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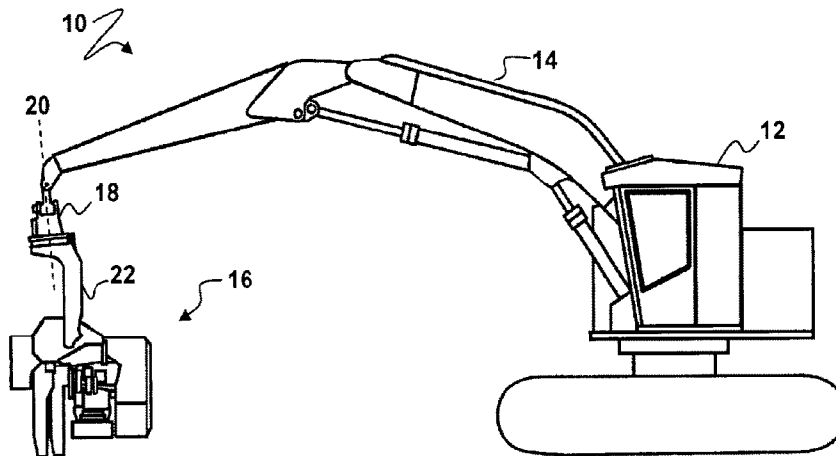
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(54) Titre : DETERMINATION DU NOMBRE DE TRONCS D'ARBRE REELLEMENT TRAITES PAR UN APPAREIL DE TRAVAIL DU BOIS D'OEUVRE

(54) Title: DETERMINATION OF NUMBER OF TREE STEMS CURRENTLY BEING PROCESSED BY A TIMBER-WORKING DEVICE



(57) Abrégé/Abstract:

Disclosed is a timber-working device, including a frame; at least one pair of arms moveably connected to the frame, and configured to hold at least one stem to be processed; a central contactless distance measuring device having a first sensing path extending between the frame and the at least one stem from a substantially central position between the pair of arms for generating a first signal indicative of a first distance between the frame and a frame facing surface of the at least one stem; a first lateral contactless distance measuring device having a second sensing path extending between the frame and the at least one stem from a first side position laterally offset from the substantially central position for generating a second signal indicative of a second distance between the frame and the frame facing surface of the at least one stem. A controller receives the first and second signals to determine the number of stems currently held. The device is used to reduce the burden on operators in order to reduce stress and fatigue.

ABSTRACT

Disclosed is a timber-working device, including a frame; at least one pair of arms moveably connected to the frame, and configured to hold at least one stem to be processed; a central contactless distance measuring device having a first sensing path extending between the frame and the at least one stem from a substantially central position between the pair of arms for generating a first signal indicative of a first distance between the frame and a frame facing surface of the at least one stem; a first lateral contactless distance measuring device having a second sensing path extending between the frame and the at least one stem from a first side position laterally offset from the substantially central position for generating a second signal indicative of a second distance between the frame and the frame facing surface of the at least one stem. A controller receives the first and second signals to determine the number of stems currently held. The device is used to reduce the burden on operators in order to reduce stress and fatigue.

**DETERMINATION OF NUMBER OF TREE STEMS CURRENTLY BEING
PROCESSED BY A TIMBER-WORKING DEVICE
FIELD OF THE DISCLOSURE**

The present disclosure relates to a timber-working device and method of operation, more particularly determination of the number of tree stems currently being processed by forestry head.

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, and processing one or more resulting stems by delimbing, debarking, and cutting those stems into logs.

The number of stems being concurrently processed heavily influences the manner in which measurements (such as diameter and length measurement) are to be interpreted – for example when calculating the number and length of logs to be cut from a stem, or evaluating productivity such as volume and harvesting intensity (essentially the number of stems per land area unit). For accuracy, the number of stems needs to be known.

One method for accomplishing this would be to have the operator of the head manually input the number of stems being processed. 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.

SUMMARY

According to an exemplary embodiment there is provided a timber-working device, including:

a frame;

at least one pair of arms moveably connected to the frame, and configured to hold at least one stem to be processed by the timber-working device;

a central contactless distance measuring device having a first sensing path extending between the frame and the at least one stem from a substantially central position between the pair of arms, and configured to output a first signal indicative of a first distance between the frame and a frame facing surface of the at least one stem;

a first lateral contactless distance measuring device having a second sensing path extending between the frame and the at least one stem from a first side position laterally offset from the substantially central position, and configured to output a second signal indicative of a second distance between the frame and the frame facing surface of the at least one stem; and

at least one controller, configured to:

receive the signals indicating the first distance and the second distance; and

determine the number of stems currently held by the at least one pair of arms based at least in part on the signals.

