individual positions of the booms of the crane wherein multiple booms are connected to each other to form a crane structure.

[0025] The control unit can detect the location of the crane tip, being the end of the last boom and an outreach state, being the elongation of the crane including the extension of the individual booms so that the geometric form of the crane is detected and displayed on the operator interface.

[0026] The engine control unit together with the RPM sensor can measure the engine speed at any moment in time and the fuel consumption. The measurement is overlaid with the crane movement and the crane position at that time so that a relation between the crane status and the engine status is created.

[0027] The operator interface displays the log location on a map like display in relation to the vehicle and crane position. The data for the log location is obtained either by import of map data or via data interface or manual input before working operation commences. The operator can manually choose the log pile to be loaded or the operator interface automatically chooses the nearest log pile for a loading operation given that the vehicle has an empty bunk space.

[0028] The operation system uses the calculated results to determine a position of the vehicle and crane to ensure a loading operation with either optimized fuel economy or with optimized loading work time.

[0029] The operation CPU correlates the measurements of the different control units and the located sensors to create a fuel matrix which provides a calculated fuel consumption that results from different movements of the crane, the load of the crane and the position of the crane and vehicle at the time of ongoing loading operation. The CPU provides a result to the operation interface that displays an optimum stopping position for the vehicle so that the fuel consumption is minimized, or the loading time is minimized. The CPU can also assist the vehicle operator to stop the vehicle when that position is reached.

[0030] The operation system allows the operator of the vehicle to find an optimized position for the forwarder vehicle to start a loading or unloading process. The fuel consumption can be reduced, limiting the use of fuel resources. The operation system can also be used to optimize the loading or unloading operation to reduce the work time for operation, reducing the outreach of the crane or a height difference.

[0031] In another embodiment the forestry vehicle can comprise an automatic steering system, so that the operation system is enabled to steer the vehicle automatically to the estimated optimum stopping position and to further stop the vehicle at that position.

[0032] The operation system calculates an optimal

position based on the data from the fuel matrix which correlates fuel consumption and the position of the vehicle, the potential movement of the crane and the weight of the load to calculate and determine the stopping position of the vehicle for a loading or unloading operation. The operation system controls the vehicle steering system so that the current position of the vehicle is moved towards the optimal calculated stopping position and the operator is relieved from making steering corrections or calculations. The vehicle will come to a full stop when the operation system determines that the stopping position is reached, and that the vehicle is in the correct orientation regarding the log pile or the unload area.

[0033] The invention is further described by the following figures, wherein

Figure 1 depicts a forestry vehicle having a crane and a load bunk for loading logs;

Figure 2 show an example of the invention;

Figure 3 shows an example of a fuel matrix.

[0034] Figure 1 depicts a forestry vehicle 100. The vehicle 100 is outfitted with the operation system 10. The vehicle 100 is used for loading, transporting, and unloading logs from a forest work site. The vehicle 100 comprises a crane 35 and a load bunk 101 on a rear part chassis. The crane 35 has multiple booms and hydraulic actuators 36 and a crane tip 40 used to attach implements for different work tasks. The crane 35 is rotatable around a vertical axis at a base connection to the vehicle chassis and comprises multiple booms wherein the last boom further comprises a movable extension.

[0035] The load bunk 101 comprises multiple poles surrounding the load area and frames, connecting the poles, and fixing these to the vehicle chassis. The load bunk 101 has a front shield on a forward side of the vehicle 100. Loading and unloading procedure requires the operator to load the logs or cut tree trunks into and out of the load bunk 101.

[0036] An operator cabin 65 is provided on a front part of the vehicle 100, having a seat and controls to fully operate the vehicle 100. The operator cabin 65 comprises an operator interface 70 being adapted to display different information to the operator. The information can have a wide range, displaying maps, vehicle information or control buttons and loading status of the load bunk 101. The cabin also comprises control surfaces to handle the crane 35 and the implement used as working tool.

