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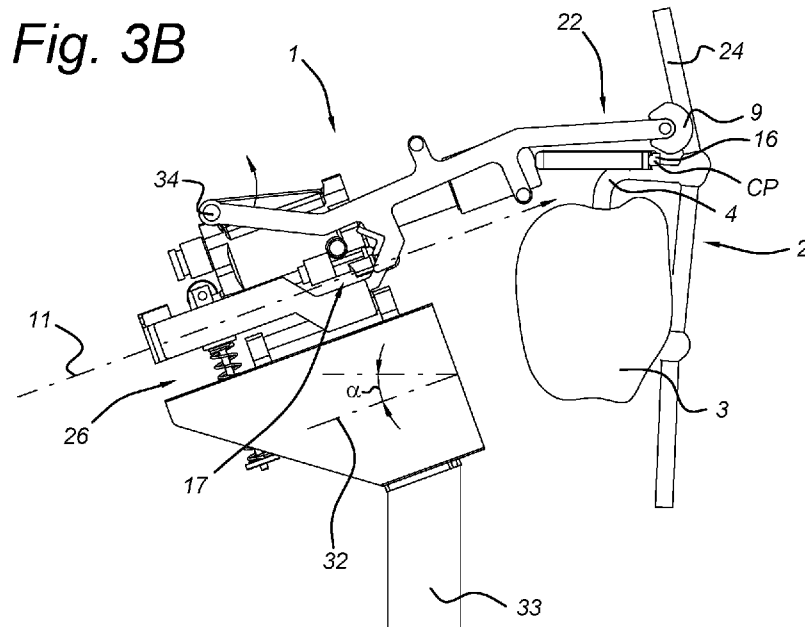
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(54) Title: HARVESTING DEVICE



(57) Abstract: The current invention provides a harvesting device for harvesting crop having a target with a peduncle, the harvesting device comprising: a main frame; a cutting device connected to the main frame and configured to cut the peduncle, an imaging system to determine a position of the target with respect to the main frame, a guide system connected to the main frame for guiding the target towards a cutting position with respect to the main frame; - wherein the guide system comprises a forward guide member configured to be the first contact of the harvesting device with the crop.



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HARVESTING DEVICE

BACKGROUND

5 Devices to assist in the harvesting of fruit or vegetables can help to reduce the manual labor involved in the harvesting process. Various devices have been developed for this, and generally include a tool with a long arm and an end tool to perform the functions of gripping the target fruit and separating the target fruit from the crop like a tree or plant. Typically, these functions are done with one tool consisting of a set of
10 fingers or suction cups that hold the target fruit. Then, a type of cutter cuts the peduncle of the fruit or stem of the vegetable.

 An example of such a device can be found in U.S. Pat. No. 7,810,305, which discloses a suction system to steady the fruit, and then a clamshell cutter which closes around the fruit for both halves of the clamshell to meet and sever the fruit from the tree
15 or plant.

 NL2013066 (B1) discloses a harvesting device for harvesting a target with a peduncle. The device has a main frame; a stabilizing apparatus to connect to the target and hold the target in a fixed orientation with respect to the main frame; a cutting device connected to the main frame; and first and second movement systems. The cutting device
20 has a first cutting portion and a second cutting portion able to rotate around the target and come together at the peduncle, with the first cutting portion having a knife edge. The first movement system is for rotating the second cutting portion around the target so that the second cutting portion rests against the peduncle; and the second movement system is for rotating at least the first cutting portion so that the knife edge cuts through the
25 peduncle.

 In other devices, the gripper, which can be a basket, fingers and/or lips, is used to encircle the target fruit or vegetable and simply twist or pull the fruit or vegetable from the tree or plant. Examples of such devices can be found in JP2002-186332 and FR2530403.

30 A problem with the above devices is that they still cause too much harm and damage to the fruit itself and/or to the crop in general.

SUMMARY

An object of the current invention is to provide a harvesting device that causes less damage to the crop in particular the fruit of the crop.

5 A further object of the current invention is to provide a harvesting device that at least partly solves a problem associated with known harvesting devices.

Still another object of the current invention is to provide an alternative harvesting device.

10 According to a first aspect of the invention, the invention therefore provides a harvesting device for harvesting crop having a target with a peduncle, the harvesting device comprising:

- a main frame;
- a cutting device connected to the main frame and configured to cut the peduncle,
- 15 - an imaging system to determine a position of the target with respect to the main frame,
- a guide system connected to the main frame for guiding the target towards a cutting position with respect to the main frame;
- wherein the guide system comprises a forward guide member configured to
- 20 be the first contact of the harvesting device with a stem portion of the crop, and wherein the cutting device comprises a cutting edge and the forward guide member in a first position with respect to the main frame is arranged adjacent the cutting edge and configured to protect the crop against the cutting edge.

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The harvesting device comprising a guide system having a forward guide member configured to be the first contact with the crop, enables to allow an error between an estimated position of the target and an actual position of the target. Such a position error is always present since targets as e.g. fruit are often occluded by leaves. In other words,

30 when the actual position of the target is within reach of the guide system, in other words a window of operation of the guide system, the target is guided from the actual position towards the cutting position. The cutting position of the target normally differs from the determined position. The determined position is only needed to bring the target within

the window of operation of the guide system. The guide system then guides the target towards the cutting position.

Guiding the target means that the guiding system constrains the target however the guide system and the target are able to move with respect to each other. Thus the guide system does not attach to the target, or grip the target. The guide system may engage any suitable part of the crop, like the stem, or the fruit, or in particular a portion of the stem right above the peduncle. The cutting position refers to a position of the target with respect to the main frame, wherein the target is within reach of the cutting device. The cutting position is determined by the design of the harvesting device. The cutting position is not a position that is determined by the imaging system. In practice, the cutting position CP is a mutual position of a cutting edge of the cutting system and the target of the crop.

The imaging system may be an optical imaging system, however any suitable system will suffice like based on ultrasonic or radar. The imaging system determines an estimated position of the target. The determination will always have an position error compare to the actual position of the target. Such a position error is always present since targets as e.g. fruit are often occluded by leaves. The harvesting device needs to be able to accommodate this position error. Therefore, the harvesting device comprises the guide system having a forward guide member configured to be the first contact with the crop, and not a cutting edge. This enables to allow an error between an estimated position of the target and an actual position of the target. The guide system subsequently moves the target into a cutting position wherein the target can be cut off.