According to an exemplary embodiment there is provided a method, including:

holding at least one stem using at least one pair of arms moveably connected to a frame of a timber-working device;

outputting a first signal indicative of a first distance between the frame and a frame facing surface of the at least one stem from a central contactless distance measuring device having a first sensing path extending between the frame and the at least one stem from a substantially central position between the pair of arms;

outputting a second signal indicative of a second distance between the frame and the frame facing surface of the at least one stem from a first lateral contactless distance measuring device having a second sensing path extending between the frame and the at least one stem from a first side position laterally offset from the substantially central position;

receiving the first signal and the second signal; and

determining the number of stems currently held by the at least one pair of arms based at least in part on the first signal and the second signal.

The timber-working device may be a forestry or harvester head, and may be referred to as such herein. Forestry heads typically have the capacity to grapple and fell a

standing tree, and/or delimb and/or debark a felled stem, and cut the stem into logs. However, a person skilled in the art should appreciate that 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.

The arms moveably connected to the frame may be drive arms. The use of opposing drive arms, one on each side of a longitudinal axis of the frame of the head, is well known in the art. Each drive arm may include a drive mechanism at the end of the arm distal from its pivotal connection to the frame – for example a rotary drive coupled with a feed wheel configured to be brought in contact with stem. Such a drive mechanism may be referred to herein as a “feed wheel”. The drive arms may be actuated, for example by hydraulic cylinders, to pivot relative to the frame in order to grapple the stem with the feed wheels. Rotation of the feed wheels may then drive or feed the stems along the longitudinal, or “feed”, axis of the head.

The timber-working device may include delimb arms moveably connected to the frame. Delimb arms are known in the art, having sharpened edges to cut limbs from the stem as it is driven by the feed wheels.

The timber-working device may include at least one angular position sensor configured to output a signal indicative of the angle of an associated arm relative to the frame. The angular position of at least one 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(s) being grasped by the arms – particularly diameter. As a point of reference, the arms may be centred on the feed axis of the frame – i.e. the feed axis may be evenly spaced from the respective points of connection between the arms and the frame.

The combined profile of the outer surfaces of the two stems will be substantially different to that of a single stem – substantially in the shape of a lemniscate as opposed to a circle. Inferences may be made regarding the profile of the stem(s) held by the arms by obtaining an indication of the distance between the frame and the surface of the stem(s) facing the frame at (a) a central position at which two stems would abut against each other, and (b) at least one position laterally offset from that central position. Generally, in the

case of a single stem the distance at the central position may be less than the distance at the laterally offset position, while the converse is true in the case of two stems.

The central contactless distance measuring device is positioned and oriented such that the first sensing path is directed to intercept the surface of the stem(s) at a position substantially aligned with the feed axis. In an exemplary embodiment, the central contactless distance measuring device may be located directly above the feed axis on the frame. However, it should be appreciated that this is not intended to be limiting, and that the device itself could be offset from a central location but oriented to direct its sensing path to intercept a workable position.

Similarly, the first lateral contactless distance measuring device may be positioned and oriented directly above the desired laterally offset position for the second sensing path. In an exemplary embodiment the timber-working device may include a second lateral contactless distance measuring device having a second sensing path extending between the frame and the at least one stem from a second side position laterally offset from the substantially central position, and configured to output a third signal indicative of a third distance between the frame and the frame facing surface of the at least one stem. It is envisaged that the first lateral contactless distance measuring device may be located on a first side of the feed axis of the timber-working device, and the second lateral contactless distance measuring device located on the opposing side of the feed axis.

In doing so, this additional data point may provide additional accuracy in determining the profile of the stem(s) being held, to accommodate for variation in shape and straightness of the stem. Further, in the case of two stems of mismatched size, the point at which they abut may not be exactly centralised between the arms. While it is envisaged a single laterally offset distance measuring device may be used to make the determination, the wider profile created by using two distance measuring devices may reduce the likelihood of error.

Numerous sensing technologies are known in the art for contactless distance measurement – for example optical (such as a laser rangefinder), capacitive, or ultrasonic distance measurement sensors. It should be appreciated that while the distance measurement at the central and laterally offset positions is described as being obtained

from distinct devices, this is not intended to exclude the use of a single device capable of obtaining multiple measurements.

