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(72) Inventors:
• **Lindholm, Jan**
79023 Svärdsjö (SE)
• **Lindholm, Thomas**
79024 Toftbyn (SE)
• **Lindholm, Martin**
79153 Falun (SE)

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(74) Representative: **Heimdal, Pär**
Heimdal Patent AB
Hökarvägen 4
129 41 Hägersten (SE)

(71) Applicant: **Limako Teknik AB**
79147 Falun (SE)

(54) **ATTACHMENT MODULE, EXCAVATOR ARM, EXCAVATOR, AND METHOD OF ROTATING A TOOL RELATIVE TO EXCAVATOR ARM**

(57) An attachment module (1) is disclosed configured to attach a tool (2) to a distal end (3') of an excavator arm (3). The attachment module (1) comprises an arm section (5) and a tool section (6). The tool section (6) is rotatably arranged relative to the arm section (5) around a rotation axis (Ra). The attachment module (1) comprises a locking assembly (7) controllable between a locked state and an unlocked state in which the locking assembly

(7) unlocks the tool section (6) from the arm section (5) such that the tool section (6) is free to rotate relative to the arm section (5) around the rotation axis (Ra). The present disclosure further relates to an excavator arm (3), an excavator machine (4), a method (100) of rotating a tool (2) relative to an excavator arm (3), a computer program, and a computer-readable medium (200).

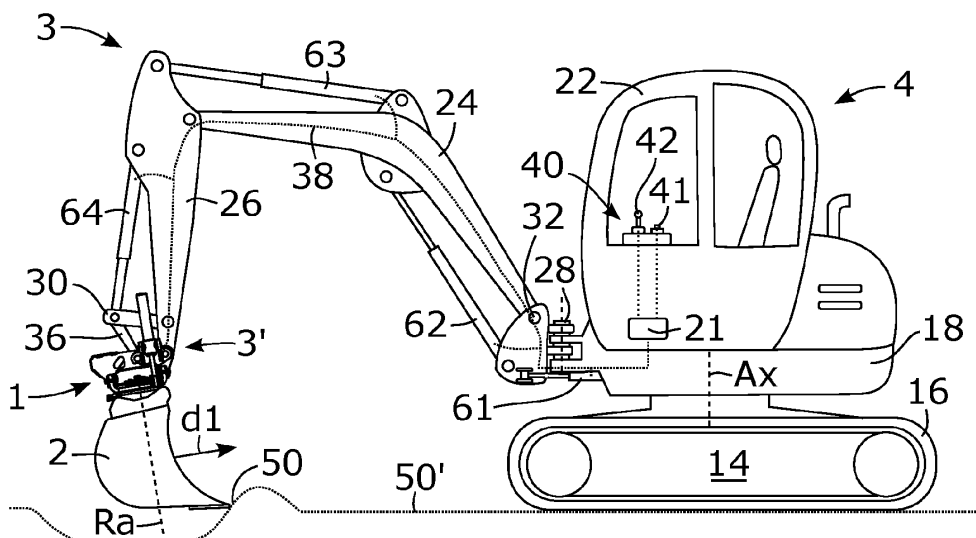


Fig. 1

Description

TECHNICAL FIELD

[0001] The present disclosure relates to an attachment module configured to attach a tool to a distal end of an excavator arm. The present disclosure further relates to an excavator arm, an excavator comprising an excavator arm, a method of rotating a tool relative to an excavator arm of an excavator, a computer program, and a computer-readable medium.

BACKGROUND

[0002] Excavators and backhoes are examples of excavator machines which use an excavator arm and a tool, such as a bucket, attached to a distal end of the excavator arm to perform various tasks such as digging, levelling, performing forestry work, demolition, and the like. An excavator is usually a heavy construction equipment comprising a cab for an operator on a rotating platform known as an upper structure. The upper structure can be arranged on an undercarriage with tracks or wheels. A backhoe, also called rear actor or back actor, is a type of excavating equipment typically mounted on the back of a tractor or front loader.

[0003] The excavator arm of an excavator machine is normally powered by a number of hydraulic cylinders such that the distal end of the excavator arm can be moved to perform a task with a tool attached to the distal end of the excavator arm. The excavator arm normally comprises a tool attachment section for a tool at a distal portion of the excavator arm to which a tool, such as a bucket can be arranged. An excavator arm typically comprises a so-called boom which is an arm section closest to the vehicle, and a so-called stick which is attached to the boom. The tool attachment section is usually attached to the stick.

[0004] Excavator machines, such as excavators and backhoes, come in various sizes and prize ranges. Most excavator machines can be provided with an excavator arm capable of rotating the tool attachment section through 360 degrees relative to the stick using a hydraulic motor. In this manner, a more versatile excavator arm is provided because the angle of the operation direction of the tool can be varied which can increase the flexibility and the precision of the operation of the tool. However, such a function can add costs, complexity, and weight to the excavator arm and thereby also to the excavator machine comprising the excavator arm.

[0005] Moreover, some different types of modules are available on the market which comprise a hydraulic motor allowing rotation of a tool section of an excavator arm and which can be mounted to existing excavator arms which lacks the above-mentioned rotator function. Such modules are commonly referred to as a tiltrotator and are also known under a number of trade names. These types of modules can provide a more versatile excavator arm

because they allow variation of the angle of the operation direction of the tool which can increase the flexibility and the precision of the operation of the tool. However, these modules may be costly and complex to manufacture and for many users, these modules may be considered to be too expensive, especially in cases where it is intended to be used on a smaller type of excavator machine.

[0006] Furthermore, the weight and size of the above-mentioned type of module may not be suited for use on a smaller type of excavator machine.

[0007] In addition, generally, on today's consumer market, it is an advantage if products comprise different features and functions while the products have conditions and/or characteristics suitable for being manufactured and assembled in a cost-efficient manner.

SUMMARY

[0008] It is an object of the present invention to overcome, or at least alleviate, at least some of the above-mentioned problems and drawbacks, such as by providing a simpler and/or more cost-efficient solution for allowing a variation of the angle of the tool of an excavator arm.

[0009] According to a first aspect of the invention, the object is achieved by an attachment module configured to attach a tool to a distal end of an excavator arm. The attachment module comprises an arm section comprising a first attachment arrangement for attaching the arm section to the distal end of the excavator arm, and a tool section comprising a second attachment arrangement for attaching the tool to the tool section. The tool section is rotatably arranged relative to the arm section around a rotation axis. The attachment module comprises a locking assembly controllable between a locked state in which the locking assembly locks the tool section from rotating relative to the arm section around the rotation axis, and an unlocked state in which the locking assembly unlocks the tool section from the arm section such that the tool section is free to rotate relative to the arm section around the rotation axis.

[0010] Since the tool section is rotatably arranged relative to the arm section around the rotation axis and since the attachment module comprises the locking assembly controllable between the locked and unlocked states, an attachment module is provided allowing a change in the operation direction of a tool attached to the tool section relative to a distal end of an excavator arm in a manner circumventing the need for a hydraulic motor for rotating the tool section.

[0011] That is, a user may rotate the tool section relative to the arm section, and thus also a tool relative to a distal end of an excavator arm, by controlling the locking assembly to the unlocked state and applying an external force or torque onto the tool section, or to a tool attached to the tool section. Since the tool section is free to rotate relative to the arm section around the rotation axis when the locking assembly is in the unlocked state, such an

external force or torque can rotate the tool section relative to the distal end of the excavator arm.

[0012] The external force or torque may be applied to the tool section, or to a tool attached to the tool section, by controlling the excavator arm such that the tool or tool section abuts against an external surface and controlling the excavator arm such that the arm section of the attachment module is moved relative to the external surface.

[0013] When a wanted angle of the tool section relative to the arm section is obtained, the user may control the locking assembly to the locked state to lock the tool section from further rotating relative to the arm section.

[0014] Since the attachment module allows a change in the operation direction of a tool attached to the tool section relative to a distal end of an excavator arm in a manner circumventing the need for a hydraulic motor for rotating the tool section, a simple and efficient attachment module is provided having conditions for improving flexibility and precision of the operation of an excavator machine while having conditions and characteristics suitable for being manufactured and assembled in a cost-efficient manner.

[0015] Furthermore, due to the features of the attachment module, an attachment module is provided capable of allowing a change in the operation direction of a tool attached to the tool section, while having conditions for being compact and having conditions for having a low weight. Therefore, the attachment module according to the embodiments herein can be made suitable for use on smaller types of excavator machines as well as for use on larger or mid-sized excavator machines.

[0016] Accordingly, an attachment module is provided overcoming, or at least alleviating, at least some of the above-mentioned problems and drawbacks. As a result, the above-mentioned object is achieved.

[0017] Optionally, the attachment module comprises an input unit connectable to the locking assembly for controlling the locking assembly between the locked and unlocked states based on input from the input unit. Thus, due to these features, the input unit can be arranged in an operator area of an excavator machine, such as a cab or other type of operator area of the excavator machine, and can be connected to the locking assembly of the attachment module. In this manner, a user is allowed to change the operation direction of a tool attached to the tool section relative to a distal end of an excavator arm without having to leave the operator area of the excavator machine.

