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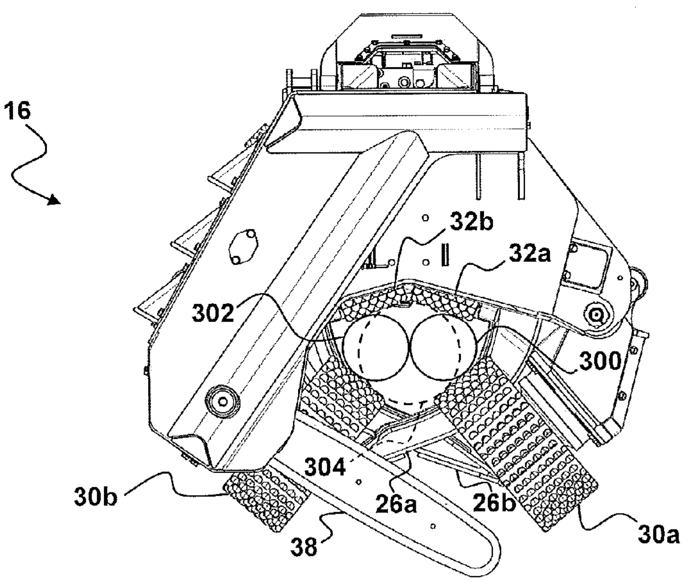
(54) **Title**: A TIMBER-WORKING DEVICE AND METHOD OF OPERATION

FIG. 4



(57) **Abstract**: A timber-working device, including a pair of pivoting delimb arms, and a pair of pivoting drive arms. The timber-working device includes a first angular position sensor configured to output a signal indicating an angular position of at least one of the delimb arms, and a second angular position sensor configured to output a signal indicating an angular position of at least one of the drive arms. At least one controller is configured to receive the signals indicating the respective angular positions of the delimb arm and the drive arm, and correlate the angular position of the delimb arm with the angular position of the drive arm to determine the number of stems currently grasped by the timber-working device.

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A TIMBER-WORKING DEVICE AND METHOD OF OPERATION

STATEMENT OF CORRESPONDING APPLICATIONS

This application is based on the specification filed in relation to New Zealand Patent Application Number 618425, the entire contents of which are incorporated herein by reference.

FIELD OF THE DISCLOSURE

The present invention relates to a timber-working device and method of operation.

BACKGROUND

It is well-known to mount timber-working devices, commonly referred to as forestry or harvester heads, to a carrier vehicle in order to perform a number of operations in connection with timber processing. These operations may include one, or a combination of, grappling and felling a standing tree, delimbing a felled stem, debarking the stem, and cutting the stem into logs – commonly using at least one chainsaw.

The maximum value of logs which may be obtained from a stem can be automatically calculated using length and diameter measurements of the stem before cutting the stem to the calculated lengths. Further, numerous measurements are made while processing stems to evaluate productivity, such as volume and harvesting intensity (essentially the number of stems per land area unit) – with diameter measurements, length measurement, and sawcuts directly correlating to those production measures.

These techniques typically assume that the head is processing a single stem at a time. For example, diameter measurements are often based on the measured angle of arms used to grapple the stem. However, a pair of stems may have an equivalent "diameter" reading to that of a large single stem, but quite a different cross-sectional area of timber. This may result in less than optimal decision making with regard to cutting the stems to length. Further, over time this discrepancy could create an undesirable degree of error with regard to evaluating productivity.

One solution would be to have the operator of the head manually input the number of stems being processed, and use this information to optimise the algorithms or calculations applied during processing. However, it is generally desirable to reduce the burden on operators in order to reduce stress and fatigue, which can in turn lead to poor decision making with regard to control of the head and lost value to the forest owner.

It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

All references, including any patents or patent applications cited in this specification are hereby incorporated by reference. No admission is made that any reference constitutes prior art. The discussion of the references states what their authors assert, and the applicants reserve the right to challenge the accuracy and pertinency of the cited documents. It will be clearly understood that, although a number of prior art publications are referred to herein, this reference does not constitute an admission that any of these documents form part of the common general knowledge in the art, in New Zealand or in any other country.

Throughout this specification, the word "comprise" or “include”, or variations thereof such as "comprises", “includes”, "comprising" or “including” will be understood to imply the inclusion of a stated element, integer or step, or group of elements integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.

SUMMARY

According to an embodiment of the present invention there is provided a method of operating a timber-working device including pivoting delimb arms and pivoting drive arms, the method including the steps of:

receiving an indication of an angular position of at least one of the delimb arms;

receiving an indication of an angular position of at least one of the drive arms;

correlating the angular position of the delimb arm with the angular position of the drive arm to determine the number of stems currently grasped by the timber-working device.