Determination of the number of stems currently held by the at least one pair of arms may include a determination that the number of stems is either one or more than one. The determination may be that the number of stems is either one, or two. More than two stems held by the head may present overall cross-sectional dimensions which correspond to a larger diameter single stem. While the processor may be configured to differentiate between individual counts, it is envisaged that in a number of applications the timber-working device may be rarely used to process three or more stems simultaneously. It may be unlikely that an operator will find that number of stems of a similar size in a stack of logs at the same time, being inefficient to purposefully search the stack for this occurrence. As such, differentiation between a single stem and two stems is envisaged as being sufficient in a number of applications.

As discussed above, the distance measurements at the central and laterally offset positions may be used to infer the profile of the stem(s), and therefore the number of stems, by a processor. It should be appreciated that this determination may be implemented in a variety of ways, and the examples provided herein are not intended to be limiting. For example, a simple algorithm for determination of the number of stems (“StemCount”) may be expressed in pseudocode as:

```

IF DistanceCentre < DistanceOffset THEN
    StemCount = 1
ELSE
    StemCount = 2
ENDIF

```

The determination of the number of stems currently held by the at least one pair of arms may be used to determine a mode of operation for the timber-working device.

A controller of the timber-working device may be configured to implement different modes of operation depending on the number of stems to be processed. For example, different data processing routines may be used to interpret measurements such as diameter and length measurement in order to automatically calculate the number and

length of logs to be cut from a stem, or in evaluating productivity measures such as volume and harvesting intensity.

Different modes of operation may also have unique device control aspects associated with them, whether automated or operator controlled.

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 one or more controllers having one or more processors, such as a microprocessor, or any other suitable means known in the art designed to perform the functions described.

The steps of a method, process, 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. 1A is a side view of an exemplary timber-working system including an exemplary forestry head;
- FIG. 1B is an elevated view of the exemplary forestry head;
- FIG. 1C is an end view of the exemplary forestry head;
- FIG. 2 is a diagrammatic view of an exemplary control system for the timber-working system;

- FIG. 3A is an end view of the exemplary forestry head illustrating the position of single stems, having a range of diameters, relative to the head;
- FIG. 3B is an end view of the exemplary forestry head illustrating the position of twin stems, having a range of diameters, relative to the head;
- FIG. 4 is a flowchart illustrating an exemplary method for determining the number of stems grasped by a forestry head.

DETAILED DESCRIPTION

FIG. 1A 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 assembly **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. 1B, 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 feed arms **28a** and **28b**. RH and LH feed wheels **30a** and **30b** are attached to RH and LH feed 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 a longitudinal feed axis **34** of the head **16**. Feed wheels **30a**, **30b**, **32a** and **32b** may collectively be referred to as the ‘feed mechanism.’ It should be appreciated that reference to the feed wheels is intended to include the hydraulic rotary drives propelling them. A measuring wheel **36** may be used to measure the length of the stem as it passes.

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. 1A). 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.

FIG. 1C illustrates the positioning of three contactless distance measurement devices, herein referred to as distance sensors **42a**, **42b**, and **42c**, on the frame **24** of the head **16**. The devices **42a**, **42b**, and **42c** may each be, for example, an optical distance sensor or an ultrasonic distance sensor, as known in the art.

Each of the distance sensors **42a**, **42b**, and **42c** has an associated sensing path **44a**, **44b**, and **44c** projecting beyond the frame **24** into the space between the delimb arms **26a** and **26b**, and feed wheels **30a** and **30b**. The central distance sensor **42a** is positioned centrally on the frame **24**, with its sensing path **44a** projecting straight down towards feed axis **34** (as seen in FIG. 1B). The RH distance sensor **42b** is laterally offset to the right hand side of the central distance sensor **42a**, while the LH distance sensor **42c** is laterally offset to the left hand side.

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 **200** as shown by FIG. 2.

The control system **200** 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 **200** includes a first controller **202** on board the carrier **10** and a second controller **204** on board the head **16**. The controllers **202**, **204** are connected to one another via a communications bus **206** (e.g., a CAN bus, or a wireless link).

A human operator operates an operator input device **208**, 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 **210** – for example a monitor. Certain automated functions may be controlled by first controller **202** and/or second controller **204**.