[0018] Optionally, the second attachment arrangement is configured to attach the tool to the tool section to allow the tool to operate in a main operation direction by a movement of the excavator arm in the main operation direction, and wherein the rotation axis is substantially perpendicular to the main operation direction of the tool. Thereby, an attachment module is provided having conditions for even further improving the flexibility and the precision of the operation of an excavator machine

while having conditions and characteristics suitable for being manufactured and assembled in a cost-efficient manner.

[0019] Optionally, the tool section is free to rotate more than 360 degrees relative to the arm section around the rotation axis when the locking assembly is in the unlocked state. Thereby, an attachment module is provided allowing a full rotation of a tool relative to a distal end of an excavator arm thereby further improving flexibility and precision of the operation of an excavator machine while having conditions and characteristics suitable for being manufactured and assembled in a cost-efficient manner.

[0020] Optionally, the locking assembly comprises a locking member and an actuator assembly operably connected to the locking member to move the locking member between a locking position, in which the locking assembly assumes the locked state, and an unlocking position, in which the locking assembly assumes the unlocked state. Thereby, a simple, efficient, and reliable locking assembly is provided.

[0021] Optionally, the locking assembly further comprises a first toothed section arranged on the arm section, a second toothed section arranged on the tool section, and a third toothed section arranged on the locking member, and wherein the third toothed section engages with both of the first and second toothed sections when the locking member is in the locking position and engages with only one of the first and second toothed sections when the locking member is in the unlocking position. Thereby, a locking assembly is provided having conditions for being simple, robust, and durable. Moreover, an attachment module is provided having conditions for having a low weight and being compact.

[0022] Optionally, the third toothed section engages with the second toothed section when the locking member is in the unlocking position. Thereby, a locking assembly is provided having conditions for being simple, compact, robust, and durable.

[0023] Optionally, each of the first, second and third toothed sections circumscribes the rotation axis. Thereby, a locking assembly is provided having conditions for being simple, compact, robust, and durable.

[0024] Optionally, each of the first and second toothed sections comprises internal teeth and wherein the third toothed section comprises external teeth. Thereby, conditions are provided for a simple, small sized, and low-cost actuator assembly. This is because the third toothed section is arranged on the locking member.

[0025] Optionally, the rotation axis extends through the actuator assembly. Thereby, conditions are provided for a simple, small sized, and low-cost actuator assembly.

[0026] Optionally, the locking member is movable in directions parallel to the rotation axis between the locking and unlocking positions. Thereby, conditions are provided for a compact, simple, and low-cost actuator assembly.

[0027] Optionally, the actuator assembly comprises an actuator configured to move the locking member to one

of the locking and unlocking positions when activated, and wherein the actuator assembly comprises at least one spring element configured to bias the locking member towards the other of the locking position and the unlocking position. Thereby, conditions are provided for an even simpler actuator assembly. This is because the actuator is only required to apply a force onto the locking member in one direction.

[0028] Optionally, the actuator assembly comprises an actuator of hydraulic type configured to move the locking member to one of the locking and unlocking positions when being fed with a hydraulic pressure. Thereby, a simple and robust actuator assembly is provided having conditions and characteristics suitable for being manufactured and assembled in a cost-efficient manner.

[0029] Optionally, the actuator comprises a centre body attached to a portion of the arm section by a fastening element extending into a hole of the centre body. Thereby, a simple and robust actuator assembly is provided having conditions and characteristics suitable for being manufactured and assembled in a cost-efficient manner.

[0030] Optionally, the actuator comprises a hydraulic connection and a hydraulic chamber configured to increase in volume when being fed with a hydraulic pressure via the hydraulic connection to move the locking member, and wherein the hydraulic chamber is fluidly connected to the hydraulic connection via a space between the fastening element and the hole of the centre body. Thereby, an actuator assembly is provided having conditions for being simple, robust, and compact. This is because the space between the fastening element and the hole of the centre body is utilized for conduction hydraulic fluid.

[0031] Optionally, the rotation axis extends through the fastening element. Thereby, a simple, robust, and compact actuator assembly is provided having conditions and characteristics suitable for being manufactured and assembled in a cost-efficient manner.

[0032] According to a second aspect of the invention, the object is achieved by an excavator arm comprising an attachment module according to some embodiments, wherein the attachment module is attached to a distal end of the excavator arm, and wherein the tool section of the attachment module is free to rotate relative to the excavator arm around the rotation axis when the locking assembly is in the unlocked state.

[0033] Since the tool section of the attachment module is rotatably arranged relative to the arm section around the rotation axis and since the attachment module comprises the locking assembly controllable between the locked and unlocked states, an excavator arm is provided allowing a change in the operation direction of a tool attached to the tool section relative to a distal end of an excavator arm in a manner circumventing the need for a hydraulic motor for rotating the tool section.

[0034] That is, a user may rotate the tool section relative to the arm section, and thus also a tool relative to a

distal end of the excavator arm, by controlling the locking assembly to the unlocked state and applying an external force or torque onto the tool section, or to a tool attached to the tool section. Since the tool section is free to rotate relative to the arm section around the rotation axis when the locking assembly is in the unlocked state, such an external force or torque can rotate the tool section relative to the distal end of the excavator arm.

[0035] Since the attachment module of the excavator arm allows a change in the operation direction of a tool attached to the tool section relative to a distal end of an excavator arm in a manner circumventing the need for a hydraulic motor for rotating the tool section, a simple and efficient excavator arm is provided having conditions for improving flexibility and precision of the operation of an excavator machine comprising the excavator arm while having conditions and characteristics suitable for being manufactured and assembled in a cost-efficient manner.

[0036] Accordingly, excavator arm is provided overcoming, or at least alleviating, at least some of the above-mentioned problems and drawbacks. As a result, the above-mentioned object is achieved.

[0037] According to a third aspect of the invention, the object is achieved by an excavator machine comprising an excavator arm according to some embodiments.

[0038] Since the excavator machine comprises an excavator arm with an attachment module allowing a change in the operation direction of a tool attached to the tool section relative to a distal end of an excavator arm in a manner circumventing the need for a hydraulic motor for rotating the tool section, a simple and efficient excavator machine is provided having conditions for improved flexibility and precision of the operation while having conditions for being manufactured and assembled in a cost-efficient manner.

[0039] Accordingly, excavator machine is provided overcoming, or at least alleviating, at least some of the above-mentioned problems and drawbacks. As a result, the above-mentioned object is achieved.

[0040] Optionally, the locking assembly of the attachment module comprises a locking member and an actuator assembly operably connected to the locking member to move the locking member between a locking position, in which the locking assembly assumes the locked state, and an unlocking position, in which the locking assembly assumes the unlocked state, wherein the excavator machine comprises an operator environment with an input unit for an operator of the excavator machine, and wherein the input unit is operably connected to the actuator assembly. Thereby, a user of the excavator machine is allowed to change the operation direction of a tool attached to the tool section relative to a distal end of the excavator arm without having to leave the operator area of the excavator machine. In this manner, a user-friendly excavator machine is provided having conditions and characteristics suitable for being manufactured and assembled in a cost-efficient manner.

[0041] According to a fourth aspect of the invention,

the object is achieved by a method of rotating a tool relative to an excavator arm of an excavator machine, the excavator machine comprising the excavator arm, an attachment module, and the tool, wherein the attachment module comprises an arm section attached to a distal end of the excavator arm and a tool section attached to the tool, wherein the tool section is rotatably arranged relative to the arm section around a rotation axis, and wherein the attachment module comprises a locking assembly controllable between a locked state, in which the locking assembly locks the tool section from rotating relative to the arm section around the rotation axis, and an unlocked state, in which the locking assembly unlocks the tool section from the arm section such that the tool section is free to rotate relative to the arm section around the rotation axis. The method comprises the steps of:

- controlling the locking assembly to the unlocked state, and
- rotating the tool relative to an excavator arm by applying an external torque onto the tool around the rotation axis.

[0042] Thereby, a method is provided allowing a change in the operation direction of a tool attached to the tool section relative to a distal end of an excavator arm in a manner circumventing the need for a hydraulic motor for rotating the tool section. As a result, a method is provided having conditions for improving flexibility and precision of the operation of an excavator machine in a cost-efficient manner.

[0043] Accordingly, method is provided overcoming, or at least alleviating, at least some of the above-mentioned problems and drawbacks. As a result, the above-mentioned object is achieved.

[0044] Optionally, the step of rotating the tool relative to an excavator arm by applying an external torque onto the tool around the rotation axis comprises the steps of:

- controlling the excavator arm such that the tool abuts against an external surface, and
- controlling the excavator arm such that the arm section of the attachment module is moved relative to the external surface.

[0045] Thereby, a method is provided capable of obtaining a wanted angle of the tool section, and a tool attached thereto, without requiring a motor or other type of arrangement for rotating the tool section relative to the arm section.

[0046] It will be appreciated that the various embodiments described for the method are all combinable with the control arrangement as described herein. That is, the control arrangement as described herein may be configured to perform any one of the method steps of the method according to the fourth aspect of the invention.