According to another aspect of the present invention there is provided a timber-working device, including:

a pair of pivoting delimb arms;

a pair of pivoting drive arms;

a first angular position sensor configured to output a signal indicating an angular position of at least one of the delimb arms;

a second angular position sensor configured to output a signal indicating an angular position of at least one of the drive arms; and

at least one controller configured to:

receive the signals indicating the respective angular positions of the delimb arm and the drive arm; and

correlate the angular position of the delimb arm with the angular position of the drive arm to determine the number of stems currently grasped by the timber-working device.

According to another aspect of the present invention there is provided an article of manufacture having computer storage medium storing computer readable program code executable by a computer to implement a method of operating a timber-working device including pivoting delimb arms and pivoting drive arms, the code including:

computer readable program code receiving an indication of an angular position of at least one of the delimb arms;

computer readable program code receiving an indication of an angular position of at least one of the drive arms;

computer readable program code correlating the angular position of the delimb arm with the angular position of the drive arm to determine the number of stems currently grasped by the timber-working device.

The timber-working device may be a forestry head, and may be referred to as such throughout the specification. Forestry heads typically have the capacity to grapple and fell a standing tree, delimb and/or debark a felled stem, and cut the stem into logs. However, a person skilled in the art should appreciate that embodiments of the present invention may be used with other timber-working devices, and that reference to the timber-working device being a forestry head is not intended to be limiting.

One well known system for forestry heads uses opposing drive arms, one on each side of a feed axis. Each drive arm may include a feed wheel configured to be brought in contact with stem. The arms may be driven, for example by hydraulic cylinders, to pivot relative to the frame of the device in order to grapple the stem with the feed wheels. The feed wheels may each connect to a rotary drive such that they may be used to drive or feed the stems along the feed axis of the head.

The timber-working device may further include one or more frame mounted feed wheels. The drive system may include a frame mounted feed wheel on either side of the feed axis, which may be controlled independently to each other. Where two stems are grasped by the drive arms, these frame mounted wheels may be controlled together with those of the respective drive arms to independently control the relative positions of the two stems along the feed axis.

The delimb arms may be configured to be closed about the one or more stems, and include sharpened edges to cut limbs from the stem as it is fed by the drive wheels. Such delimb arms may be curved to better align with the surface of the at least one stem and thereby cut the limbs off more closely to the trunk of the stem.

Where the collective profile of the stems varies from the generally circular shape as in the case of a single stem, the relationship between the angular positions of the drive and delimb arms may also change. This may enable correlation of these angles to determine the number of stems held by the arms.

In an embodiment, determining the number of stems includes comparing the angular position of the drive arm or the delimb arm to a predetermined threshold established for the angular position of the other arm.

For example, the collective profile of two stems side by side may be substantially elliptical, requiring the delimb arms to be opened to a greater extent than in a single stem case in which the position of the drive arms remains the same. The threshold may, for example, be a midpoint between those two angular positions.

It should be appreciated that the relationship between the arms and number of stems may be influenced by the cross-sectional size of the stem, or stems. The shape of the drive and/or delimb arms may be such that the relationship between the respective angular positions changes across the range of movement. Correlation of the angular positions may account for this.

The angular position sensors may be any suitable means known to a person skilled in the art for determining rotation of the arms – whether absolute or incremental. For example, the angular position sensor may be a rotary encoder.

It should be appreciated that the angular position sensor may not directly measure rotation of the arm. For example, the angular position sensor may be configured to output a signal indicative of the position of a linear actuator driving the pivoting arm. Reference to the position of the linear actuator should be understood to mean the position of a point on the actuator which may be used to determine the degree to which the actuator is extended. For example, the linear actuator may be a hydraulic cylinder including a linear position sensor. Various technologies are known in the art for achieving this – for example operating using magnetostrictive principles, or Hall-Effect. Given known geometries of the head, the position of the actuator may be used to derive the angular position of the arm, or arms.

The angular positions of the arms may be used in conjunction with the known geometry of the frame to determine the relative position of various points on the device, and thereby geometry of the stem or stems being grasped by the arms.

Control of various operations of the timber-working device may be conducted on the basis of the determined number of stems, as well as calculation of various performance metrics.

For example, determination of the length of logs may be influenced by the number of stems in order to maximise value or meet quotas. As a further example, calculation of the volume of wood processed by the timber-working device may account for the number of stems.