The system **200** includes angular position sensors – for example at least one delimb rotation sensor **212a** mounted to one or both of delimb arms **26a** or **26b**, and/or at least one feed rotation sensor **212b** mounted to one or both of feed arms **28a** or **28b** – each configured to output a signal indicative of the angular position of the associated arm for

transmission to first controller **202** via second controller **204** and bus **206**. This arm angle may be used to determine diameter of the stem(s) held by the head **16**, as known in the art. The head **16** has a number of valves **214** arranged, for example, in a valve block and coupled electrically to the second controller **204** so as to be under its control. The valves **214** include, for example, delimb arm valves **216** configured to control pivotal movement of the delimb arms **26a** and **26b**, and feed arm valves **218** configured to control pivotal movement of the feed arms **28a** and **28b**. The valves **214** also include, for example, saw valves **220**, configured to control movement and operation of the main saw **38** and the topping saw **38**. The valves **214** also include, for example, feed wheel valves **222**, configured to control movement and operation of the rotary drives associated with **30a**, **30b**, **32a** and **32b**.

The distance sensors **42a**, **42b**, and **42c** are configured to output signals to the second controller **204**, indicative of the respective distances to the surface of one or more stem(s) in the respective sensing paths **44a**, **44b**, and **44c**.

FIG. 3A illustrates the range of stem diameters to be accommodated by the head **16** in the case of single stem processing, while FIG. 3B illustrates twin stem processing. The control system **200** is configured to implement method **400** of FIG. 4, which will be described with reference to foregoing description of the figures.

In step **402**, a human operator operates the operator input device **208** to grasp one or more stems with the delimb arms **26a** and **26b**, such that the stem(s) is held against the frame-mounted feed wheels **32a** and **32b**.

In step **404** the distance sensors **42a**, **42b**, and **42c** output signals indicative of the respective distances between the sensors and the surface of stem(s) held by the head **16** within the sensing paths **44a**, **44b**, and **44c**.

In step **406** the second controller **208** receives the signals, and transmits the distance information to the first controller **202**, where it is received and processed to determine the number of stems held by the head.

For example, the number of stems may be determined using the following algorithm:

```
IF DistanceCentre < DistanceOffsetRight
OR DistanceCentre < DistanceOffsetLeft THEN
    StemCount = 1
ELSE
    StemCount = 2
ENDIF
```

Alternatively, the determination of the StemCount being one (1) may require that the distance output from both distance sensors **42b** and **42c** are greater than the central distance sensor **42a**, i.e.:

```
IF DistanceCentre < DistanceOffsetRight
AND DistanceCentre < DistanceOffsetLeft THEN
    StemCount = 1
ELSE
    StemCount = 2
ENDIF
```

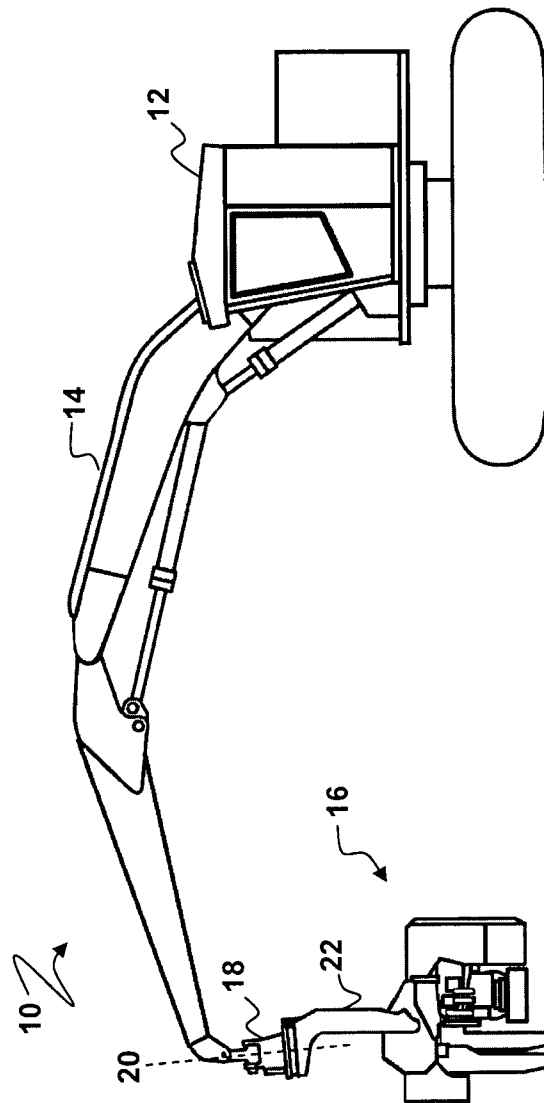
On determining the number of stems, the first controller **202** may determine and set an appropriate control and measurement protocol for the head **16**.