[0047] According to a fifth aspect of the invention, the object is achieved by a computer program comprising

instructions which, when the program is executed by a computer, cause the computer to carry out the method according to some embodiments of the present disclosure. Since the computer program comprises instructions which, when the program is executed by a computer, cause the computer to carry out the method according to some embodiments described herein, a computer program is provided which provides conditions for overcoming, or at least alleviating, at least some of the above-mentioned drawbacks. As a result, the above-mentioned object is achieved.

[0048] According to a sixth aspect of the invention, the object is achieved by a computer-readable medium comprising instructions which, when executed by a computer, cause the computer to carry out the method according to some embodiments of the present disclosure. Since the computer-readable medium comprises instructions which, when the program is executed by a computer, cause the computer to carry out the method according to some embodiments described herein, a computer-readable medium is provided which provides conditions for overcoming, or at least alleviating, at least some of the above-mentioned drawbacks. As a result, the above-mentioned object is achieved.

[0049] Further features of, and advantages with, the present invention will become apparent when studying the appended claims and the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0050] Various aspects of the invention, including its particular features and advantages, will be readily understood from the example embodiments discussed in the following detailed description and the accompanying drawings, in which:

Fig. 1 schematically illustrates an excavator machine according to some embodiments,

Fig. 2 illustrates a perspective view of an attachment module 1 according to embodiments illustrated in Fig. 1,

Fig. 3 illustrates the attachment module illustrated in Fig. 2 in which a tool section has been rotated relative to an arm section around a rotation axis,

Fig. 4 illustrates a first cross section of the attachment module illustrated in Fig. 2 and Fig. 3

Fig. 5 illustrates the first cross section of the attachment module illustrated in Fig. 4 in which a locking member has been moved to an unlocking position,

Fig. 6 illustrates a second cross section of the attachment module illustrated in Fig. 2 - Fig. 5,

Fig. 7 illustrates the second cross section of the attachment module illustrated in Fig. 6 in which the locking member has been moved to the unlocking position,

Fig. 8 illustrates an enlarged cross section of an actuator assembly of the attachment module illustrated

in Fig. 2 - Fig. 7,

Fig. 9 illustrates the enlarged cross section of the actuator assembly illustrated in Fig. 8 in which an actuator has displaced the locking member to the unlocking position,

Fig. 10 illustrates a method of rotating a tool relative to an excavator arm of an excavator machine, and

Fig. 11 illustrates a computer-readable medium.

DETAILED DESCRIPTION

[0051] Aspects of the present invention will now be described more fully. Like numbers refer to like elements throughout. Well-known functions or constructions will not necessarily be described in detail for brevity and/or clarity.

[0052] Fig. 1 schematically illustrates an excavator machine 4 according to some embodiments comprising an excavator arm 3. According to the illustrated embodiments, the excavator machine 4 is a small sized excavator. According to further embodiments, the excavator machine 4, as referred to herein, may be another type of excavator machine 4 comprising an excavator arm 3, such as a mid- or large-sized excavator, a backhoe, or the like.

[0053] According to the illustrated embodiments, the excavator machine 4 comprises an undercarriage 14 with continuous tracks 16 for moving the excavator machine 4. According to further embodiments, the excavator machine 4 may comprise another type of propulsion units for moving the excavator machine 4 such as wheels. Moreover, according to the illustrated embodiments, the excavator machine 4 comprises an upper structure 18 with a cab 22 for an operator of the excavator machine 4. The upper structure 18 is sometimes referred to as a house. The cab 22 comprises an operator environment 40.

[0054] According to the illustrated embodiments, the upper structure 18 can be rotated relative to the undercarriage 14 around an axis of rotation Ax by a hydraulic motor of the excavator machine 4. The hydraulic motor of the excavator machine 4 is not illustrated in Fig. 1 for reasons of brevity and clarity.

[0055] The excavator arm 3 comprises a first arm unit 24 and a second arm unit 26 pivotally attached to the first arm unit 24. The first arm unit 24 may also be referred to as a boom and the second arm unit 26 may also be referred to as a stick. The first arm unit 24 of the excavator arm 3 is attached to the upper structure 18 of the excavator machine 4 through a first pivot 28 also known as a king-post. The first pivot 28 allows the excavator arm 3 to pivot left and right as seen from the operator environment 40 of the excavator machine 4. The first arm unit 24 of the excavator arm 3 is also attached to the upper structure 18 of the excavator machine 4 through a second pivot 32 allowing the excavator arm 3 to pivot up and down as seen from the operator environment 40 of the excavator machine 4. The excavator arm 3 further com-

prises a linkage unit 30 attached to the second arm unit 26.

[0056] Moreover, the excavator arm 3 comprises a number of hydraulic units 61, 62, 63, 64 for moving at least parts of the excavator arm 3. In more detail, the excavator arm 3 comprises a first hydraulic unit 61 configured to move, i.e., pivot, the first arm unit 24, and thus the excavator arm 3, around the first pivot 28. Moreover, the excavator arm 3 comprises a second hydraulic unit 62 configured to move, i.e., pivot, the first arm unit 24, and thus the excavator arm 3, around the second pivot 32. Furthermore, the excavator arm 3 comprises a third hydraulic unit 63 configured to move, i.e., pivot, the second arm unit 26 relative to the first arm unit 24. Moreover, the excavator arm 3 comprises a fourth hydraulic unit 64 configured to move, i.e., pivot, the linkage unit 30 relative to the second arm unit 26.

[0057] Each hydraulic unit 61, 62, 63, 64 may comprise a hydraulic cylinder and a piston arranged in the cylinder. The excavator machine 4 further comprises a control arrangement 21 configured to control the hydraulic unit 61, 62, 63, 64 based on input from a control unit 42 arranged in the operator environment 40 of the excavator machine 4. According to the illustrated embodiments, the control arrangement 21 is a hydraulic control arrangement 21 but may alternatively or additionally comprise one or more electrical components, units, or systems, as is further explained herein.

[0058] The excavator machine 4 illustrated in Fig. 1 comprises an attachment module 1, according to embodiments herein, and a tool 2 attached to a distal end 3' of the excavator arm 3 via the attachment module 1. According to the illustrated embodiments, the distal end 3' of the excavator arm 3 is a distal end of the second arm unit 26. Moreover, the tool 2 according to the illustrated embodiments is a bucket, i.e., a tool 2 which can be used for digging. The tool 2 is associated with a main operation direction d1. In cases where the tool 2 is a bucket, the main operation direction d1 coincides with a facing direction of an open portion of the bucket.

[0059] Fig. 2 illustrates a perspective view of the attachment module 1 according to the embodiments illustrated in Fig. 1. Below, simultaneous reference is made to Fig. 1 - Fig. 2, if not indicated otherwise. As mentioned, the attachment module 1 is configured to attach a tool 2 to a distal end 3' of an excavator arm 3.

[0060] The attachment module 1 comprises an arm section 5 comprising a first attachment arrangement 5', 5" for attaching the arm section 5 to the distal end 3' of the excavator arm 3. According to the illustrated embodiments, the first attachment arrangement 5', 5" comprises a first pair of holes 5' each configured to accommodate a journal for connecting the arm section 5 to a connecting element 36 connected to the linkage unit 30 of the excavator arm 3. Moreover, according to the illustrated embodiments, the first attachment arrangement 5' comprises a second pair of holes 5" each configured to accommodate a journal for connecting the arm section 5 to the

second arm unit 26 of the excavator arm 3.

[0061] The attachment module 1 further comprises a tool section 6. The tool section 6 comprises a second attachment arrangement 6', 6" for attaching the tool 2 to the tool section 6 to allow the tool 2 to operate in a main operation direction d1 by a movement of the excavator arm 3 in the main operation direction d1. According to the illustrated embodiments, the second attachment arrangement 6', 6" of the tool section 6 comprises a first pair of controllable locking rods 6' and a pair of recesses 6". The first pair of controllable locking rods 6' and the pair of recesses 6" are configured to engage with structures of a tool 2 so as to attach the tool 2 to the tool section 6 of the attachment module 1.

[0062] The controllable locking rods 6' may be controllable between a locked state, in which the tool 2 is locked to the tool section 6 and an unlocked state, in which the tool 2 is unlocked from the tool section 6 of the attachment module 1.

[0063] As is further explained herein, the tool section 6 is rotatably arranged relative to the arm section 5 around a rotation axis Ra. According to the illustrated embodiments, the rotation axis Ra is substantially perpendicular to the main operation direction d1 of the tool 2.

[0064] Moreover, as is further explained herein, the attachment module 1 comprises a locking assembly 7 controllable between a locked state in which the locking assembly 7 locks the tool section 6 from rotating relative to the arm section 5 around the rotation axis Ra and an unlocked state in which the locking assembly 7 unlocks the tool section 6 from the arm section 5 such that the tool section 6 is free to rotate relative to the arm section 5 around the rotation axis Ra.

[0065] In this manner, a more versatile excavator machine 4 is provided in a simple and cost-efficient manner, as is further explained herein.