By determining the number of stems based on the correlation of the angular positions of the arms, rather than relying on operator input, these processes may be streamlined or accuracy improved. Relieving the operator of this input step may reduce fatigue, and enable the operator to focus on other operations which require their attention.

The various illustrative logical blocks, modules, circuits, and algorithm steps described in connection with the embodiments disclosed herein may be implemented as electronic hardware, computer software, or combinations of both. In particular, they may be implemented or performed with a general purpose processor such as a microprocessor, or any other suitable means known in the art designed to perform the functions described.

The steps of a method or algorithm and functions described in connection with the embodiments disclosed herein may be embodied directly in hardware, in a software module executed by a processor, or in a combination of the two. If implemented in software, the functions may be stored as processor readable instructions or code on a tangible, non-transitory processor-readable medium – for example Random Access Memory (RAM), flash memory, Read Only Memory (ROM), hard disks, a removable disk such as a CD ROM, or any other suitable storage medium known to a person skilled in the art. A storage medium may be connected to the processor such that the processor can read information from, and write information to, the storage medium.

BRIEF DESCRIPTION OF DRAWINGS

Further aspects of the present invention will become apparent from the following description which is given by way of example only and with reference to the accompanying drawings in which:

FIG. 1 is a side view of an exemplary timber-working system including, for example, a forestry head according to one aspect of the present invention;

FIG. 2 is an elevated view of the forestry head;

FIG. 3 is a diagrammatic view of an exemplary control system for the timber-working system;

FIG. 4 is an end view of the forestry head in use;

FIG. 5 is a flowchart illustrating an exemplary method for operating the forestry head according to one aspect of the present invention, and

FIG. 6 is a line graph showing an exemplary relationship between the angular position of a delimb arm relative to the angular position of a drive arm of a forestry head.

DETAILED DESCRIPTION

FIG. 1 illustrates a timber-working system including a carrier 10 for use in forest harvesting. The carrier 10 includes an operator cab 12 from which an operator (not shown) controls the carrier 10. The carrier 10 further includes a boom assembly 14, to which a timber-working device in the form of a forestry head 16 is connected.

Connection of the head 16 to the boom 14 includes a rotator 18, configured to rotate the head 16 about the generally vertical axis of rotation marked by dashed line 20. A tilt bracket 22 further allows rotation of the head 16 between a prone position (as illustrated) and a standing position.

Referring to FIG. 2, the head 16 includes a frame 24 to which the tilt bracket 22 of FIG. 1 is pivotally attached. Right hand (RH) and left hand (LH) delimb arms 26a and 26b are pivotally attached to the frame 24, as are opposing RH and LH drive arms 28a and 28b. RH and LH feed wheels 30a and 30b are attached to RH and LH drive arms 28a and 28b respectively, which together with RH and LH frame-mounted feed wheels 32a and 32b may be controlled to feed one or more stems (not illustrated) along feed axis 34 of the head 16. Feed wheels 30a, 30b, 32a and 32b may collectively be referred to as the ‘feed mechanism.’ A measuring wheel 36 may be used to measure the length of the stem.

A main chainsaw 38, and a topping chainsaw 40, are attached to the frame 24. The main saw 38 is typically used to fell a tree when the head 16 is in a harvesting position, and to buck stems into logs in the processing position of the head 16 (as seen in FIG. 1). The topping saw 40 may be used to cut off a small-diameter top portion of the stem(s) to maximize the value recovery of the trees.

The various operations of the head 16 may be controlled by the operator using hand and foot controls as known in the art. Further, certain automated functions of the harvester head 16 may be controlled by an electronic control system 100 as shown by FIG. 4.

The control system 100 includes one or more electronic controllers, each controller including a processor and memory having stored therein instructions which, when executed by the processor, causes the processor to perform the various operations of the controller.

For example, the control system 100 includes a first controller 102 on board the carrier 10 and a second controller 104 on board the head 16. The controllers 102, 104 are connected to one another via a communications bus 106 (e.g., a CAN bus).

A human operator operates an operator input device 108, for example hand and foot controls, located at the operator's cab 12 of the carrier 10 to control the head 16. Details of operation are output to an output device 110 – for example a monitor. Certain automated functions may be controlled by first controller 102 and/or second controller 104.

The system 100 includes angular position sensors – for example rotation sensor 112 mounted to either delimb arm 26a or 26b, and rotation sensor 114 mounted to either drive arm 28a or 28b – each configured to output a signal indicative of the angular position of the associated arm for transmission to first controller 102. As an example, the rotation sensors 112 and 114 are rotary encoders.