CLAIMS:

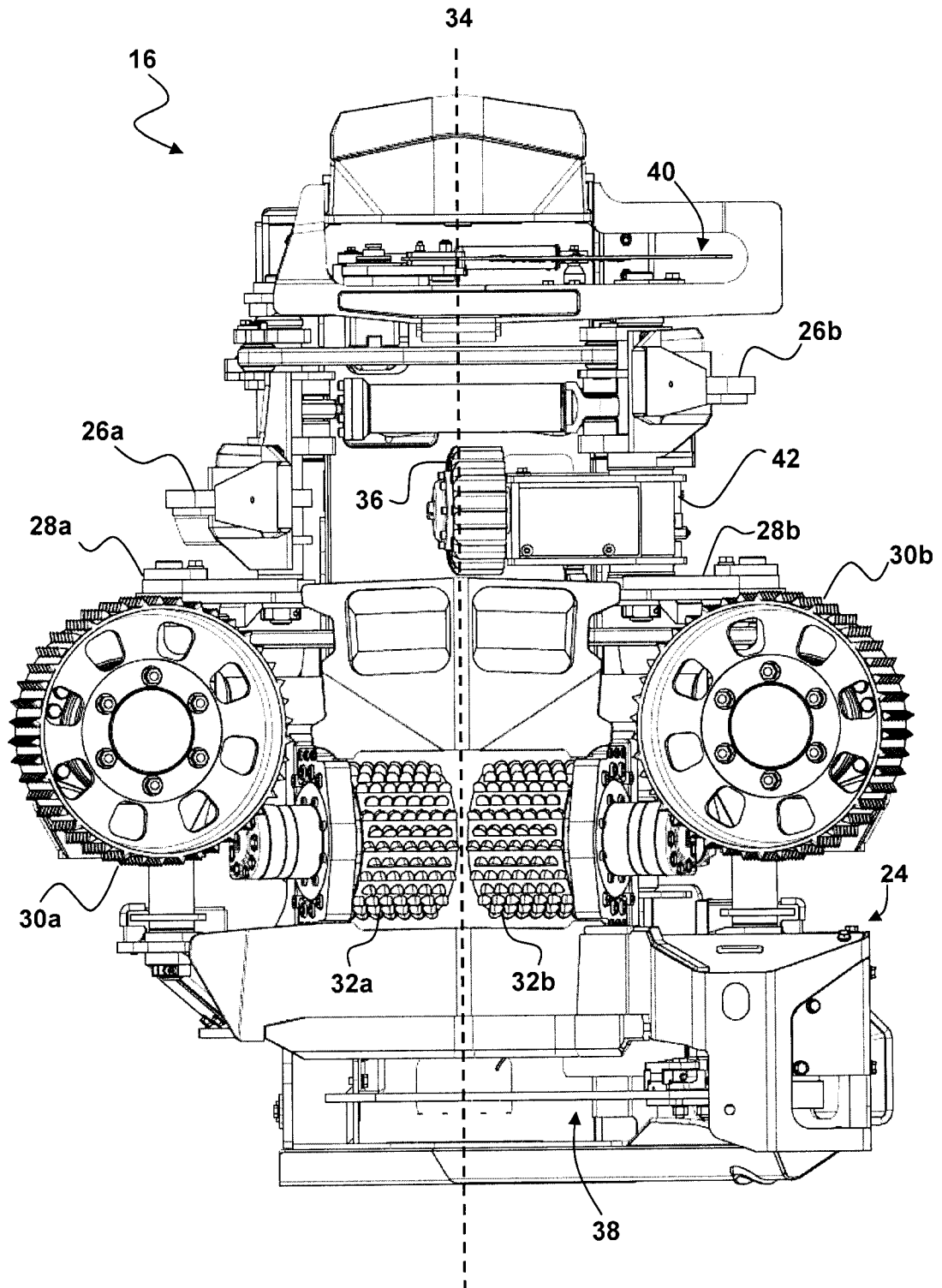
1. A timber-working device, including:
 - a frame;
 - at least one pair of arms moveably connected to the frame, and configured to hold at least one stem to be processed by the timber-working device;
 - a central contactless distance measuring device having a first sensing path extending between the frame and the at least one stem from a substantially central position between the pair of arms, and configured to output a first signal indicative of a first distance between the frame and a frame facing surface of the at least one stem;
 - a first lateral contactless distance measuring device having a second sensing path extending between the frame and the at least one stem from a first side position laterally offset from the substantially central position, and configured to output a second signal indicative of a second distance between the frame and the frame facing surface of the at least one stem; and
 - at least one controller, configured to:
 - receive the signals indicating the first distance and the second distance; and
 - determine the number of stems currently held by the at least one pair of arms based at least in part on the signals;
 - wherein determination of the number of stems currently held by the at least one pair of arms includes comparing the first distance to the second distance, and determining that the number of stems is one if the first distance is less than the second distance.
2. The timber-working device of claim 1, wherein the timber-working device includes a longitudinal feed axis located centrally between the arms.
3. The timber-working device of claim 2, wherein the central contactless distance measuring device is located directly above the feed axis on the frame.