The main frame is configured to mount the harvesting device on a robotic system like a robot arm, with the required Degrees of Freedom.

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In an embodiment of the harvesting device, the forward guide member comprises a beveled face with respect to a forward direction of the harvesting device for guiding the target towards the cutting position while at least the forward guide member moves in the forward direction. The forward guide member moves in unity with the main frame, however it may be conceivable that the forward guide member moves with respect to the main frame of the harvesting device.

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In an embodiment of the harvesting device, the forward guide member comprises opposite beveled faces with respect to the forward direction of the harvesting device for guiding the target towards the cutting position and towards a centre of the harvesting device.

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In an embodiment of the harvesting device, the bevelled face comprises a curvature. The curvature assures a gentle contact between the guiding device and the crop.

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In an embodiment of the harvesting device the forward guide member comprises a catchment area open towards the crop. The catchment area assures a suitable allowable error band for the determined target position TP. The catchment area has a width dimension between 50 to 80 mm, in particular of about 70 mm. This width dimension fits with peppers. It will be clear that the width dimension can be adjusted depending on the target.

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In an embodiment of the harvesting device, the forward guide member is configured to determine a position of the cutting edge in the forward direction with respect to the crop. This enables to define the cutting position within the forward guide member. The position of the cutting edge with respect to the crop can be determined by a pair of stop surfaces of the forward guide member. One stop surface faces towards the crop and contacts the crop while the other stop surface contacts the cutting edge. The stop surfaces can be a pair of opposite stop surfaces.

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In an embodiment of the harvesting device, the guide system is moveably coupled with the main frame and pretensioned in the forward direction towards the target. This enables to move the guide system with respect to the cutting device once the guide system contacts the crop. The pretension of the guide system in the forward direction enables to maintain contact between the guide system and the crop under all circumstances. The pretension does not need to be entirely aligned with the forward direction. The pretension at least has a component in the forward direction.

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In an embodiment, the harvesting device comprises a stop mechanism to hold or release the guide system with respect to the main frame. The stop mechanism provides control with respect to the movability of the guide system which is important since when approaching the crop, a defined position of the guide system with respect to the main frame is required. During release of the cutting blade and during cutting, movement of the guide system with respect to the main frame, more specific the cutting device, is required.

In an embodiment of the harvesting device, the cutting device is moveably connected to the main frame, in particular rotatably connected to the main frame, in particular rotatable around an axis of rotation transverse with respect to the forward direction of the harvesting device. This enables to improve control of cutting forces to the crop. Therefore, the cutting device may be coupled with the main frame through a pretension system.

In an embodiment of the harvesting device, the guiding system is rotatably connected to the main frame, in particular rotatable around an axis of rotation transverse with respect to the forward direction of the harvesting device.

In an embodiment of the harvesting device, the cutting device comprises a cutting device frame, the guiding system comprises a guiding system frame and the main frame, cutting device frame and guiding system frame are series connected. In other words, the harvesting device has a stacked frame configuration. This series connected configuration enables a compact construction of the harvesting device which is important for introducing the harvesting device into crop. In other words, the frontal area in a forward direction is minimized by arranging hinges that connect the frames, and systems at the back of the harvesting device relative to the forward direction.

In an embodiment of the harvesting device, the cutting device comprises an actuator operationally coupled with the cutting edge. Because of the presence of the actuator, cutting action does not only rely on movement of the harvesting device itself. The actuator may cause vibration of the cutting edge or other suitable movement of the cutting edge.

In an embodiment of the harvesting device, the cutting device and the guide system comprise a common forward end section that projects from the main frame over at least 150 mm in the forward direction, and wherein the forward end section has a frontal area below 1500 mm². The cutting device and the guide system comprising a common forward end section that projects from the main frame enables to minimize contact between the harvesting device and the crop which in turn minimizes damage to the crop. It will be clear that the dimensions of the projection may vary depending on the type of target.

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In an embodiment of the harvesting device, the imaging system has an optical axis under an angle α with respect to the horizontal of between 10° to 30°, in particular about 20°. The imaging system having an optical axis under an angle α of about 20° with respect to the forward direction enables to make a better estimation of the position of the target. The reason therefore is that if the target is occluded, it is mostly at the top of the target at the peduncle.

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The invention also relates to an end effector for a robotic system comprising a harvesting device according to the invention, as well as to a robotic system comprising such an end effector.

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According to a further aspect of the invention, the invention therefore provides a use of harvesting device according to the invention, comprising the steps of;

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- determining a position **TP** of a centre of the target,
- determining a position **SP** of at least a stem portion holding the target,
- defining a trajectory for the harvesting device from an initial position **IP** towards an end position **EP** wherein the guide system first contacts with at least a stem portion of the crop based on the determined positions of the target and the stem portion **TP**, **SP**,
- guiding the target towards the cutting position.

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The method comes with the same benefits as described in connection with the harvesting device. In addition, it is an advantage that the trajectory can be defined based on minimum amount of data, that is only two positions, **TP** and **SP**. Once contact

has been made between the guide system of the harvesting device and the crop at the end of the trajectory, the target is guided towards the cutting position by additional limited movement of the harvesting device while the guide system and the target maintain contact.

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In an embodiment of the use, in the first contact position, the forward guide member and the cutting edge are positioned right above a peduncle of a target. This is an ideal starting situation to centre the target and its peduncle with respect to the cutting device and to initiate cutting action by moving the harvesting device downwards.

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In an embodiment of the use, the trajectory comprises a linear end section of between 50 to 300 mm. This linear end section, even more reduces damage to the crop. It will be clear that the length of the end section may vary depending on the type of target.

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In an embodiment, the use comprises defining a trajectory for the harvesting device towards the target based on a reference model of the target. The reference model includes at least a mean position vector between the centre of the target and the peduncle, in particular a weak spot of the peduncle where the target will be cut off when the target is in cutting position with respect to the harvesting device. The weak spot is often referred to as the abscission zone. The mean position vector may be dependent on the type of target, the time of the year, the season etc. The reference model may take the form of a look up table made available on board in local memory or through access to a data network.

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In an embodiment of the use, the guiding the target towards the cutting position comprises guiding the target towards the cutting position in a direction transverse with respect to the forward direction. This enables to centre the target and its peduncle with respect to the cutting device and optimizes the position of the target with respect to the cutting device.