The head 16 has a number of valves 116 arranged, for example, in a valve block and coupled electrically to the second controller 104 so as to be under its control. The valves 116 include, for example, drive valves configured to control opening and closing of the delimb arms 26a and 26b and drive arms 28a and 28b, and drive valves configured to control operation of the motors associated with the RH and LH feed wheels 30a and 30b and RH and LH frame-mounted feed wheels 32a and 32b.

The valves 116 further include drive valves for controlling operation of the saws 38 and 40.

The control system 100 is configured to implement method 200 of FIG. 5, which will be described with reference to FIGS. 1 through 3, together with FIG. 4 showing the head 16 in use.

In step 202, a human operator operates the operator input device 108 to cause one or more stems to be grasped by the delimb arms 26a and 26b, and drive arms 28a and 28b, such that the stem(s) is positioned between the arm-mounted feed wheels 30a and 30b, and frame-mounted feed wheels 32a and 32b.

In step 204, rotation sensors 112 and 114 transmits signals indicating the angular positions of the respective associated arms to the first controller 102 via second controller 104.

In step 206 the first controller 100 correlates the angular position of the delimb arm 26a or 26b with the angular position of the drive arm 28a or 28b to determine the number of stems currently grasped by the head 16. Reference will be made to the angular positions of the RH delimb arm 26a and RH drive arm 28a – but it should be appreciated that this is not intended to be limiting.

For example, FIG. 4 illustrates a case in which the head 16 is grasping two stems 300 and 302, with both the delimb arms 26a and 26b, and the drive arms 28a and 28b positioned against the stems 300 and 302.

In comparison, ghosted line stem 304 illustrates a single stem case in which the position of the drive arms 28a and 28b remains the same. Because the collective profile of the two stems 300 and 302 differs to the single stem 304, it may be seen that the delimb arms 26a and 26b would need to be closed in order to be positioned against stem 304 – resulting in a differential relationship between the two cases.

FIG. 6 illustrates an exemplary relationship between the angular position of RH delimb arm 26a and the angular position of RH feed arm 28a. The line designated at 400 represents the relationship in the case of grasping a single stem, and the line designated at 402 represents the relationship in the case of grasping two stems.

It may be seen that there is the relationship between the RH delimb arm 26a and RH drive arm 28a may be distinguished between the two cases (single stem 400 and two stems 402). It should be appreciated that exact angular position values may vary between head configurations and geometries, but that the general principle applies.

Determination of the number of stems may thus be achieved, for example, by referencing the angular position of the RH drive arm 28a and comparing the angular position of the RH delimb arm 28a with a threshold delineating the two cases (see line designated at 404).

As an example, where the angular position of the RH drive arm 28a is 25 degrees, if the angle of the RH delimb arm 26a is less than 64 degrees the first controller 102 determines that a single stem is currently grasped by the head 16. If the angle of the RH delimb arm 26a is greater than 64 degrees the first controller 102 determines that two stems are currently grasped by the head 16.

In step 208 the first controller 102 sets the state of a stem count parameter according to the number of stems determined in step 206. The stem count state may be displayed to the operator on output device 110 for validation or correction using input device 108.

In step 210 the stem count parameter may be referenced by various functions controlled by the first controller 102 and/or second controller 104, which may be selected or modified according to the current stem count.

For example, an algorithm used to calculate the volume of wood processed by the head may be selected from the set of algorithms based on the number of stems.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof as defined in the appended claims.

WHAT WE CLAIM IS:

1. A timber-working device, including:

a pair of pivoting delimb arms;

a pair of pivoting drive arms;

a first angular position sensor configured to output a signal indicating an angular position of at least one of the delimb arms;

a second angular position sensor configured to output a signal indicating an angular position of at least one of the drive arms; and

at least one controller configured to:

receive the signals indicating the respective angular positions of the delimb arm and the drive arm; and

correlate the angular position of the delimb arm with the angular position of the drive arm to determine the number of stems currently grasped by the timber-working device.

2. The device of claim 1, wherein the controller is configured to determine the number of stems based at least in part on a comparison of the angular position of the drive arm or the delimb arm to a predetermined threshold established for the angular position of the other arm.

3. The device of claim 1 or claim 2, wherein the controller is configured to control one or more operations of the timber-working device based at least in part on the determined number of stems.

4. A method of operating a timber-working device including pivoting delimb arms and pivoting drive arms, the method including the steps of:

receiving an indication of an angular position of at least one of the delimb arms;

receiving an indication of an angular position of at least one of the drive arms;

correlating the angular position of the delimb arm with the angular position of the drive arm to determine the number of stems currently grasped by the timber-working device.