4. The timber-working device of either claim 2 or claim 3, including a second lateral contactless distance measuring device having a second sensing path extending between the frame and the at least one stem from a second side position laterally offset from the substantially central position, and configured to output a third signal indicative of a third distance between the frame and the frame facing surface of the at least one stem.
5. The timber-working device of claim 4, wherein the first lateral contactless distance measuring device is located on a first side of the feed axis of the timber-working device, and the second lateral contactless distance measuring device is located on the opposing side of the feed axis.
6. The timber-working device of any one of claims 1 to 5, wherein the processor is configured to determine a mode of operation for the timber-working device based on the determination of the number of stems currently held by the at least one pair of arms.
7. A method, including:
 - holding at least one stem using at least one pair of arms moveably connected to a frame of a timber-working device;
 - outputting a first signal indicative of a first distance between the frame and a frame facing surface of the at least one stem from a central contactless distance measuring device having a first sensing path extending between the frame and the at least one stem from a substantially central position between the pair of arms;
 - outputting a second signal indicative of a second distance between the frame and the frame facing surface of the at least one stem from a first lateral contactless distance measuring device having a second sensing path extending between the frame and the at least one stem from a first side position laterally offset from the substantially central position;
 - receiving the first signal and the second signal; and
 - determining the number of stems currently held by the at least one pair of arms based at least in part on the first signal and the second signal.