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In an embodiment, the use comprises, after completion of the trajectory, moving the cutting device downwards along the stem portion before and/or while cutting the

target from the stem portion of the crop. During this step, the guide system maintains contact with the stem portion but is able to move freely along the stem portion.

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BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1a shows a perspective view of a harvesting device according to the invention.

Fig. 2 shows an exploded perspective view of the harvesting device according to fig. 1.

10 Fig. 3A and 3B show different steps of a use of the harvesting device according to fig. 1.

Fig. 4A-D show a number of embodiments of a forward guide member of the harvesting device according to fig. 1.

15 Fig. 5 shows a schematic side view of the crop that can be harvested by the harvesting device according to fig. 1. position.

Fig. 6 shows a top view of fig. 5.

DETAILED DESCRIPTION

20 The harvesting device 1 will be described referring to fig. 1 and fig. 2. The harvesting device is suitable for harvesting crop 2 having a target 3 with a peduncle 4. Examples of targets 3 with a peduncle are peppers and cucumber. These fruits have in common that they suspend down from a peduncle. Such a peduncle 4 has a weakening close to where the peduncle 4 branches out from the stem portion 24. The weakening is
25 a suitable place to cut off the target 3 from the stem portion 24.

The harvesting device 1 comprises a main frame 5. The main frame 5 is the central support for the structural parts of the harvesting device 1. Also, the main frame 5 is the interface to a robotic system that is not described nor shown.

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The harvesting device 1 comprises a cutting device 6. The cutting device 6 is connected to the main frame 5. The cutting device 6 is configured to cut the peduncle 4 of the target 3. Here, the cutting device 6 is moveably connected to the main frame 5.

The cutting device 6 is rotatably connected to the main frame 5. The cutting device 6 is rotatable around an axis of rotation 18. The axis of rotation extends transverse with respect to the forward direction 11 of the harvesting device 1. Here, the cutting device 6 is coupled with the main frame 5 through a pretension system 26. The pretension system 26 provides an improved control regarding cutting forces and allows to accommodate position errors. The pretension system 26 may comprise locking means (not shown) to lock or release the cutting device 6 with respect to the main frame 5. The cutting device 6 comprises a cutting device frame 20. The cutting device frame 20 is rotatably connected to the main frame 5 to make the cutting device 6 rotatable. The cutting device 6 comprises an actuator 28. The actuator 28 is operationally coupled with the cutting edge 16. In this case, the actuator 28 is a vibratory type actuator 28.

The harvesting device 1 comprises an imaging system 7. The imaging system 7 serves the purpose to determine a position **TP** of the target 3 with respect to the main frame 5. The position **TP** is a vector. The imaging system 7 is a camera system in this case. The optical axis 32 of the imaging system 7 extends under an angle α of about 20° with respect to a forward direction 11 of the harvesting device 1.

The harvesting device 1 comprises a guide system 8. The guide system 8 is connected to the main frame 5. The guide system 8 is configured for guiding the target 3 towards a cutting position CP with respect to the main frame 5 as can be seen in fig. 3B. The guide system 8 comprises a forward guide member 9. The forward guide member is configured to be the first contact of the harvesting device 1 with the crop 2. In this case, the forward guide member 9 is configured to first contact a stem portion 24 of the crop 2.

The forward guide member 9 comprises a bevelled face 10. The face 10 is bevelled with respect to the forward direction 11. Therefore, while the harvesting device 1 moves towards the crop 2 in the forward direction 11, the forward guide member 9 moves the target 3 towards a cutting position, here at a middle plane 13 of the harvesting device 1.

In this case, the forward guide member 9 comprises opposite bevelled faces 10, 12. Both faces 10, 12 are bevelled with respect to the forward direction 11. The forward guide member 9 has a symmetrical configuration with respect to the middle plane 13 of

the harvesting device 1. Therefore, the forward guide member 9 guides the target 3 always towards the middle plane 13 of the harvesting device 1. Other details of the forward guide member 9 are described on the basis of fig. 4A-4D.

5 The cutting system comprises a cutting edge 16. The forward guide member 9 is arranged adjacent the cutting edge 16 as can be best seen in fig. 1. The forward guide member 9 is configured to protect the crop 2 against the cutting edge 16. The shown position in fig. 1 is referred to as the first position of the guide system 8 with respect to the main frame 5. The forward guide member 9 is configured to determine a position of
10 the cutting edge 16 in the forward direction 11 with respect to the crop 2, more precisely, the stem portion 24 of the crop 2.

 The guiding system 8 is moveably coupled with the main frame 5. Here, the guiding system 8 is rotatably connected to the main frame 5. The guiding system 8 is rotatable around an axis of rotation 34. The axis of rotation 34 extends transverse with
15 respect to the forward direction 11 of the harvesting device 1. The guiding system 8 is pretensioned in the forward direction 11 towards the target 3. Therefore, the guiding system 8 comprises a stop mechanism 17 to hold or release the guide system 8 with respect to the main frame. The stop mechanism 17 pretensions the guide system 8 towards the first position. As wished, the stop mechanism 17 can hold or release the
20 guide system 8 with respect to the main frame 5. The rotation of the guiding system 8 is limited by limiting means, in this case opposite stop bars 30, 31. The stop bars 30, 31 assure that the guiding system 8, in particular the guiding system frame 21 thereof, stays in reach of the stop mechanism and can always be forced back to the first position of the guide system 8 with respect to the main frame 5.

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 The guiding system 8 comprises a guiding system frame 21. The guiding system frame 21 is rotatably connected to the main frame 5 to make the guiding system 8 rotatable. The guiding system frame 21 is rotatably connected to the main frame 5 through the cutting device frame 20. In other words, the main frame 5, cutting device
30 frame 20 and guiding system frame 21 are series connected.

 The cutting device 6 and the guide system 8 comprises a common forward end section 22. The common forward section 22 projects from the main frame. The common forward section 22 projects from the main frame 5 over about 150 mm in the forward

direction 11. The frontal area of the forward end section 23 in the forward direction 11 is below about 1500 mm².

Fig. 3A and 3B show different steps of a use of the harvesting device 1 according to fig. 1. To use the harvesting device 1, the device 1 is mounted as an end effector on a robotic system 33. It will be clear that the robotic system is only partly and schematically shown. The robotic system 33 is able to move the harvesting device 1 in all required degrees of freedom.