[0066] Fig. 3 illustrates the attachment module 1 illustrated in Fig. 2 in which the tool section 6 has been rotated relative to the arm section 5 around the rotation axis Ra. That is, as can be seen when comparing Fig. 2 and Fig. 3, the tool section 6 has been rotated relative to the arm section 5 around the rotation axis Ra such that the angle of the tool section 6 is different as measured relative to the rotation axis Ra. In Fig. 3, the tool section 6 has been rotated approximately 80 degrees relative to the arm section 5 around the rotation axis Ra from the position illustrated in Fig. 2. However, according to embodiments herein, the tool section 6 is free to rotate more than 360 degrees relative to the arm section 5 around the rotation axis Ra when the locking assembly 7 is in the unlocked state. The feature that the tool section 6 is free to rotate relative to the arm section 5 means that no arrangement, structure, component, or system of the attachment module 1 prevents or restricts rotation of tool section 6 relative to the arm section 5 around the rotation axis Ra. Moreover, according to the illustrated embodiments, the attachment module 1 has no restrictions on where to start or stop rotation of the tool section 6 relative to the arm

section 5 around the rotation axis Ra, other than some fixed locking positions of the tool section 6 relative to the arm section 5 explained below. Below, simultaneous reference is made to Fig. 1 - Fig. 3, if not indicated otherwise.

[0067] As is further explained herein, according to the illustrated embodiments, the locking assembly 7 is controllable between the locked and unlocked state via an input unit 41 for an operator of the excavator machine 4. According to the illustrated embodiments, the input unit 41 is arranged in the operator environment 40 inside the cab 22.

[0068] The tool 2 may be rotated relative to an excavator arm 3 by applying an external torque onto the tool 2 around the rotation axis Ra. The external torque may be applied onto the tool 2 around the rotation axis Ra by controlling the excavator arm 3 such that the tool 2 abuts against an external surface 50 and by controlling the excavator arm 3 such that the arm section 5 of the attachment module 1 is moved relative to the external surface 50.

[0069] That is, an operator of the excavator machine 4 may first control the locking assembly 7 to the unlocked state and control the excavator arm 3 such that the tool 2 abuts against an external surface 50 and control the excavator arm 3 such that the arm section 5 of the attachment module 1 is moved relative to the external surface 50. The arm section 5 of the attachment module 1 may be moved relative to the external surface 50 by controlling the first hydraulic unit 61 to pivot the first arm section 24, and thus the excavator arm 3, around the first pivot 28. As an alternative, or in addition, the arm section 5 of the attachment module 1 may be moved relative to the external surface 50 by controlling the hydraulic motor of the excavator machine 4 to rotate the upper structure 18 relative to the undercarriage 14 around the axis of rotation Ax. In such a procedure, the section 5 of the attachment module 1 is moved relative to the external surface 50 because the excavator arm 3 is attached to the upper structure 18. As a further alternative, or in addition, the arm section 5 of the attachment module 1 may be moved relative to the external surface 50 by controlling the entire excavator machine 4 to move relative to the external surface 50, such as by a control of at least one of the continuous tracks 16 of the excavator machine 4. In this manner, the abutting contact between a portion of the tool 2 and the external surface 50 can apply a force onto the tool 2 in a direction transversal and off centre relative to the rotation axis Ra and a torque is thereby applied onto the tool 2 around the rotation axis Ra which rotates the tool section 6 relative to the arm section 5 around the rotation axis Ra.

[0070] When a wanted angle of the tool section 6, and thus of the tool 2 attached to the tool section 6, is reached, the operator may control the locking assembly 7 to the locked position to prevent further rotation of the tool section 6 relative to the arm section 5. In this manner, more versatile excavator machine 4 is provided in a simple and cost-efficient manner allowing a user to utilize the tool 2

in a more versatile manner with higher flexibility and precision of the operation.

[0071] The attachment module 1 according to the embodiments herein may be sold as a separate unit configured to be attached to a distal end 3' of an excavator arm 3 of an already existing excavator machine 4. A more versatile excavator machine 4 can thus be provided in a simple and cost-efficient manner by mounting the attachment module 1 according to the embodiments herein to the distal end 3' of the excavator arm 3. Possibly, the attachment module 1 according to the embodiments herein may be sold as a kit comprising the attachment module 1 and one or both of an input unit 41 for controlling the locking assembly 7 between the locked and unlocked state and a control arrangement 21 for controlling the locking assembly 7 between the locked and unlocked state.

[0072] As understood from the herein described, the attachment module 1 lacks a motor or another type of arrangement configured to rotate the tool section 6 relative to the arm section 5 around the rotation axis Ra. Instead, the tool section 6 can be rotated relative to the arm section 5 around the rotation axis Ra when the locking assembly 7 is in the unlocked state by applying an external torque onto the tool section 6 or a tool 2 attached thereto. This is because, the tool section 6 of the attachment module 1 is free to rotate relative to the excavator arm 3 around the rotation axis Ra when the locking assembly 7 is in the unlocked state.

[0073] Due to the features of the attachment module 1, the attachment module 1 can be made compact and light weighted. Therefore, the attachment module 1 according to the embodiments herein can be made suitable for use on smaller types of excavator machines as well as for use on larger or mid-sized excavator machines.

[0074] Obviously, the tool section 6 may be rotated relative to the arm section 5 around the rotation axis Ra in another manner than in the above described manner, for example using hands or gravity acting onto the tool section 6, gravity acting onto a tool 2 attached to the tool section 6, and/or gravity acting onto matter accommodated in a tool 2 attached to the tool section 6.

[0075] As is indicated in Fig. 2 and Fig. 3, the attachment module 1 according to the illustrated embodiments comprises a tilt axis Pa between the arm section 5 and the tool section 6 allowing the tool section 6 to be tilted around the tilt axis Pa to some degree relative to the arm section 5. Moreover, according to the illustrated embodiments, the attachment module 1 comprises a fifth hydraulic unit 65 controllable to tilt the tool section 6 relative to the arm section 5 around the tilt axis Pa. According to the illustrated embodiments, the fifth hydraulic unit 65 comprises a hydraulic cylinder and a hydraulic piston arranged in the hydraulic cylinder. Moreover, in Fig. 1, the fifth hydraulic unit 65 is operably connected to the control unit 42 via the control arrangement 21 of the excavator machine 4. The tilt axis Pa and the fifth hydraulic unit 65 controllable to tilt the tool section 6 relative to the arm

section 5 around the tilt axis Pa may be of conventional type.

[0076] As seen in Fig. 2 and Fig. 3, according to the illustrated embodiments, the rotation axis Ra is substantially perpendicular to the tilt axis Pa. Moreover, according to the illustrated embodiments, the rotation axis Ra extends through the tilt axis Pa. Furthermore, according to the illustrated embodiments, the tool section 6 is rotatably arranged relative to the arm section 5 in a rotation plane. The rotation plane of the tool section 6 is perpendicular to rotation axis Ra and is parallel to the tilt axis Pa regardless of a current tilt angle of the tool section 6 relative to the arm section 5 around the tilt axis Pa.

[0077] Fig. 4 illustrates a first cross section of the attachment module 1 illustrated in Fig. 2 and Fig. 3. In Fig. 4, the cross section is made in a plane comprising the rotation axis Ra. Below, simultaneous reference is made to Fig. 1 - Fig. 4, if not indicated otherwise.

[0078] In Fig. 4, the first attachment arrangement 5', 5" and the second attachment arrangement 6', 6" of the attachment module 1 can be seen in more detail. Moreover, as can be seen in Fig. 4, the locking assembly 7 comprises a locking member 9 and an actuator assembly 10 operably connected to the locking member 9. The actuator assembly 10 is controllable to move the locking member 9 between a locking position, in which the locking assembly 7 assumes the locked state, and an unlocking position, in which the locking assembly 7 assumes the unlocked state. According to the illustrated embodiments, the actuator assembly 10 is operably connected to the input unit 41 of the excavator machine 4 via a hydraulic circuit 38 of the excavator machine 4, as is further explained herein.

[0079] In Fig. 4, the locking member 9 is illustrated in the locking position and the locking assembly 7 is thus illustrated in the locked state.

[0080] Fig. 5 illustrates the first cross section of the attachment module 1 illustrated in Fig. 4 in which the locking member 9 has been moved to the unlocking position. In other words, as compared to Fig. 4, the locking assembly 7 has been controlled from the locked state to the unlocked state in Fig. 5.

[0081] As can be seen in Fig. 4 and Fig. 5, the locking assembly 7 comprises a first toothed section 11 arranged on the arm section 5, a second toothed section 12 arranged on the tool section 6, and a third toothed section 13 arranged on the locking member 9. According to the illustrated embodiments, the first toothed section 11 is a section of a first plate-like member attached to the arm section 5. The first plate-like member may be attached to the arm section 5 via a number of bolts. Likewise, the second toothed section 12 is a section of a second plate-like member attached to the tool section 6. The second plate-like member may be attached to the tool section 6 via a number of bolts. The second toothed section 12 is arranged adjacent to the first toothed section 11.

[0082] As can be seen in Fig. 4, the third toothed section 13 engages with both of the first and second toothed

sections 11, 12 when the locking member 9 is in the locking position. In this manner, the tool section 6 is locked from rotating relative to the arm section 5 around the rotation axis Ra. This is because the second toothed section 12 is locked from rotating relative to the first toothed section 11 by the third toothed section 13 engaging both of the first and second toothed sections 11, 12.