[0037] The loading unloading operation without the invention is described as follows. First, the operator steers the vehicle 100 in a position to load the logs into the load bunk 101. The crane 35 is extended, and the implement is used to grab and load the logs into the load bunk. The loading requires repeated movement of the crane 35 and especially the crane tip 40 and the implement towards the logs and towards the load bunk.

[0038] The operation system 10 comprises a crane control unit 20 and crane sensors 30 which are connected

to the hydraulic actuators 36 of the crane 35. The sensors 30 measure the extension of the hydraulic actuators 36 or the pressure of the hydraulic actuators 36 to determine an extended length measurement and enable to detect the status of the crane position and state of each boom and the position of the crane tip 40 in relation to the vehicle 100 and the chassis.

[0039] The crane control unit 20 receives the measurements and delivers these to the CPU unit 80 which also receives data input from the engine control unit 50 and the engine sensors 60 about the current engine speed and current fuel consumption.

[0040] The CPU unit 80 is receiving the data and is adapted to calculate a fuel matrix 110 via the CPU software 90 that correlates the engine speed, the fuel consumption, and the crane position, so that a current fuel consumption state is established, and can be used for further work estimating an expected fuel consumption behavior.

[0041] Figure 2 depicts a first diagram showing the vehicle position in relation to a loading or unloading area. The diagram can be displayed to the operator on the interface 70 when the operator steers the vehicle 100 to a loading work site. The diagram shows a load placement area 130 depending on the actual log piles around a possible vehicle position. The position of the log piles or an unloading position can be entered manually into the operator interface 70 or can be directly imported from a map system used for the forestry production. The different cubes in Fig 2 represent the determined loading or unloading locations and can be of different color or in different shadings and be displayed a heat map with different color indicators or different graphical representations, depending on the assumed fuel consumption of the vehicle 100 regarding the load distance and a resulting crane reach for loading or unloading the logs.

[0042] The locations of the log can also be integrated via an interface using a camera for identification of logs in the view field of the camera, being mounted on the vehicle 100. The center position of the vehicle 100 is the estimated optimal position of the vehicle 100 and is used to guide the operator towards that position. Figure 2 represents the state when the vehicle 100 is stopped at the calculated optimal position. Beforehand the operation system 10 can display a map or an approach route to the calculated position so that the operator is guided through the correct approach and is relieved of any stress or workload to plan the approach. The approach can also estimate the best route, having access to the vehicles map data and thus to the terrain conditions, slopes, obstacles or soft ground conditions.

[0043] Figure 3 shows a fuel matrix 110 being calculated by the operation system 10, where a specific fuel consumption 140 is displayed and related to a loading distance of the crane 35 or to the position of the vehicle 100. In Fig. 3 the vehicle 100 is represented in the middle of the fuel matrix 110. A loading distance shown in meters is recorded by the crane control unit 20 and the sensors

30 over time and is evaluated by the CPU 80, as well as the engine speed and the fuel use for these crane positions and the resulting crane reach. It is also possible to record the weight of the load and further calculate the fuel matrix 110 also considering the weight of the logs.

[0044] The weight can be an estimation based on the production data, having a length and amount of logs of a specific tree type. The weight can also be transferred from a harvester vehicle which records the total amount and weight of the harvested trees. The weight estimation can then be used to calculate the hydraulic power necessary to lift the load based on the position of the vehicle 100 and the resulting crane reach.

[0045] Once the fuel matrix 110 has a broad enough data base, e.g. based on 10 or more loading operations from the crane 35, the CPU 80 can begin to estimate the fuel matrix 110 for future loading or unloading procedures and is used to find a position of the vehicle 100 or the crane 35, where the fuel consumption is minimized, but most or all of the logs can be reached from that position. The operation system 10 is then further advising the operator via the operator interface 70 to drive the vehicle 100 in the correct orientation to the stopping position and begin the work operations of loading or unloading.