The use of the harvesting device 1 comprises the steps of determining the position TP of a centre of the target 3. The position TP of the centre of the target 3 is here a x, y, z, coordinate in space. The position TP of the centre of the target 3 is determined using the imaging system 7. Determining the position TP of the centre of the target 3 can be done once or continuously while the harvesting device 1 approaches the crop 2. The position TP of the centre of the target 3 is determined before the harvesting device 1 contacts the crop 2, in particular the target 3.

Here, the use of the harvesting device 1 comprises the step of determining a position SP of a stem portion 24 that holds the target 3. In principle, a position of an adjacent stem portion may suffice as well. The position of the stem portion 24 is here the x,y position of the stem portion 24 in the horizontal plane when seen from the top, like shown in fig. 6.

The use of the harvesting device 1 comprises the step of defining a trajectory 25 for the harvesting device. The harvesting device 1 starts from an initial position IP, which may be a position in a path between lines of crop 2. The harvesting device 1 starts from the initial position IP and moves towards an end position EP like shown in fig. 6. When the harvesting device 1 is in the end position EP, the guide system first contacts with the stem portion 24 of the crop 2. The trajectory 25 is based on the determined positions TP, SP of the target 3 and the stem portion 24. Obviously, there can be a lot more to base a trajectory on, however basing the trajectory only on the determined positions TP, SP of the target 3 and the stem portion 24 turns out to be sufficient and is beneficial in terms of amount of data processed and processing power.

The use of the harvesting device 1 comprises the step of guiding the target 3 towards the cutting position CP. The cutting position CP refers to a mutual position of the cutting edge 16 of the cutting system 6 and the target 3 of the crop 2. In the cutting

position, the cutting edge 16 cuts off the target 3 from the stem portion 24 when the cutting system 6 is activated by the actuator 28 and/or movement of the harvesting device 1 itself.

The guiding of the target 3 towards the cutting position CP may comprise defining the movement trajectory 25 for the harvesting device 1 towards the target 3 in the forward direction 11 in combination with guiding the target 3 towards the cutting position in a direction 27 transverse with respect to the forward direction 11. Here, this guiding of the target 3 in the transverse direction 27 is caused by the opposite bevelled faces 10, 12 of the forward guide member 9, described referring to figures 4A-D, in combination with forward movement of the harvesting device 1.

As can be best seen in fig. 3A, in the end position EP, the forward guide member 9 and the cutting edge 16 are positioned right above a peduncle 4 of a target 3. The forward guide member 9 contacts the stem portion 42 above the peduncle 4. The cutting edge 16 contacts or is adjacent the forward guide member 9. Therefore, the forward guide member 9 determines the position of the cutting edge 16 with respect to the stem portion 24. The knife edge 16 is in cutting position, which is at the abscission zone of the peduncle 4 of the target 3. The abscission zone is a commonly known spot of a peduncle 4 that is weaker at a certain point of time.

In this case, the trajectory comprises a linear end section 35 of between 50 to 300 mm, as can be best seen in fig. 6.

The use of the harvesting device 1 may comprise the step of defining the movement trajectory for the harvesting device 1 towards the target 3 also based on a reference model of the target 3. The reference model at least includes average dimensions of the target. For example with respect to the determined Target position TP, the end position with EP of the trajectory can be partly based on half an average height h_T of the reference model plus an average height of the peduncle 4 h_p plus a safety margin of between 10 to 20 mm.

In this case, the use of the harvesting device 1 comprises after completion of the trajectory 25, moving the cutting device 6 downwards along the stem portion 24 before and/or while cutting the target 3 from the stem portion 24 of the crop 2. This moving downwards of the cutting device 6 involves release of the guide system 8 with respect to

the main frame 5 by the stop mechanism 17. The guide system 8 is therefore able to hinge away from the cutting device 6 which releases the cutting edge 16. In fig. 3B the guide system 8 is shown when hinged upward with respect to the cutting device 6. In addition, the pretension system 26 is able to release the cutting device 6 in order to allow the pretension system to control cutting forces exerted by the cutting device 6 to the crop 2.

Fig. 4A-D show a number of embodiments of a forward guide member of the harvesting device according to fig. 1.

The forward guide member 9 of fig. 4A comprises opposite bevelled faces 10, 12. Both faces 10, 12 are bevelled with respect to the forward direction 11. The forward guide member 9 has a symmetrical configuration with respect to the middle plane 13 of the harvesting device 1. Therefore, the forward guide member 9 guides the target 3 always towards the middle plane 13 of the harvesting device 1.

The forward guide member 19 of fig. 4B has a bevelled face that comprises a curvature 14. The forward guide member 19 comprises a catchment area 15. The catchment area 15 is open towards the crop 2, that is open in the forward direction 11 of the harvesting device 1. The catchment area 15 has a width dimension W between 50 to 80 mm, in particular of about 70 mm.

The forward guide member 29 of fig. 4C shows a forward guide member 29 that is not axisymmetric like the ones shown in fig. 4A and 4B. Also the curvature is different compared with fig. 4B.

The forward guide member 39 of fig. 4C shows also a forward guide member 39 that is not axisymmetric.

Fig. 5 shows a schematic side view of the crop 2 that can be harvested by the harvesting device 1 according to fig. 1. The target 3 has a central target position TP. The target 3 suspends from a peduncle 4. The peduncle 4 branches off from a stem portion 24. The position of the stem portion 24 is here the x,y position of the stem portion 24 in the horizontal plane when seen from the top, like shown in fig. 6.

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Fig. 6 shows a top view of fig. 5. An example of a defined trajectory 25 for the harvesting device 1 is schematically shown. The harvesting device 1 starts from an initial position IP, which may be a position in a path between lines of crop 2. The

harvesting device 1 starts from the initial position IP and moves towards an end position EP. In this case, the trajectory comprises a linear end section 35 of between 50 to 300 mm. The orientation of the linear end section 35 can be determined by the target position TP of the target 3 and the position SP of the stem portion 24. The height, z coordinate of the end position EP, is based on the target position TP plus half an average height h_T of the reference model of the target 3 plus an average height of the peduncle 4 h_p plus a safety margin of between 10 to 20 mm depending on the type of target.