[0083] As can be seen in Fig. 5, the third toothed section 13 engages only with the second toothed section 12 when the locking member 9 is in the unlocking position. In this manner, the tool section 6 is free to rotate relative to the arm section 5 around the rotation axis Ra. This is because the second toothed section 12 is free to rotate relative to the first toothed section 11 because the third toothed section 13 engages with only one of the first and second toothed sections 11, 12. As mentioned, according to the illustrated embodiments, the third toothed section 13 engages only with the second toothed section 12 when the locking member 9 is in the unlocking position. However, according to further embodiments, the third toothed section 13 may be configured to only engage with the first toothed section 11 when the locking member 9 is in the unlocking position.

[0084] Fig. 6 illustrates a second cross section of the attachment module 1 illustrated in Fig. 2 - Fig. 5. Like in Fig. 4 and Fig. 5, the cross section is made in a plane comprising the rotation axis Ra in Fig. 6. Below, simultaneous reference is made to Fig. 1 - Fig. 6, if not indicated otherwise.

[0085] As is best seen in Fig. 6, each of the first, second and third toothed sections 11, 12, 13 circumscribes the rotation axis Ra. Moreover, according to the illustrated embodiments, each of the first and second toothed sections 11, 12 comprises internal teeth 11', 12' whereas the third toothed section 13 comprises external teeth 13'. The feature that each of the first and second toothed sections 11, 12 comprises internal teeth 11', 12' means that the internal teeth 11', 12' face towards a geometrical centre of the respective first and second toothed sections 11, 12. According to the illustrated embodiments, the geometrical centre of the respective first and second toothed sections 11, 12 coincides with the rotation axis Ra. Moreover, the feature that the third toothed section 13 comprises external teeth 13' means that the external teeth 13' face outward of a geometrical centre of the third toothed section 13. According to the illustrated embodiments, the geometrical centre of the third toothed section 13 coincides with the rotation axis Ra.

[0086] Furthermore, as is best seen in Fig. 6, the third toothed section 13 is a section of an element arranged inside of the first and second toothed sections 11, 12, wherein the element is attached to the locking member 9 to form one moving part. Thus, the third toothed section 13 can be said to be a toothed section of the locking member 9, wherein the locking member 9 is arranged inside the first and second toothed sections 11, 12.

[0087] In Fig. 6, the locking member 9 is illustrated in the locking position and the locking assembly 7 is con-

sequently illustrated in the locked state.

[0088] Fig. 7 illustrates the second cross section of the attachment module 1 illustrated in Fig. 6 in which the locking member 9 has been moved to the unlocking position. In other words, as compared to Fig. 6, the locking assembly 7 has been controlled from the locked state to the unlocked state in Fig. 7.

[0089] As can be seen in Fig. 6 and Fig. 7, as well as in Fig. 4 and Fig. 5, according to the illustrated embodiments, the locking member 9 is movable in directions parallel to the rotation axis Ra between the locking and unlocking positions.

[0090] Fig. 8 illustrates an enlarged cross section of the actuator assembly 10 of the attachment module 1 illustrated in Fig. 2 - Fig. 7. Like in Fig. 4 - Fig. 7, the cross section is made in a plane comprising the rotation axis Ra in Fig. 8. Moreover, in Fig. 8, the locking member 9 is illustrated in the locking position and the locking assembly 7 is consequently illustrated in the locked state.

[0091] As is indicated in Fig. 8, the actuator assembly 10 comprises an actuator 20. According to the illustrated embodiments, the actuator 20 is configured to move the locking member 9 to the unlocking position when activated. As can be seen in Fig. 8, according to the illustrated embodiments, the actuator assembly 10 comprises a spring element 23. The spring element 23 is configured to bias the locking member 9 towards the locking position. In Fig. 8, only one spring element 23 is illustrated. However, the actuator assembly 10 may comprise a greater number of spring elements 23, such as a number between two and twelve, wherein each of the number of spring elements 23 is configured to bias the locking member 9 towards the locking position.

[0092] Fig. 9 illustrates the enlarged cross section of the actuator assembly 10 illustrated in Fig. 8 in which the actuator 20 has displaced the locking member 9 to the unlocking position. In other words, in Fig. 9, the locking assembly 7 is illustrated in the unlocked state.

[0093] As can be seen in Fig. 9, the third toothed section 13 only engages the second toothed section 12 when the locking member 9 is in the unlocking position. Moreover, as can be seen in Fig. 9, the spring element 23 has been compressed upon the movement of the locking member 9 from the locked position to the unlocking position.

[0094] As understood from the herein described, the actuator 20 according to the illustrated embodiments is of hydraulic type and is configured to move the locking member 9 to the unlocking position when being fed with a hydraulic pressure. The biasing force of the spring element 23, or by the number of spring elements 23, forces the locking member 9 to the locked state when the hydraulic pressure is released.

[0095] According to the illustrated embodiments, the actuator 20 comprises a centre body 25 attached to a portion 27 of the arm section 5 by a fastening element 29 extending into a hole 31 of the centre body 25. According to the illustrated embodiments, the fastening el-

ement 29 is a bolt, i.e., an elongated object with a threaded portion. Moreover, the actuator 20 comprises a hydraulic connection 33 and a hydraulic chamber 35, 35' configured to increase in volume when being fed with a hydraulic pressure via the hydraulic connection 33 to move the locking member 9 towards the unlocking position. The hydraulic connection 33 indicated in Fig. 8 and 9 is connected to the control arrangement 21 of the excavator machine 4 illustrated in Fig. 1 via a hydraulic circuit 38 of the excavator machine 4.

[0096] Moreover, as can be seen in Fig. 8 and Fig. 9, according to the illustrated embodiments, the hydraulic chamber 35, 35' is fluidly connected to the hydraulic connection 33 via a space 34 between the fastening element 29 and the hole 31 of the centre body 25. According to the illustrated embodiments, also a threaded portion of the interface between the fastening element 29 and the hole 31 is utilized for fluidly connecting the hydraulic chamber 35, 35' to the hydraulic connection 33. In this manner, a space efficient solution is provided for connecting hydraulic chamber 35, 35' to the hydraulic connection 33.

[0097] Moreover, as seen in Fig. 8 and Fig. 9, according to the illustrated embodiments, the rotation axis Ra extends through the actuator assembly 10 and extends through the fastening element 29.

[0098] According to further embodiments, the actuator 20 of the actuator assembly 10 may be configured to move the locking member 9 to the locking position when activated. According to such embodiments, the actuator assembly 10 may comprise a number of spring elements configured to bias the locking member 9 towards the unlocking position. Moreover, according to some embodiments, the actuator 20 of the actuator assembly 10 may be controllable to move the locking member 9 between the locked and unlocked positions, i.e., in both directions. According to such embodiments, the actuator assembly 10 may lack spring elements 23 configured to bias the locking member 9 to one of the locking and unlocking positions.

[0099] Below, simultaneous reference is made to Fig. 1 - Fig. 9, if not indicated otherwise. As indicated above, tool section 6 is free to rotate relative to the arm section 5 around the rotation axis Ra when the locking assembly 7 is in the unlocked state. According to the illustrated embodiments, the attachment module 1 is provided with some fixed locking positions of the tool section 6 relative to the arm section 5. The number of fixed locking positions of the tool section 6 relative to the arm section 5 is determined by the number of teeth 11', 12', 13' of the first, second, and third toothed sections 11, 12, 13. According to the illustrated embodiments, each of the first, second, and third toothed sections 11, 12, 13 comprises twenty-four teeth 11', 12', 13'. In other words, according to the illustrated embodiments, the attachment module 1 is provided with twenty-four fixed locking positions of the tool section 6 relative to the arm section 5. According to further embodiments, the attachment module 1 may

be provided with another number of fixed locking positions and number of teeth 11', 12', 13' of the respective first, second, and third toothed sections 11, 12, 13, such as for example a number between eight and one hundred, or a number between twelve and forty-eight.

[0100] Fig. 10 illustrates a method of rotating a tool relative to an excavator arm of an excavator machine, the excavator machine comprising the excavator arm, an attachment module, and the tool. The excavator machine may be an excavator machine 4 explained with reference to Fig. 1 and the attachment module may be an attachment module 1 explained with reference to Fig. 1 - Fig. 9. Therefore, below, simultaneous reference is made to Fig. 1 - Fig. 10, if not indicated otherwise. The method 100 is a method 100 of rotating a tool 2 relative to an excavator arm 3 of an excavator machine 4, the excavator machine 4 comprising the excavator arm 3, an attachment module 1, and the tool 2. The attachment module 1 comprises an arm section 5 attached to a distal end 3' of the excavator arm 3 and a tool section 6 attached to the tool 2 allow the tool 2 to operate in a main operation direction d1 by a movement of the excavator arm 3 in the main operation direction d1. The tool section 6 is rotatably arranged relative to the arm section 5 around a rotation axis Ra. The attachment module 1 comprises a locking assembly 7 controllable between a locked state, in which the locking assembly 7 locks the tool section 6 from rotating relative to the arm section 5 around the rotation axis Ra, and an unlocked state, in which the locking assembly 7 unlocks the tool section 6 from the arm section 5 such that the tool section 6 is free to rotate relative to the arm section 5 around the rotation axis Ra. The method 100 comprises the steps of:

- controlling 110 the locking assembly 7 to the unlocked state, and
- rotating 120 the tool 2 relative to an excavator arm 3 by applying an external torque onto the tool 2 around the rotation axis Ra.