[0046] The operation system 10 can further optimize regarding the estimated loading time. In this operation mode, the loading matrix is not calculated regarding fuel consumption but crane reach and estimated crane movement time. The time optimized mode may be contrary to the optimized fuel matrix 110, as the crane reach may be higher, or the hydraulic pump power consumption may be higher. The operation system 10 calculates a stopping position for an optimized loading time and directs the operator towards that position and advises the correct stopping moment.

Claims

1. Loading and unloading operation system (10) adapted for use in a forestry vehicle (100), comprising

a crane control unit (20) and crane sensors (30), adapted to measure the turn angle of the crane (35), and

the extension position of each hydraulic actuator (36) of the crane (35), so that the crane tip location (40) and a maximum crane outreach state is detected,

an engine control unit (50) and engine sensors (60), adapted to measure the RPM speed of the engine and the fuel consumption,

an operator interface (70),

the operation system (10) adapted to display the location of logs and various adjectives of the logs and the locations and a calculated optimum position of the vehicle (100) for loading and

unloading operation,
an operation CPU (80) with CPU software (90),

adapted to correlate the measurements and
establish a fuel matrix (110), depending on 5
measured values of the crane (35), and on
the fuel consumption, calculating an esti-
mated fuel consumption depending on the
established fuel matrix (110) and a theoret- 10
ical crane reach as well as the number of
logs, size and position in relation to an es-
timated vehicle position,
displaying a calculated optimum stopping
position of the vehicle (100) for loading or
unloading the logs based on the calculation 15
and a minimal fuel consumption or a mini-
mal operation time,
adapted to assist the operator to find the
optimum stopping position by displaying the
vehicle (100) on a map display, and/or stop- 20
ping the vehicle (100) automatically at the
optimum stopping position.

2. Operation system (10) according to claim 1, wherein
the crane sensors (30) are adapted to measure the 25
pressure of each hydraulic actuator (36) of the crane
(35),
so that the weight of the load of the crane (35) is
detected. 30
3. Operation system (10) according to any of the pre-
ceding claims, wherein the crane sensors (30) are
adapted to detect the position of each of the crane
booms and the position of the crane tip (40). 35
4. Operation system (10) according to any of the pre-
ceding claims, further comprising a hydraulic pump
control unit and hydraulic sensors, adapted to mea-
sure the power consumption and the speed of the
hydraulic pump. 40
5. Operation system (10) according to any of the pre-
ceding claims, wherein the weight estimate of the
logs is calculated, and a maximum outreach of the
crane (35) is modified depending on the weight 45
estimate.
6. Operation system (10) according to any of the pre-
ceding claims, further comprising a camera and/or a
data map system, being used to calculate an esti-
mated weight of the logs. 50
7. Forestry vehicle (100) with a loading and unloading
operation system (10), comprising 55
a crane control unit (20) and crane sensors (30),
adapted to measure the turn angle of the crane
(35), and

the extension position of each hydraulic actuator
(36) of the crane (35), so that the crane tip
location (40) and a maximum crane outreach
state is detected,
an engine control unit (50) and engine sensors
(60), adapted to measure the RPM speed of the
engine and the fuel consumption,
an operator interface (70),
the operation system (10) adapted to display the
location of logs and various adjectives of the
logs and the locations and a calculated optimum
position of the vehicle (100) for loading and
unloading operation,
an operation CPU (80) with CPU software (90),

adapted to correlate the measurements and
establish a fuel matrix (110), depending on
measured values of the crane (35), and on
the fuel consumption, calculating an esti-
mated fuel consumption depending on the
established fuel matrix (110) and a theoret-
ical crane reach as well as the number of
logs, size and position in relation to an es-
timated vehicle position,
displaying a calculated optimum stopping
position of the vehicle (100) for loading or
unloading the logs based on the calculation
and a minimal fuel consumption or a mini-
mal operation time,
adapted to assist the operator to find the
optimum stopping position by displaying the
vehicle (100) on a map display, and/or stop-
ping the vehicle automatically at the opti-
mum stopping position.