10 While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from
15 the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiments disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

CLAIMS

1. Harvesting device (1) for harvesting crop (2) having a target (3) with a peduncle (4), the device comprising:
 - 5 - a main frame (5);
 - a cutting device (6) connected to the main frame and configured to cut the peduncle,
 - an imaging system (7) to determine a position (**TP**) of the target with respect to the main frame,
 - 10 - a guiding system (8) connected to the main frame for guiding the target towards a cutting position (**CP**) with respect to the main frame;wherein the guide system comprises a forward guide member (9) configured to be the first contact of the harvesting device with a stem portion of the crop, and wherein the cutting device comprises a cutting edge (16) and the forward guide member in a first position with respect to the main frame is arranged adjacent the cutting edge and
15 configured to protect the crop against the cutting edge.
2. Harvesting device according to claim 1, wherein the forward guide member comprises a beveled face (10) with respect to a forward direction (11) of the
20 harvesting device for guiding the target towards the cutting position.
3. Harvesting device according to claim 2, wherein the forward guide member comprises opposite beveled faces (10, 12) with respect to the forward direction of the harvesting device for guiding the target towards the cutting position and
25 towards a centre (13) of the harvesting device.
4. Harvesting device according to claim 2 or 3, wherein the beveled face comprises a curvature (14).
- 30 5. Harvesting device according to any of the preceding claims, wherein the forward guide member comprises a catchment area (15) open towards the crop and having a width dimension (W) between 50 to 80 mm, in particular of about 70 mm.

6. Harvesting device according to claim 5, wherein the forward guide member is configured to determine a position of the cutting edge in the forward direction with respect to the crop.
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7. Harvesting device according to any of the preceding claims, wherein the guide system is moveably coupled with the main frame and pretensioned in the forward direction towards the target.
- 10 8. Harvesting device according to any of the preceding claims, comprising a stop mechanism (17) to hold or release the guide system with respect to the main frame.
- 15 9. Harvesting device according to any of the preceding claims, wherein the cutting device is moveably connected to the main frame, in particular rotatably connected to the main frame, in particular rotatable around an axis of rotation (18) transverse with respect to the forward direction of the harvesting device.
- 20 10. Harvesting device according to any of the preceding claims 7-9, wherein the guiding system is rotatably connected to the main frame, in particular rotatable around an axis of rotation (34) transverse with respect to the forward direction of the harvesting device.
- 25 11. Harvesting device according to any of the preceding claims, wherein the cutting device comprises a cutting device frame (20), the guiding system comprises a guiding system frame (21) and the main frame, cutting device frame and guiding system frame are series connected.
- 30 12. Harvesting device according to any of the preceding claims 5-10, wherein the cutting device comprises an actuator (28) operationally coupled with the cutting edge.
13. Harvesting device according to any of the preceding claims, wherein the cutting device and the guide system comprise a common forward end section (22) that

projects from the main frame in particular over at least 150 mm in the forward direction, and wherein in particular the forward end section has a frontal area (23) below 1500 mm².

- 5 14. Harvesting device according to any of the preceding claims, wherein the imaging system has an optical axis (32) under an angle α with respect to the horizontal of between 10° to 30°, in particular about 20°.
- 10 15. End effector for a robotic system comprising a harvesting device according to any of the preceding claims.
16. Robotic system comprising the end effector according to claim 15.
- 15 17. Use of harvesting device according to any preceding claim 1-14, comprising the steps of;
- determining a position (**TP**) of a centre of the target,
 - determining a position (**SP**) of at least a stem portion (24) holding the target,
 - defining a trajectory (25) for the harvesting device, from an initial position (**IP**) towards an end position (**EP**) wherein the guide system first contacts with at least a stem portion of the crop, based on the determined position(s) of the target and optionally the stem portion (TP, SP).
 - guiding the target towards the cutting position.
- 20
- 25 18. Use according to claim 17, wherein in the end position (EP), the forward guide member and the cutting edge are positioned right above a peduncle of a target.
19. Use according to claim 17 or 18, wherein the trajectory comprises a linear end section (35) of between 50 to 300 mm.
- 30 20. Use according to any of the preceding claims 17-19, comprising defining a trajectory for the harvesting device towards the target based on a reference model of the target.

21. Use according to any of the preceding claims 17-20, comprising guiding the target towards the cutting position in a direction transverse with respect to the forward direction trajet.

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22. Use according to any of the preceding claims 17-21, comprising after completion of the trajectory, moving the cutting device downwards along the stem portion before and/or while cutting the target from the stem portion of the crop.