5. The method of claim 4, wherein determining the number of stems includes comparing the angular position of the drive arm or the delimb arm to a predetermined threshold established for the angular position of the other arm.

6. The method of claim 4 or claim 5, including the step of controlling one or more operations of the timber-working device based at least in part on the determined number of stems.

7. An article of manufacture having computer storage medium storing computer readable program code executable by a computer to implement a method of operating a timber-working device including pivoting delimb arms and pivoting drive arms, the code including:

computer readable program code receiving an indication of an angular position of at least one of the delimb arms;

computer readable program code receiving an indication of an angular position of at least one of the drive arms;

computer readable program code correlating the angular position of the delimb arm with the angular position of the drive arm to determine the number of stems currently grasped by the timber-working device.

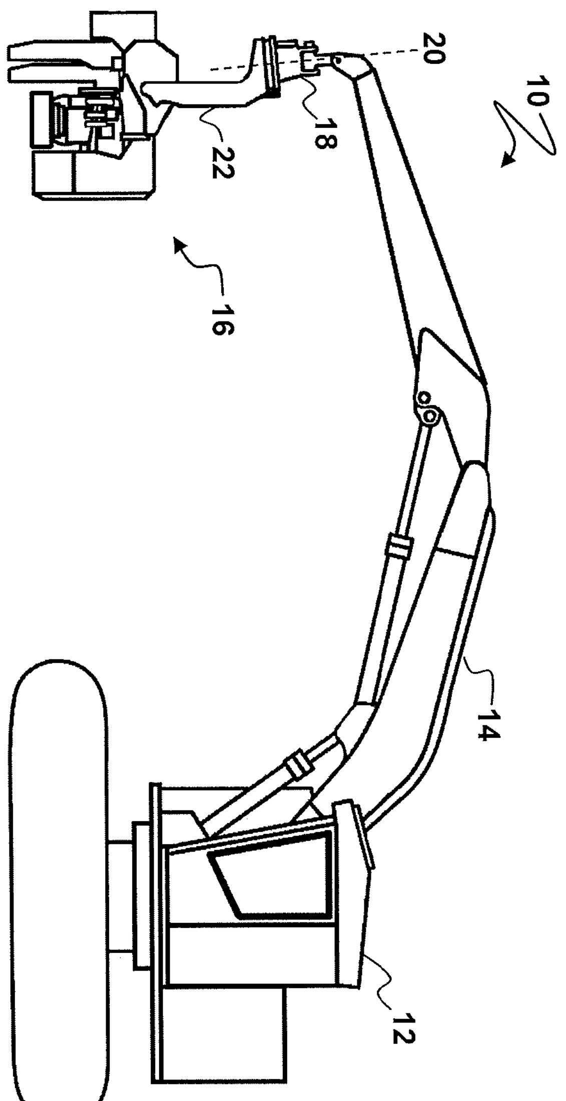


FIG. 1

FIG. 2

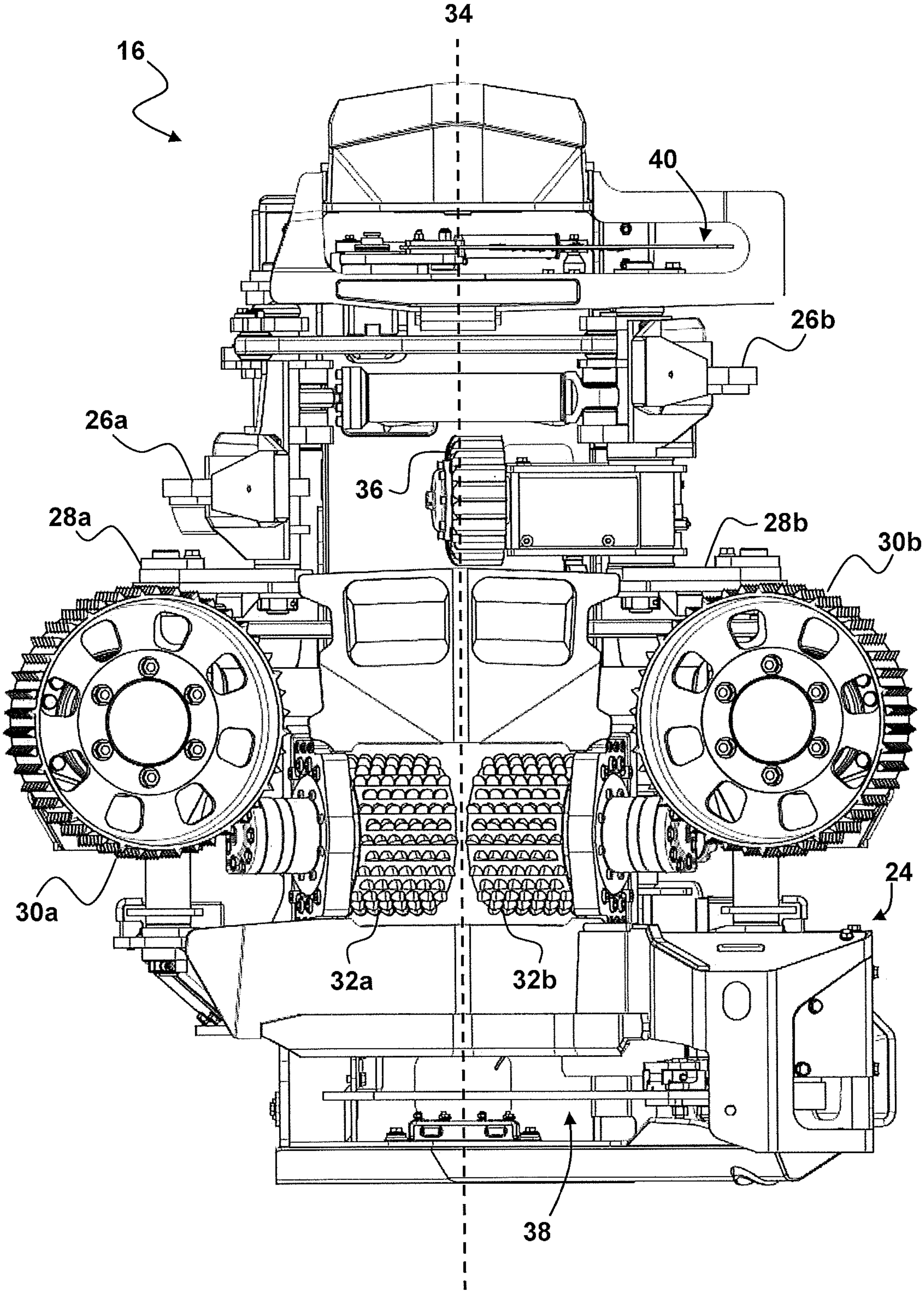


FIG. 3

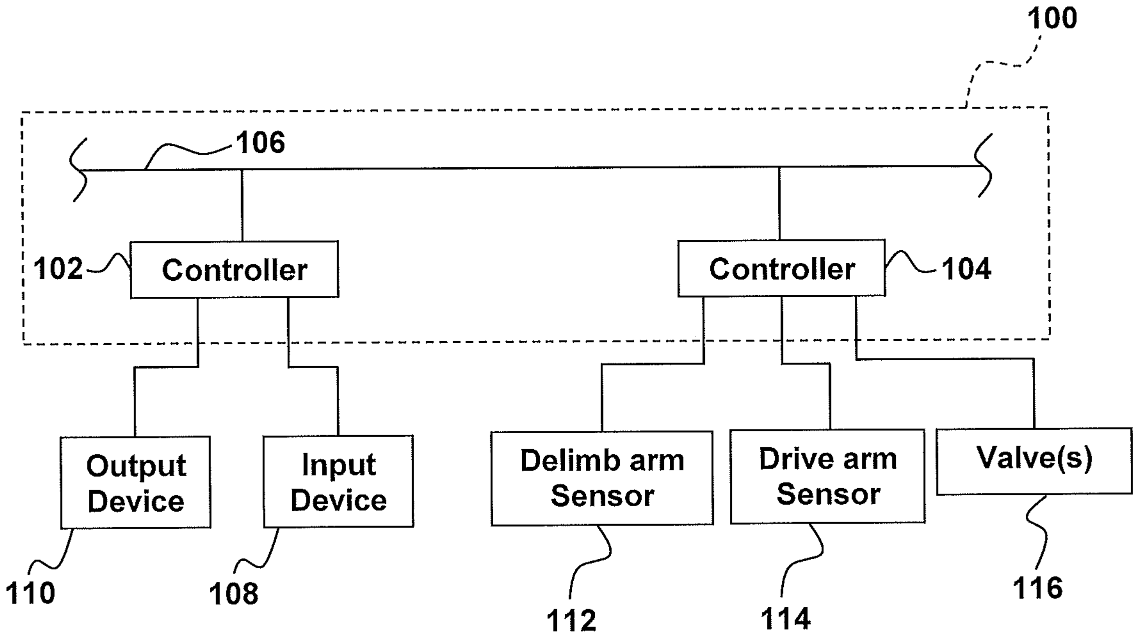

100
106
102
Controller
Controller
104
Output Device
Input Device
Delimb arm Sensor
Drive arm Sensor
Valve(s)
110
108
112
114
116