8. Forestry vehicle (100) of claim 8, wherein the vehicle
(100) further comprises an automatic steering sys-
tem, so that the operation system (10) is enabled to
steer the vehicle (100) automatically to the estimated
optimum stopping position and to further stop the
vehicle (100) at that position.

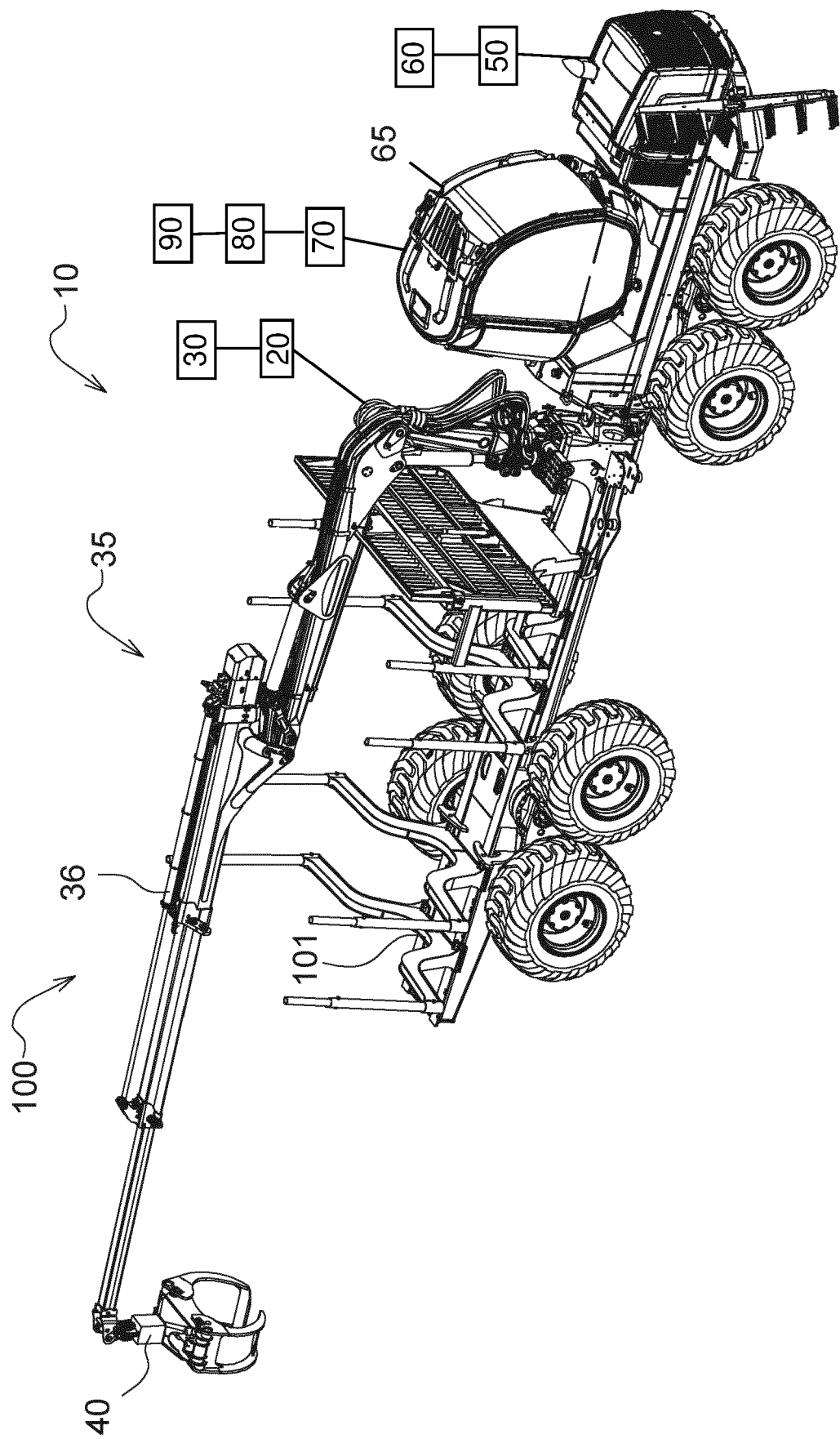