[0101] As indicated in Fig. 10, the step of rotating 120 the tool 2 relative to an excavator arm 3 by applying an external torque onto the tool 2 around the rotation axis Ra may comprise comprises the steps of:

- controlling 121 the excavator arm 3 such that the tool 2 abuts against an external surface 50, and
- controlling 122 the excavator arm 3 such that the arm section 5 of the attachment module 1 is moved relative to the external surface 50.

[0102] It will be appreciated that the various embodiments described for the method 100 are all combinable with the control arrangement 21 as described herein. That is, the control arrangement 21 may be configured to perform any one of the method steps 110, 120, 121, and 122 of the method 100.

[0103] Fig. 11 illustrates a computer-readable medium

200 comprising instructions which, when executed by a computer, cause the computer to carry out the method 100 according to some embodiments of the present disclosure. According to some embodiments, the computer-readable medium 200 comprises a computer program comprising instructions which, when the program is executed by a computer, cause the computer to carry out the method 100 according to some embodiments.

[0104] One skilled in the art will appreciate that the method 100 of rotating a tool 2 relative to an excavator arm 3 of an excavator machine 4 may be implemented by programmed instructions. These programmed instructions are typically constituted by a computer program, which, when it is executed in the control arrangement 21, ensures that the control arrangement 21 carries out the desired control, such as the method steps 110, 120, 121, and 122 of the method 100 described herein. The computer program is usually part of a computer program product 200 which comprises a suitable digital storage medium on which the computer program is stored.

[0105] The control arrangement 21 may comprise a calculation unit which may take the form of substantially any suitable type of processor circuit or microcomputer, e.g., a circuit for digital signal processing (digital signal processor, DSP), a Central Processing Unit (CPU), a processing unit, a processing circuit, a processor, an Application Specific Integrated Circuit (ASIC), a microprocessor, or other processing logic that may interpret and execute instructions. The herein utilised expression "calculation unit" may represent a processing circuitry comprising a plurality of processing circuits, such as, e.g., any, some or all of the ones mentioned above.

[0106] The control arrangement 21 may further comprise a memory unit, wherein the calculation unit may be connected to the memory unit, which may provide the calculation unit with, for example, stored program code and/or stored data which the calculation unit may need to enable it to do calculations. The calculation unit may also be adapted to store partial or final results of calculations in the memory unit. The memory unit may comprise a physical device utilised to store data or programs, i.e., sequences of instructions, on a temporary or permanent basis. According to some embodiments, the memory unit may comprise integrated circuits comprising silicon-based transistors. The memory unit may comprise e.g. a memory card, a flash memory, a USB memory, a hard disc, or another similar volatile or non-volatile storage unit for storing data such as e.g. ROM (Read-Only Memory), PROM (Programmable Read-Only Memory), EPROM (Erasable PROM), EEPROM (Electrically Erasable PROM), etc. in different embodiments.

[0107] The control arrangement 21 may be connected to components of the excavator machine 4, the excavator arm 3, and/or the attachment module 1, for receiving and/or sending input and output signals. These input and output signals may comprise waveforms, pulses, or other attributes which the input signal receiving devices can detect as information and which can be converted to sig-

nals processable by the control arrangement 21. These signals may then be supplied to the calculation unit. One or more output signal sending devices may be arranged to convert calculation results from the calculation unit to output signals for conveying to other parts of the vehicle's control system and/or the component or components for which the signals are intended. Each of the connections to the respective components of the excavator machine 4, the excavator arm 3, and/or the attachment module 1, for receiving and sending input and output signals may take the form of one or more from among a hydraulic circuit, a cable, a data bus, e.g., a CAN (controller area network) bus, a MOST (media orientated systems transport) bus or some other bus configuration, or a wireless connection.

[0108] In the embodiments illustrated, the excavator machine 4 comprises a control arrangement 21 but might alternatively be implemented wholly or partly in two or more control arrangements or two or more control units.

[0109] Control systems in modern excavator machines 4 can comprise a communication bus system consisting of one or more communication buses for connecting a number of electronic control units (ECUs), or controllers, to various components on board the excavator machine 4. Such a control system may comprise a large number of control units and taking care of a specific function may be shared between two or more of them. Excavator machines 4 of the type here concerned are therefore often provided with significantly more control arrangements 21 than depicted in Fig. 1, as one skilled in the art will surely appreciate.

[0110] The computer program product 200 may be provided for instance in the form of a data carrier carrying computer program code for performing at least some of the method steps 110, 120, 121, and 122 of the method 100 according to some embodiments when being loaded into one or more calculation units of the control arrangement 21. The data carrier may be, e.g. a CD ROM disc, as is illustrated in Fig. 11, or a ROM (read-only memory), a PROM (programmable read-only memory), an EPROM (erasable PROM), a flash memory, an EEPROM (electrically erasable PROM), a hard disc, a memory stick, an optical storage device, a magnetic storage device or any other appropriate medium such as a disk or tape that may hold machine readable data in a non-transitory manner. The computer program product may furthermore be provided as computer program code on a server and may be downloaded to the control arrangement 21 remotely, e.g., over an Internet or an intranet connection, or via other wired or wireless communication systems.

[0111] The wording "substantially perpendicular to", as used herein, may encompass that the angle between the objects referred to is within the range of 80 - 100 degrees or is within the range of 83 - 97 degrees.

[0112] It is to be understood that the foregoing is illustrative of various example embodiments and that the invention is defined only by the appended independent claims. A person skilled in the art will realize that the

example embodiments may be modified, and that different features of the example embodiments may be combined to create embodiments other than those described herein, without departing from the scope of the present invention, as defined by the appended independent claims.

[0113] As used herein, the term "comprising" or "comprises" is open-ended, and includes one or more stated features, elements, steps, components, or functions but does not preclude the presence or addition of one or more other features, elements, steps, components, functions, or groups thereof.

Claims

1. An attachment module (1) configured to attach a tool (2) to a distal end (3') of an excavator arm (3), the attachment module (1) comprising:

- an arm section (5) comprising a first attachment arrangement (5', 5'') for attaching the arm section (5) to the distal end (3') of the excavator arm (3), and
- a tool section (6) comprising a second attachment arrangement (6', 6'') for attaching the tool (2) to the tool section (6),

wherein the tool section (6) is rotatably arranged relative to the arm section (5) around a rotation axis (Ra), and
wherein the attachment module (1) comprises a locking assembly (7) controllable between

- a locked state in which the locking assembly (7) locks the tool section (6) from rotating relative to the arm section (5) around the rotation axis (Ra), and
- an unlocked state in which the locking assembly (7) unlocks the tool section (6) from the arm section (5) such that the tool section (6) is free to rotate relative to the arm section (5) around the rotation axis (Ra).

2. The attachment module (1) according to claim 1, wherein the second attachment arrangement (6', 6'') is configured to attach the tool (2) to the tool section (6) to allow the tool (2) to operate in a main operation direction (d1) by a movement of the excavator arm (3) in the main operation direction (d1), and wherein the rotation axis (Ra) is substantially perpendicular to the main operation direction (d1) of the tool (2).
3. The attachment module (1) according to claim 1 or 2, wherein the tool section (6) is free to rotate more than 360 degrees relative to the arm section (5) around the rotation axis (Ra) when the locking as-

sembly (7) is in the unlocked state.

4. The attachment module (1) according to any one of the preceding claims, wherein the locking assembly (7) comprises a locking member (9) and an actuator assembly (10) operably connected to the locking member (9) to move the locking member (9) between a locking position, in which the locking assembly (7) assumes the locked state, and an unlocking position, in which the locking assembly (7) assumes the unlocked state.

5. The attachment module (1) according to claim 4, wherein the locking assembly (7) further comprises:

- a first toothed section (11) arranged on the arm section (5),
- a second toothed section (12) arranged on the tool section (6), and
- a third toothed section (13) arranged on the locking member (9), and

wherein the third toothed section (13) engages with both of the first and second toothed sections (11, 12) when the locking member (9) is in the locking position and engages with only one of the first and second toothed sections (11, 12) when the locking member (9) is in the unlocking position.

6. The attachment module (1) according to claim 5, wherein the third toothed section (13) engages with the second toothed section (12) when the locking member (9) is in the unlocking position.

7. The attachment module (1) according to claim 5 or 6, wherein each of the first, second and third toothed sections (11, 12, 13) circumscribes the rotation axis (Ra).

8. The attachment module (1) according to any one of the claims 5 - 7, wherein each of the first and second toothed sections (11, 12) comprises internal teeth (11', 12') and wherein the third toothed section (13) comprises external teeth (13').

9. An excavator arm (3) comprising an attachment module (1) according to any one of the preceding claims, wherein the attachment module (1) is attached to a distal end (3') of the excavator arm (3), and wherein the tool section (6) of the attachment module (1) is free to rotate relative to the excavator arm (3) around the rotation axis (Ra) when the locking assembly (7) is in the unlocked state.