FIG. 4

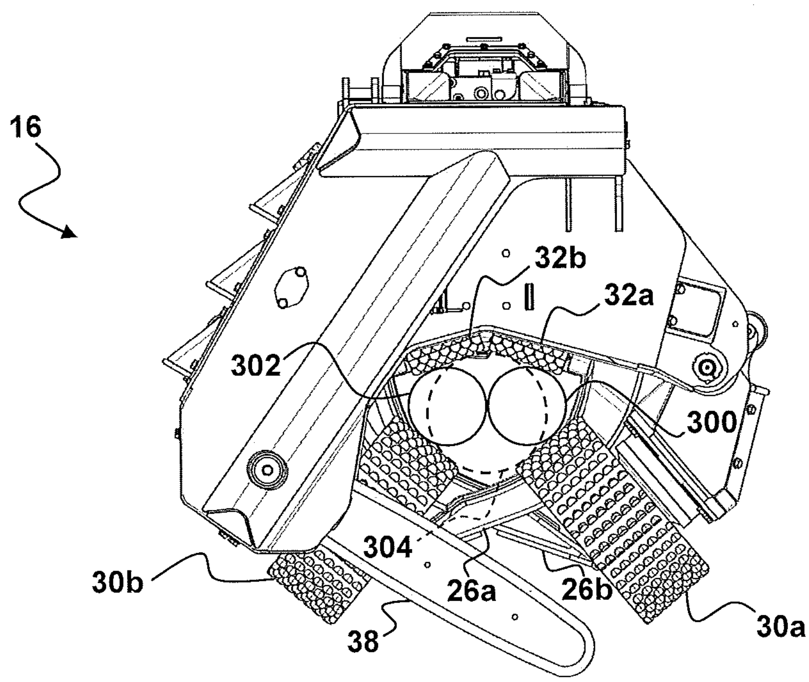
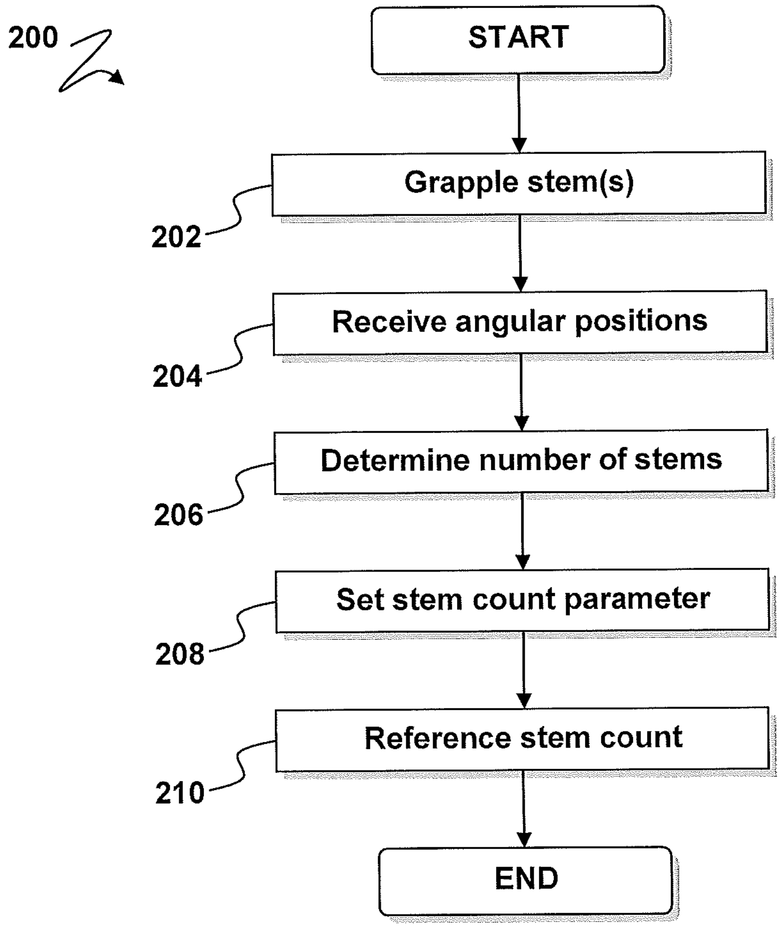