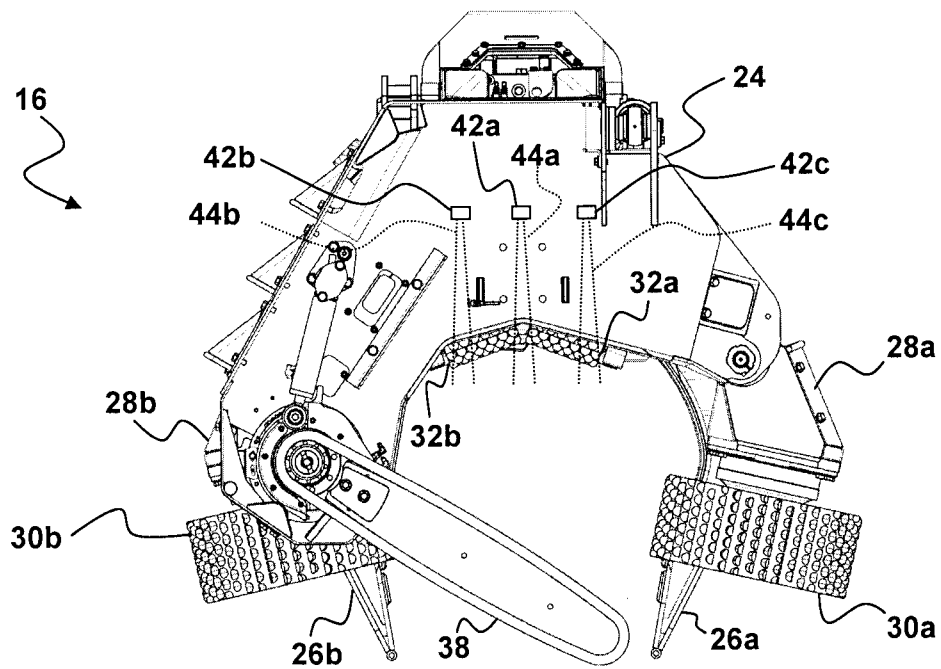
FIG. 1A



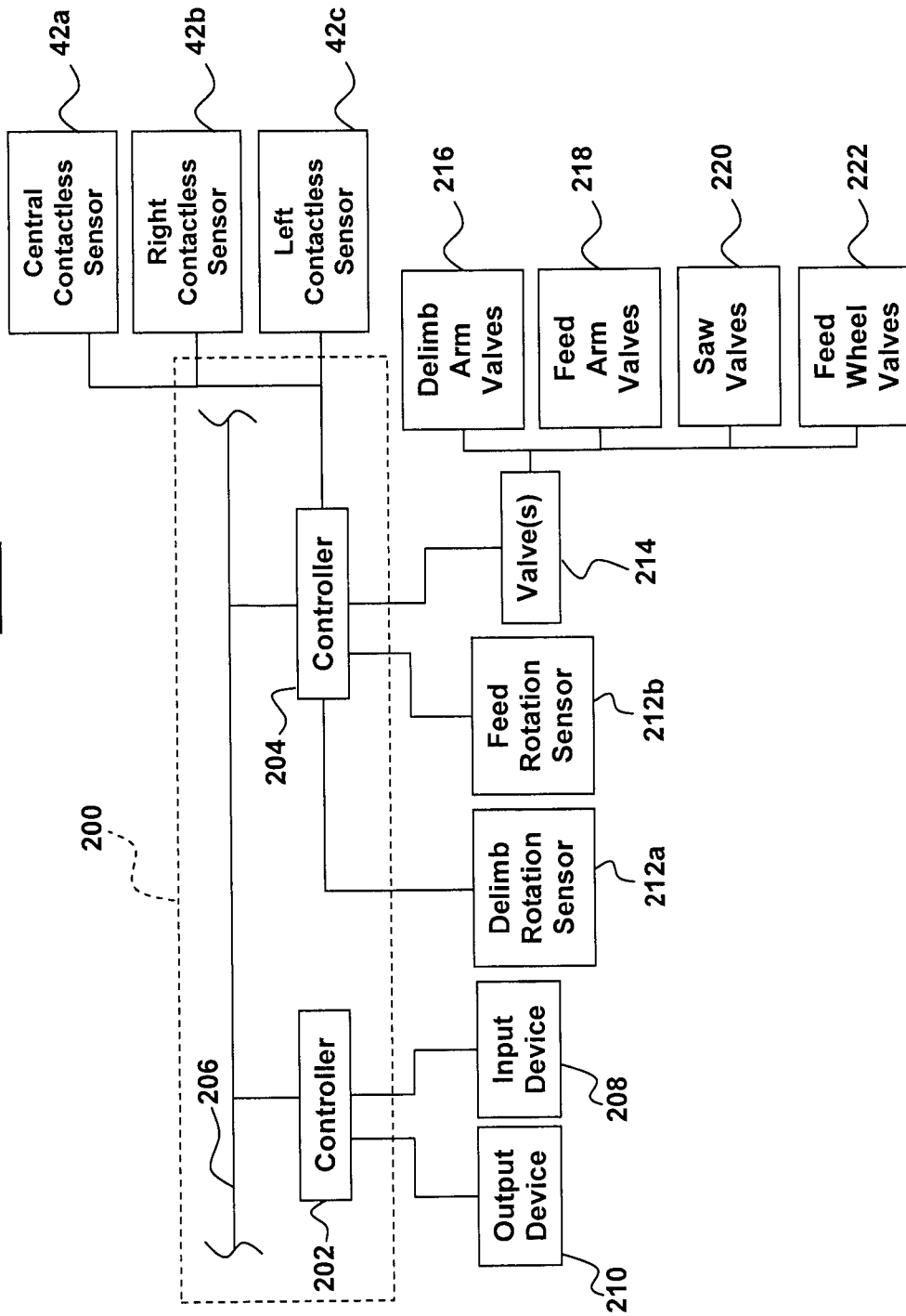
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FIG. 1B