10. An excavator machine (4) comprising an excavator arm (3) according to claim 9.

11. The excavator machine (4) according to claim 10,

wherein the locking assembly (7) of the attachment module (1) comprises a locking member (9) and an actuator assembly (10) operably connected to the locking member (9) to move the locking member (9) between a locking position, in which the locking assembly (7) assumes the locked state, and an unlocking position, in which the locking assembly (7) assumes the unlocked state, wherein the excavator machine (4) comprises an operator environment (40) with an input unit (41) for an operator of the excavator machine (4), and wherein the input unit (41) is operably connected to the actuator assembly (10).

12. A method (100) of rotating a tool (2) relative to an excavator arm (3) of an excavator machine (4), the excavator machine (4) comprising the excavator arm (3), an attachment module (1), and the tool (2),

wherein the attachment module (1) comprises an arm section (5) attached to a distal end (3') of the excavator arm (3) and a tool section (6) attached to the tool (2),

wherein the tool section (6) is rotatably arranged relative to the arm section (5) around a rotation axis (Ra), and wherein the attachment module (1) comprises a locking assembly (7) controllable between a locked state, in which the locking assembly (7) locks the tool section (6) from rotating relative to the arm section (5) around the rotation axis (Ra), and an unlocked state, in which the locking assembly (7) unlocks the tool section (6) from the arm section (5) such that the tool section (6) is free to rotate relative to the arm section (5) around the rotation axis (Ra), and wherein the method (100) comprises the steps of:

- controlling (110) the locking assembly (7) to the unlocked state, and
- rotating (120) the tool (2) relative to an excavator arm (3) by applying an external torque onto the tool (2) around the rotation axis (Ra).

13. The method (100) according to claim 12, wherein the step of rotating (120) the tool (2) relative to an excavator arm (3) by applying an external torque onto the tool (2) around the rotation axis (Ra) comprises the steps of:

- controlling (121) the excavator arm (3) such that the tool (2) abuts against an external surface (50), and
- controlling (122) the excavator arm (3) such that the arm section (5) of the attachment module (1) is moved relative to the external surface (50).

14. A computer program comprising instructions which, when the program is executed by a computer, cause the computer to carry out the method (100) according to any one of the claims 12 - 13.

15. A computer-readable medium (200) comprising instructions which, when executed by a computer, cause the computer to carry out the method (100) according to any one of the claims 12 - 13.