16
32b
32a
302
300
304
30b
26a
26b
30a
38

FIG. 5


200
START
Grapple stem(s)
202
Receive angular positions
204
Determine number of stems
206
Set stem count parameter
208
Reference stem count
210
END

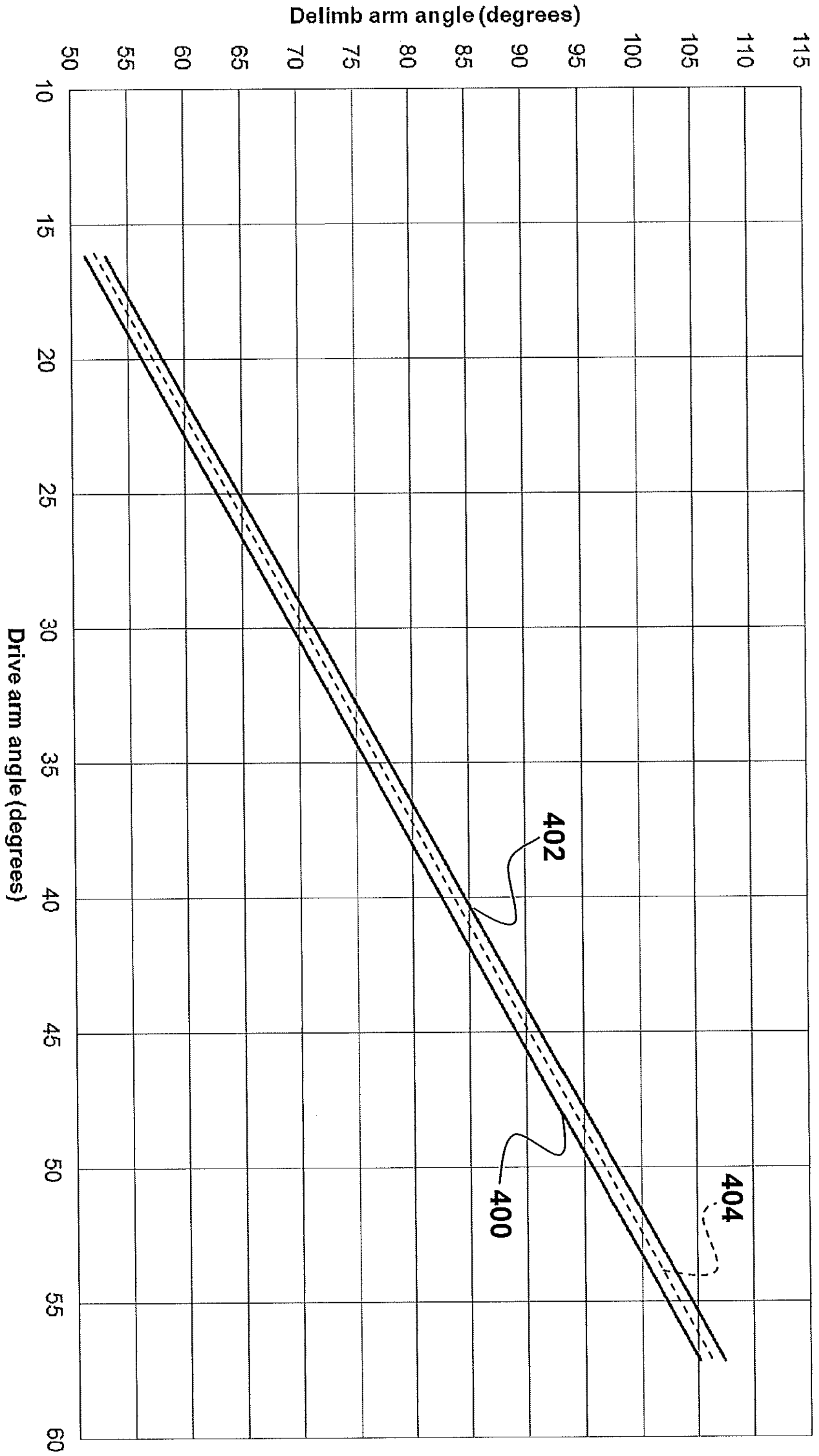

Delimb arm angle (degrees)
50 55 60 65 70 75 80 85 90 95 100 105 110 115
Drive arm angle (degrees)
10 15 20 25 30 35 40 45 50 55 60
402
400
404

FIG. 6