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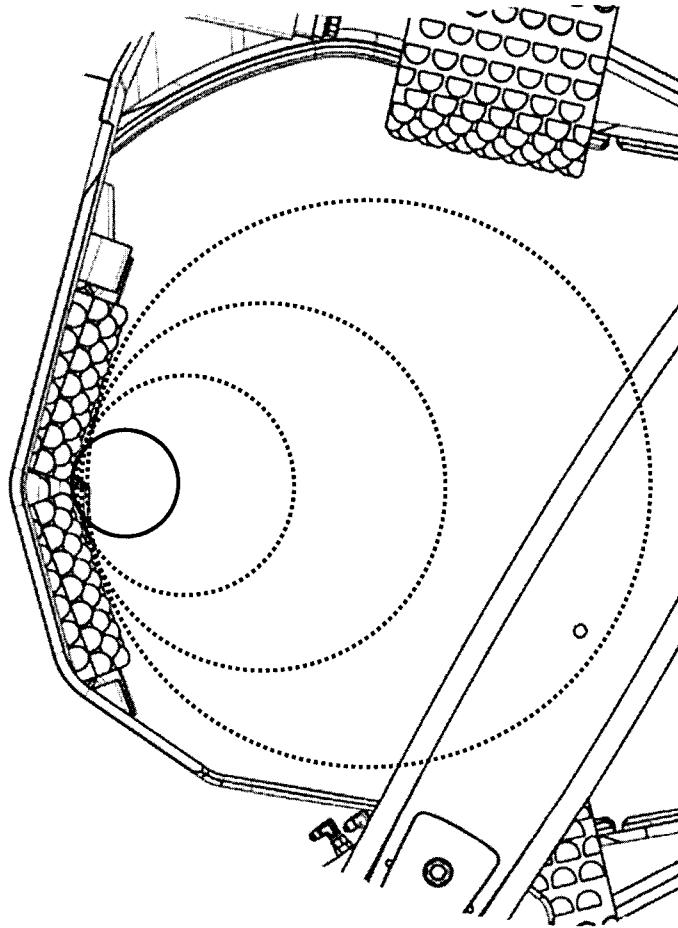
FIG. 1C

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FIG. 2

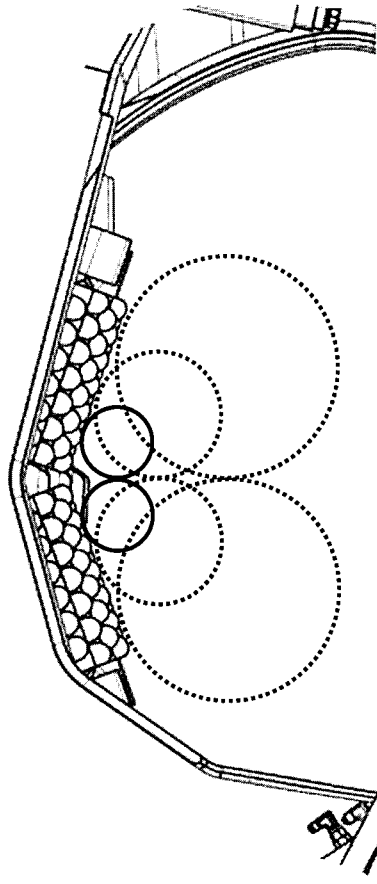
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FIG. 3A



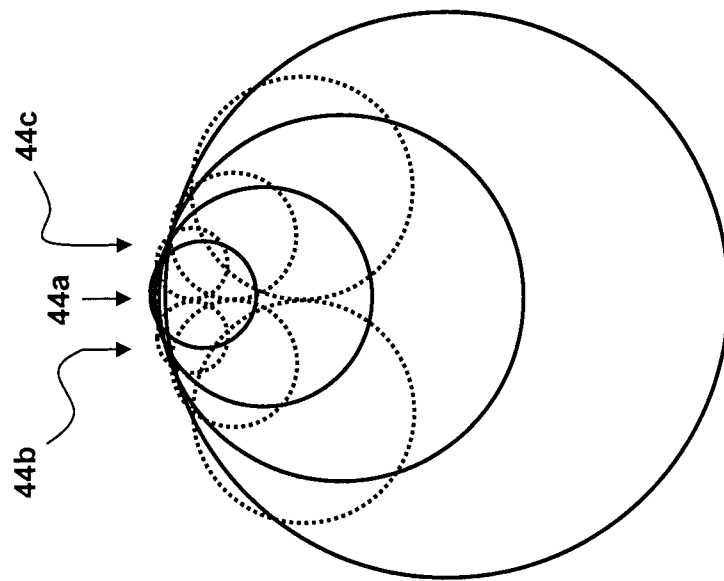
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FIG. 3B



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FIG. 3C



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FIG. 4