FIG. 1

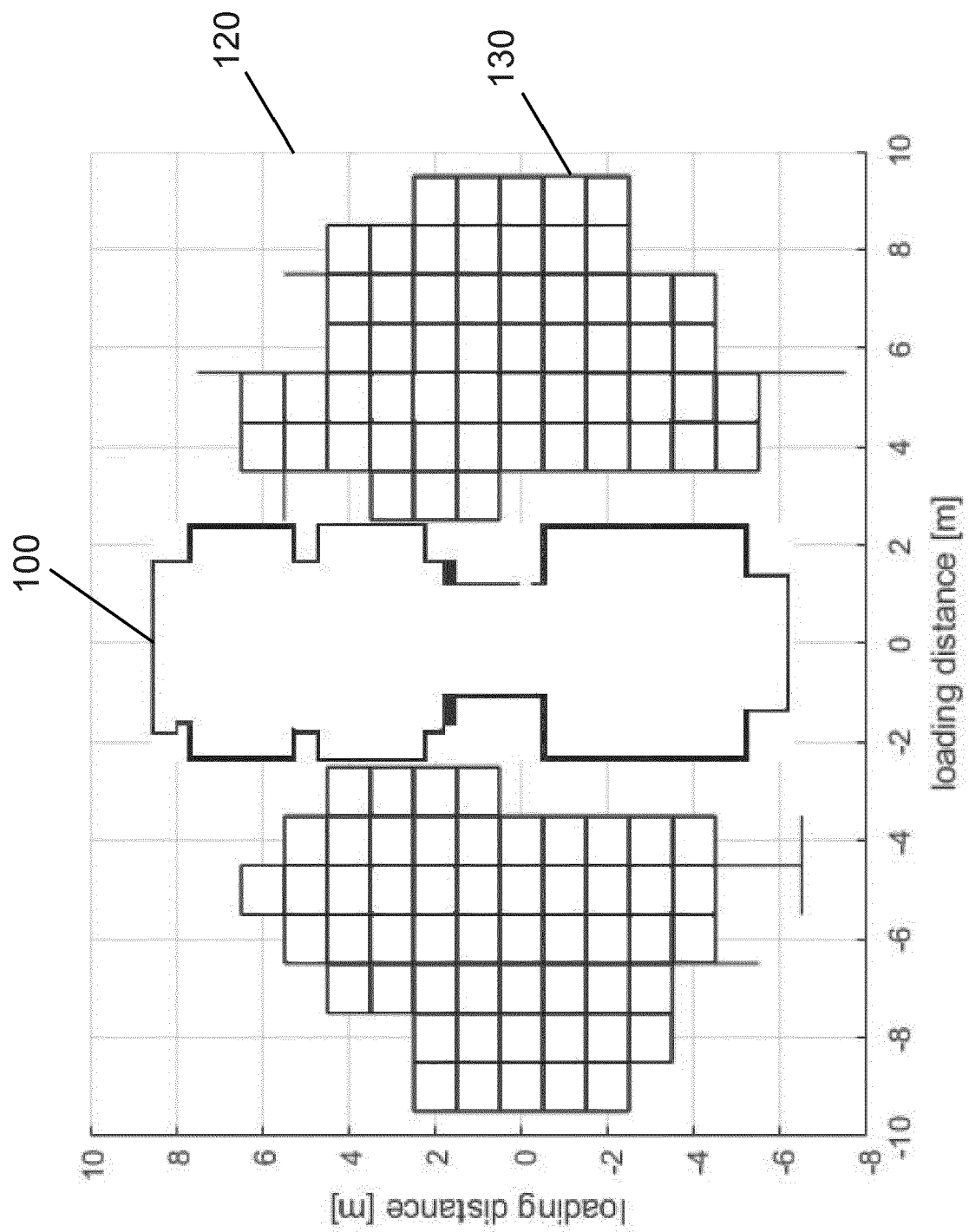


FIG. 2

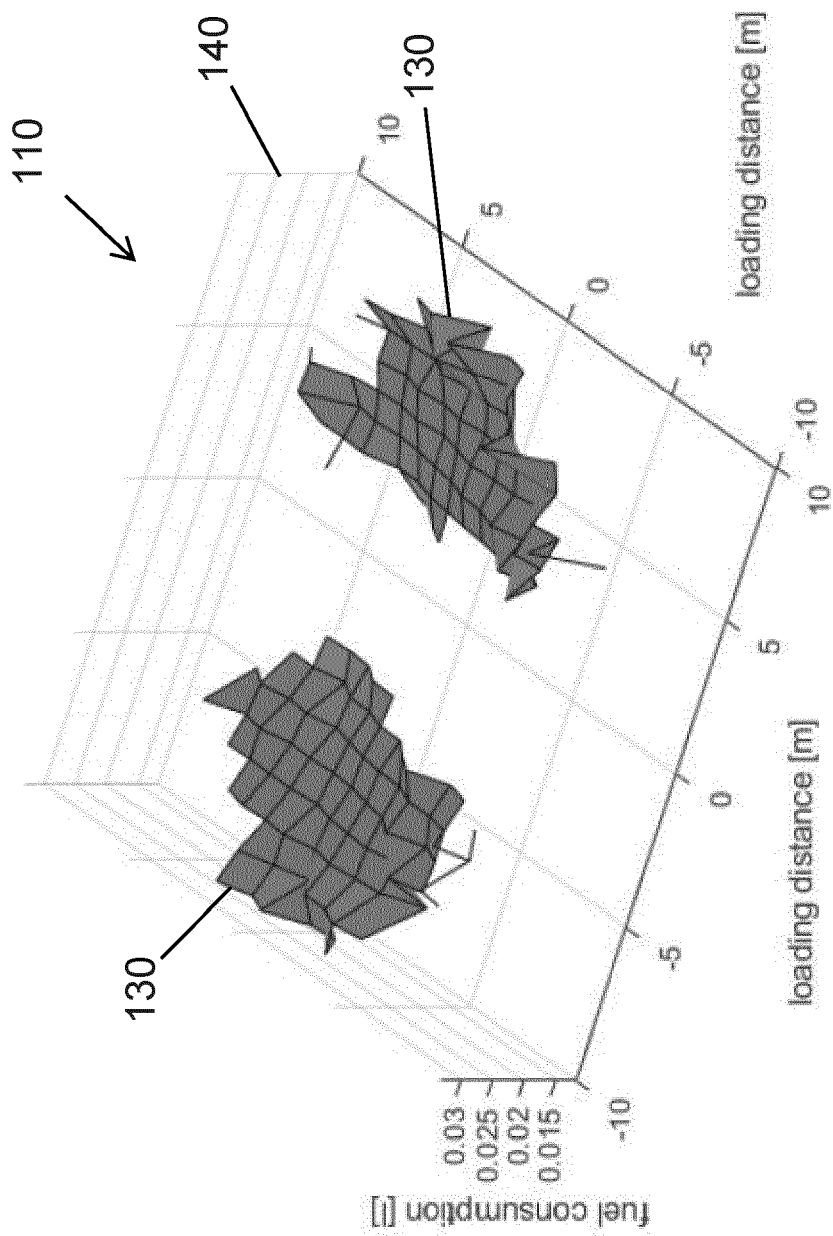


FIG. 3



EUROPEAN SEARCH REPORT

Application Number

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	EP 3 568 001 A1 (PONSSE OYJ [FI]) 20 November 2019 (2019-11-20) * pages 11-16 * * abstract * * figures *	1-8	INV. B66C23/70 B66C23/90 B66C1/58 B66C1/68 B66C13/46 B66C13/48 B66C23/00
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The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
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CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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