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Fig. 1

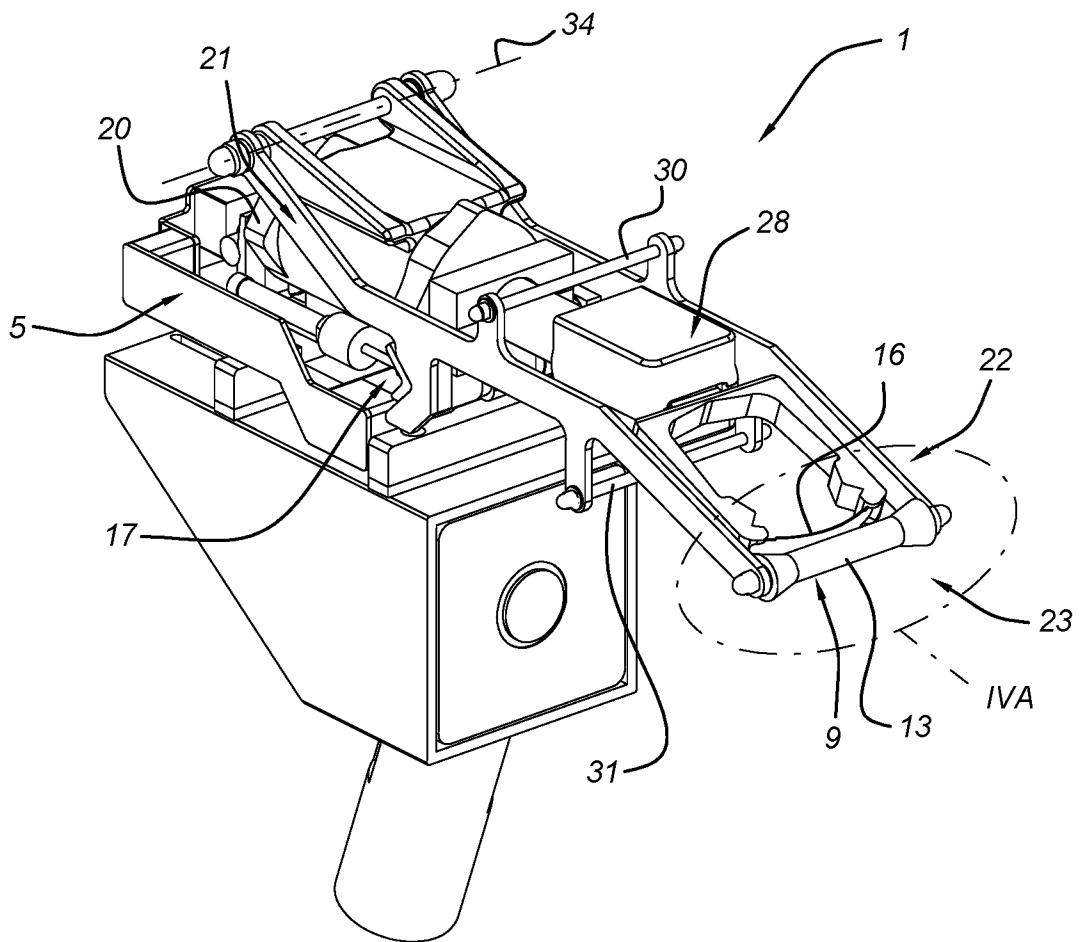


Fig. 2

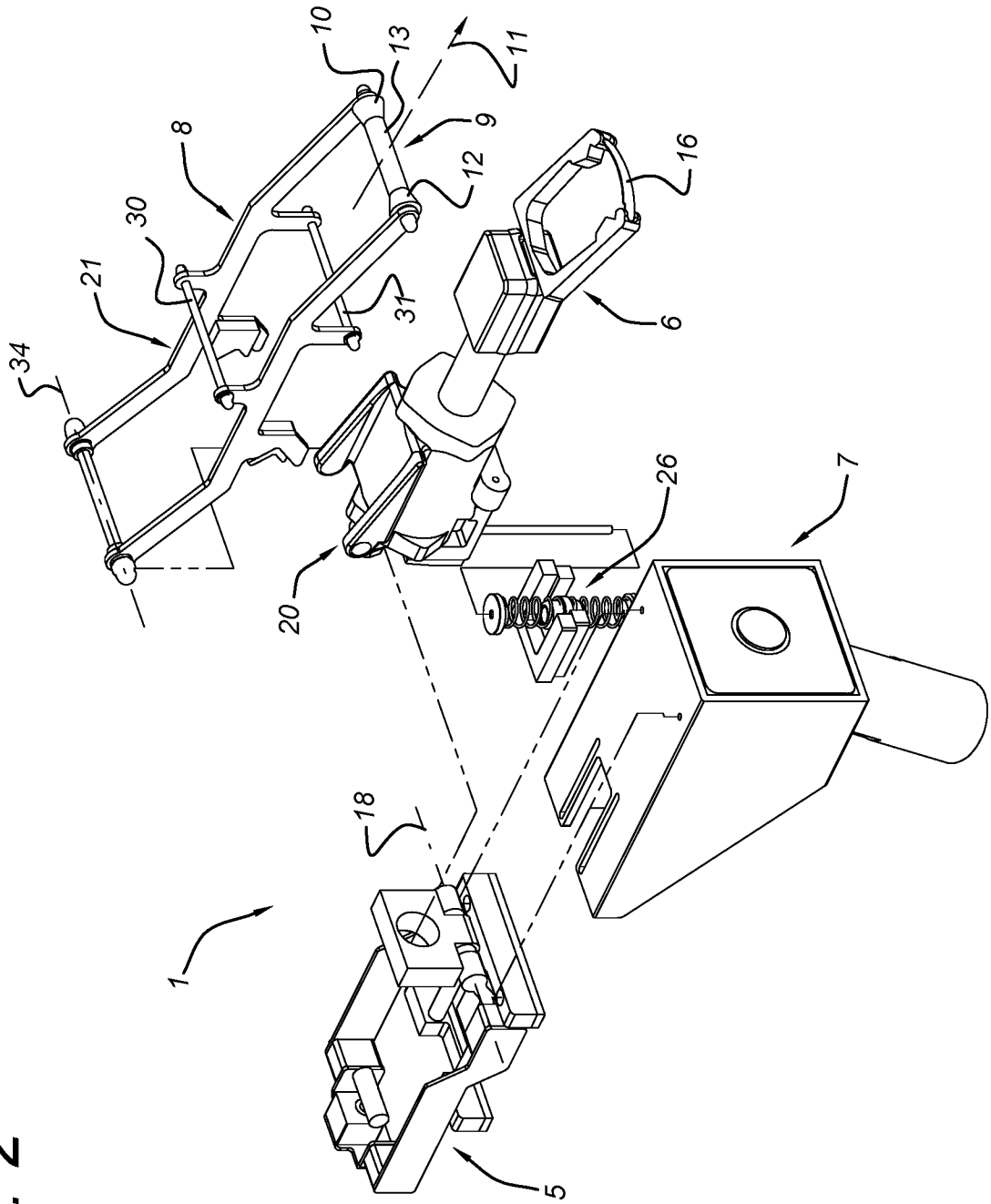


Fig. 3A

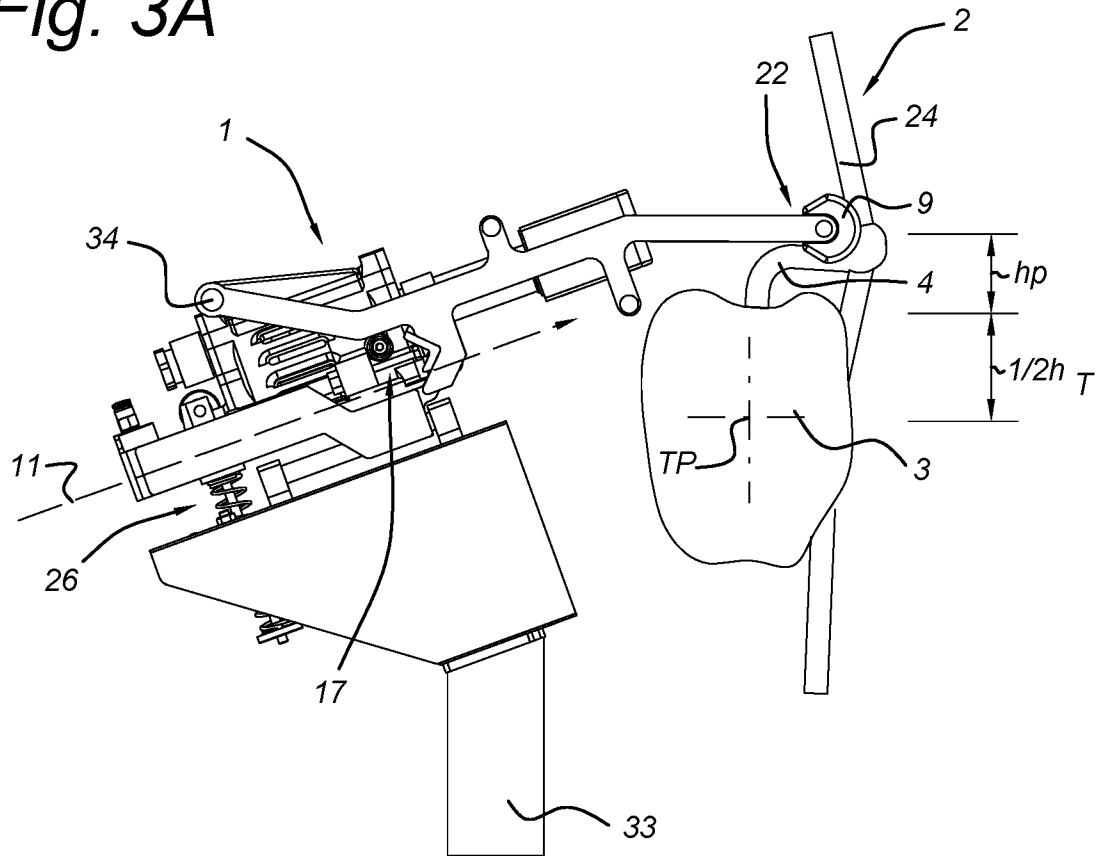


Fig. 3B

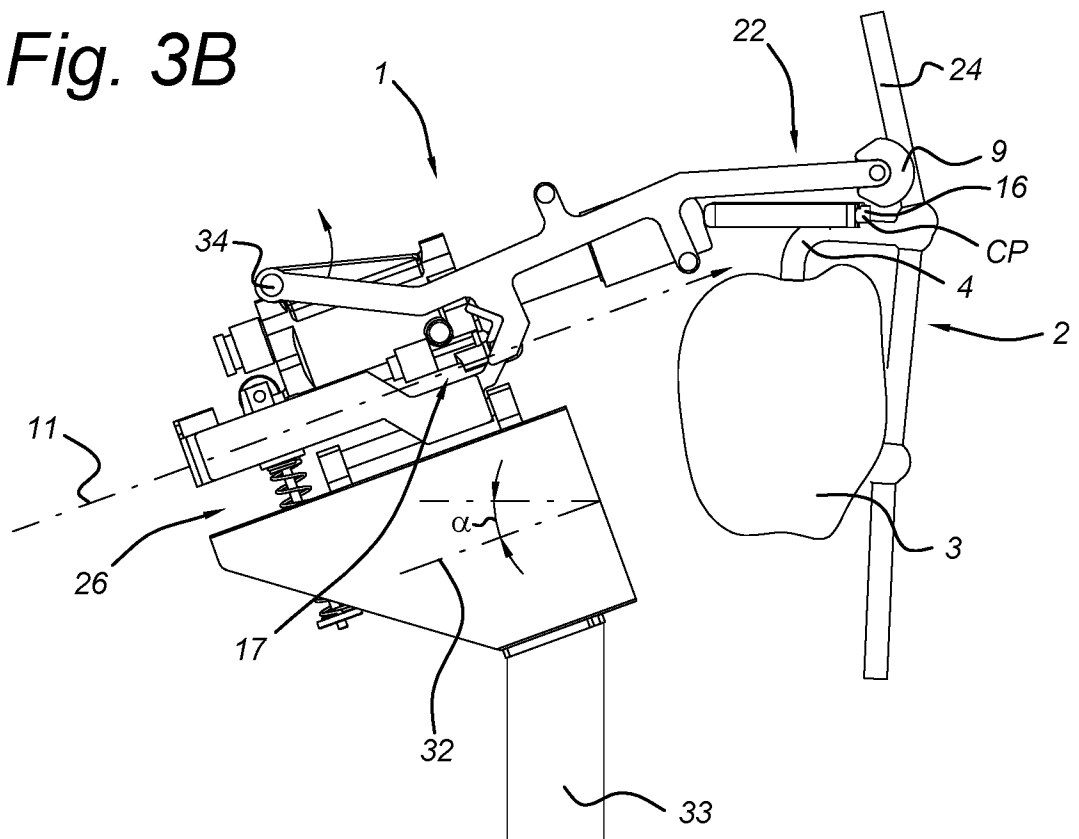


Fig. 4A

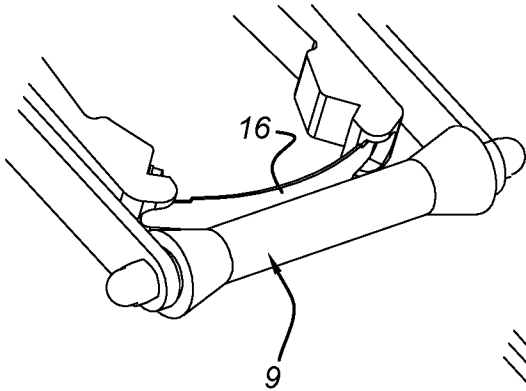


Fig. 4B

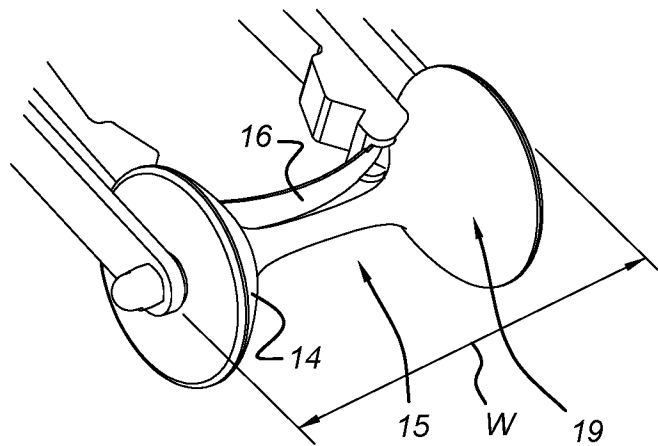


Fig. 4C

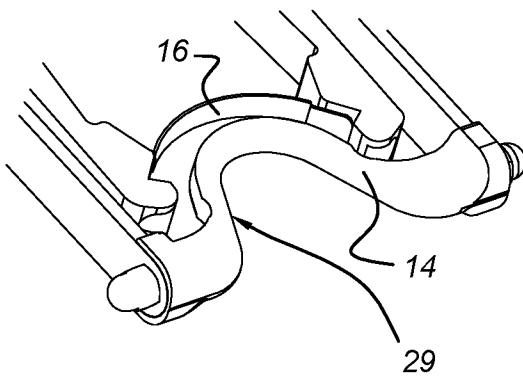


Fig. 4D

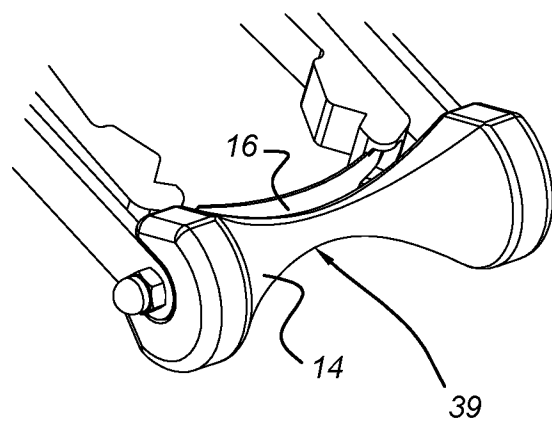


Fig. 5

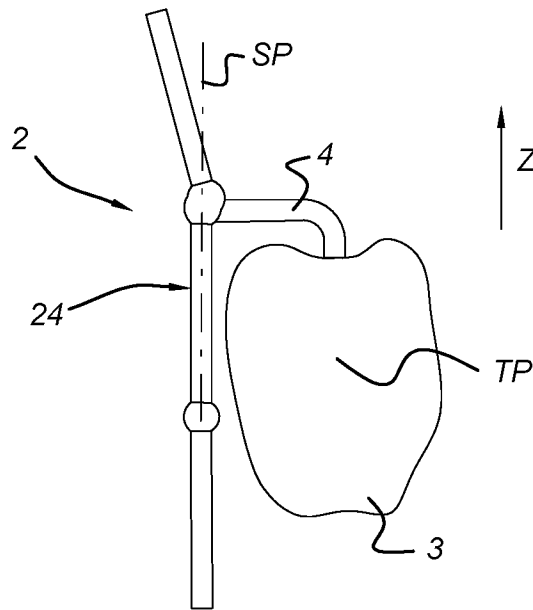
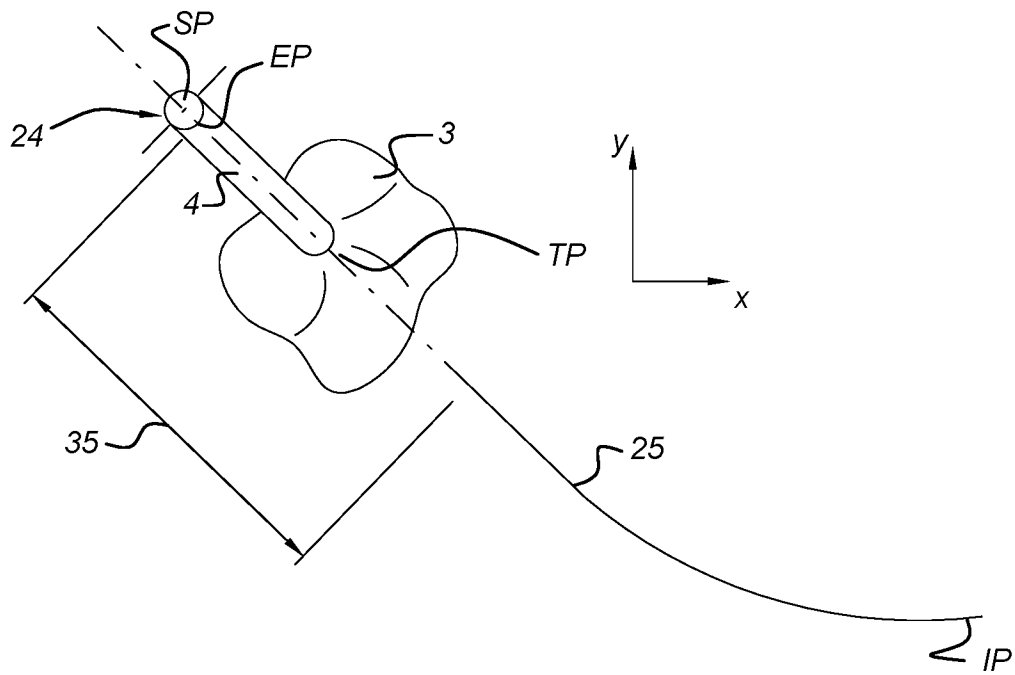


Fig. 6



INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2019/050396

A. CLASSIFICATION OF SUBJECT MATTER
INV. A01D46/30
ADD.
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)
A01D
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	NL 2 013 066 B1 (STICHTING DIENST LANDBOUWKUNDIG ONDERZOEK [NL]) 11 May 2016 (2016-05-11) figures 1, 2 page 4, line 21 - line 32 -----	1,6-10
X A	WO 2018/087546 A1 (DOGTUOTH TECH LIMITED [GB]) 17 May 2018 (2018-05-17) figures 20-27 page 22, line 10 - line 15 page 23, line 7 - line 19 -----	1,17-20 21,22
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Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"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</p> <p>"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</p> <p>"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</p> <p>"&" document member of the same patent family</p>
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Date of the actual completion of the international search 3 September 2019	Date of mailing of the international search report 11/09/2019
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Holtermann, Timm
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INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2019/050396

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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International application No

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