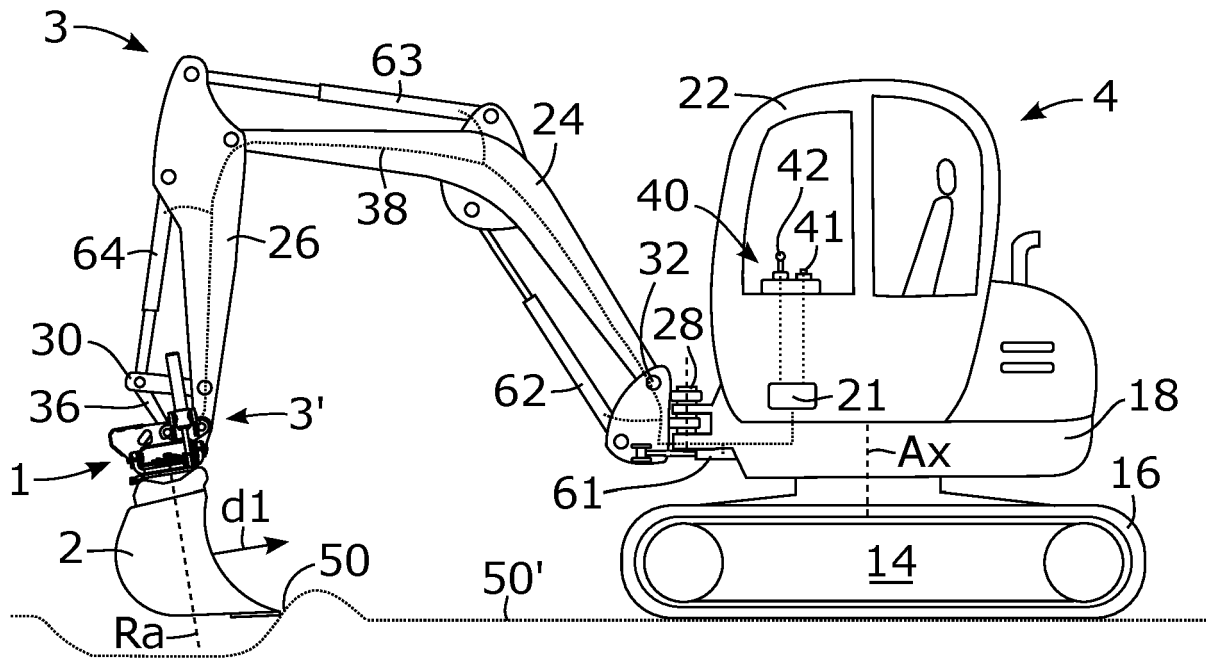


Fig. 1

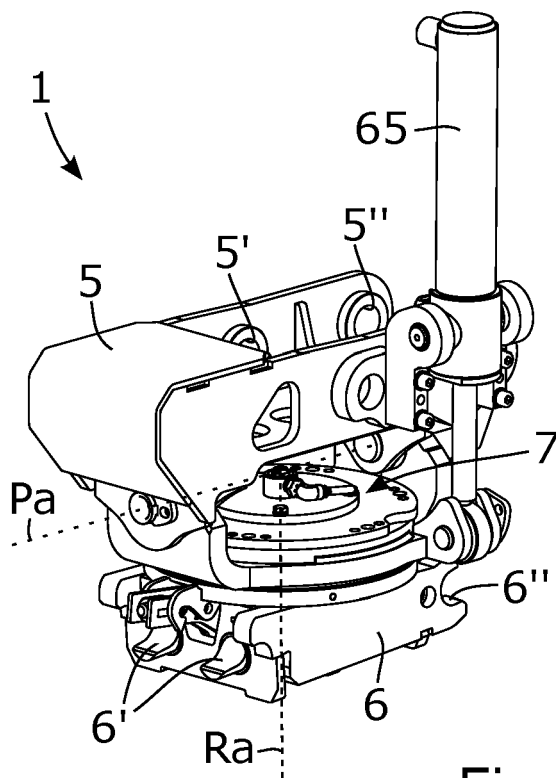


Fig. 2

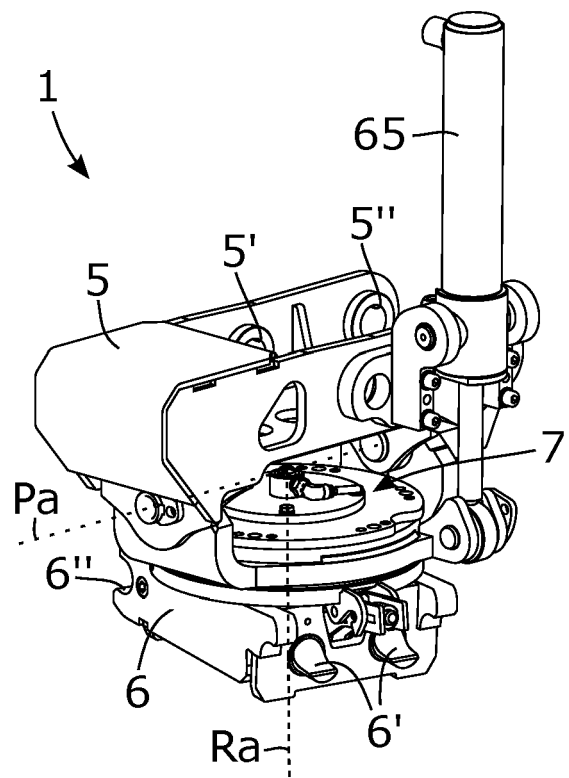


Fig. 3

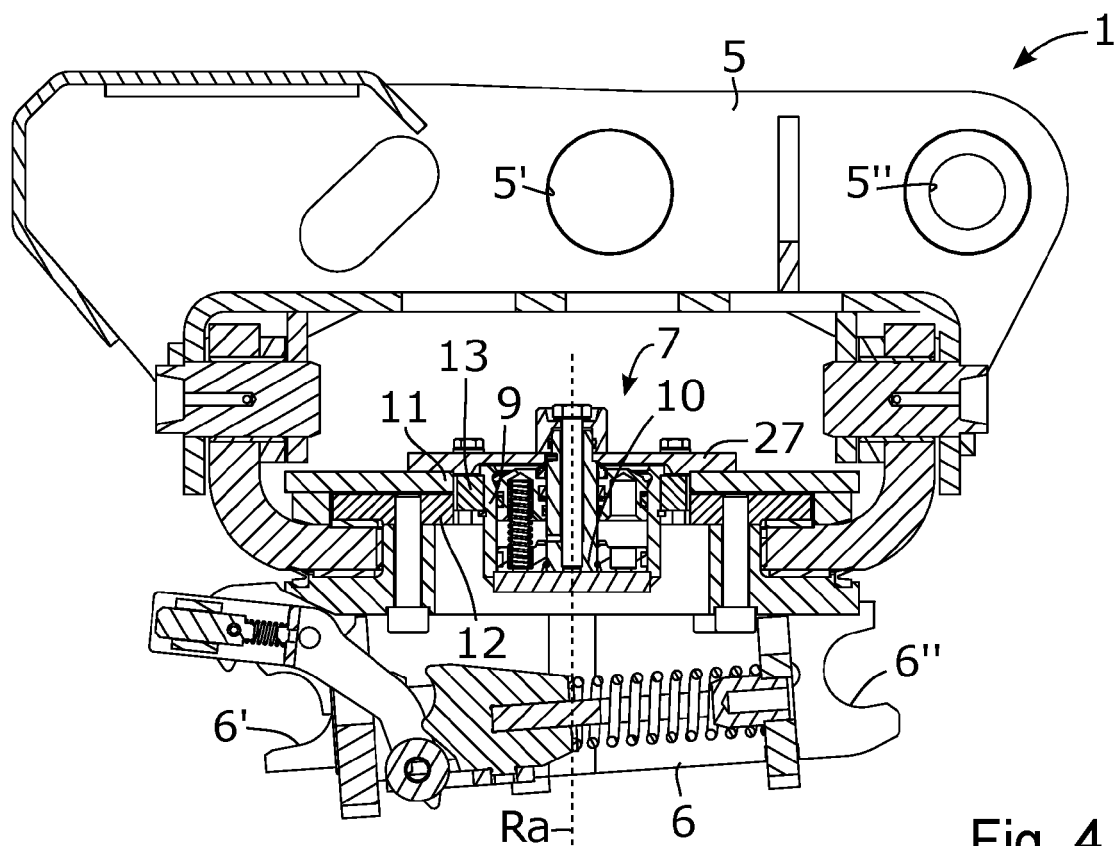


Fig. 4

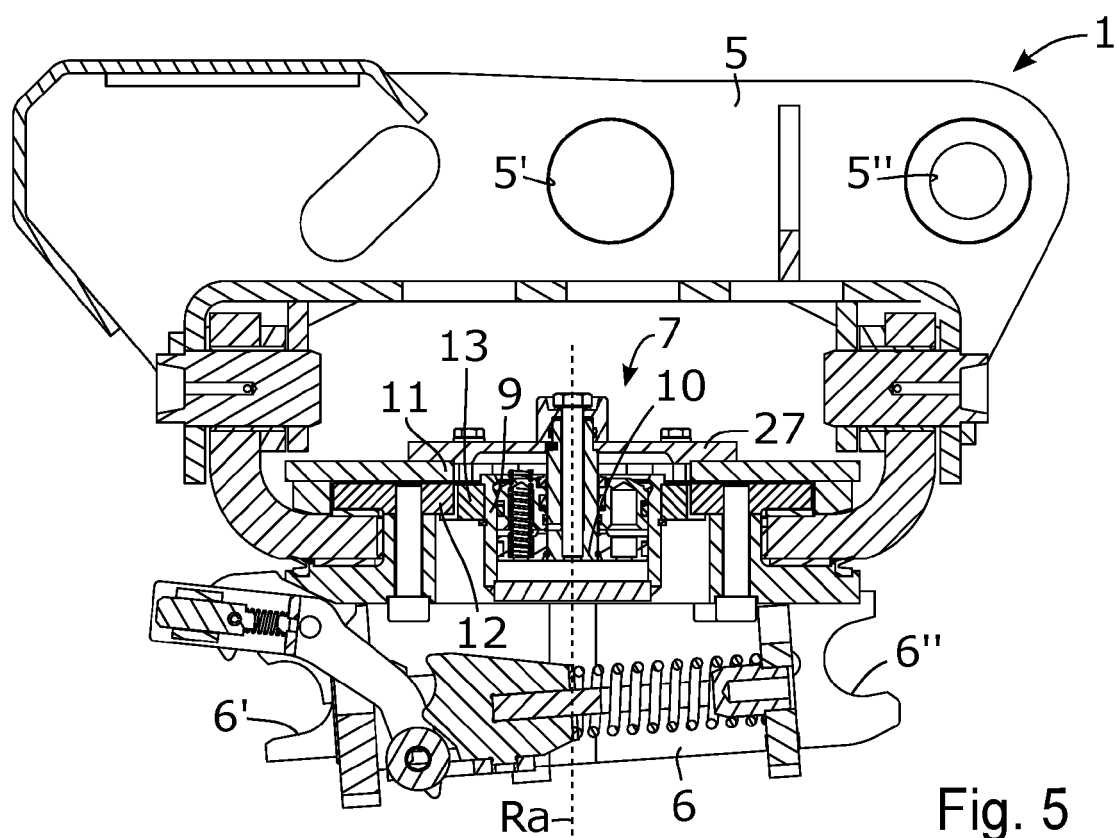


Fig. 5

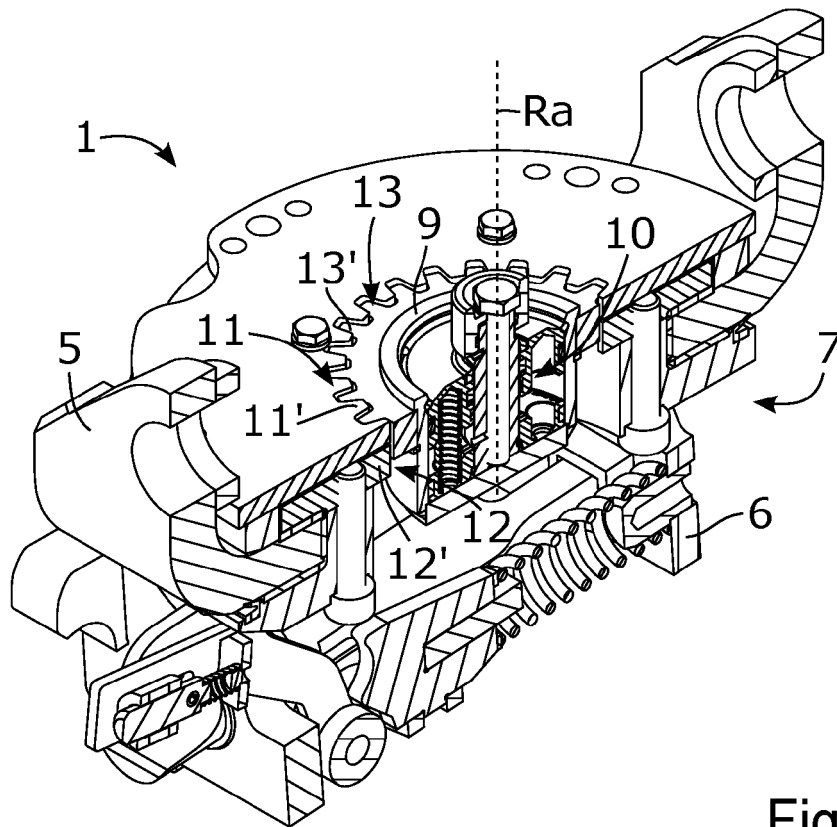


Fig. 6

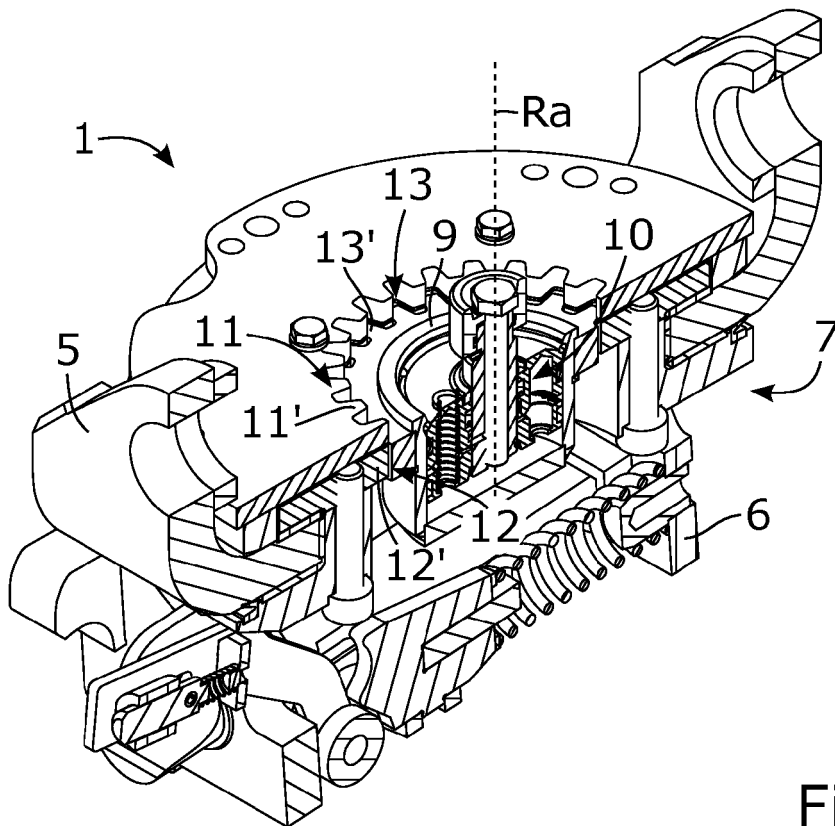


Fig. 7

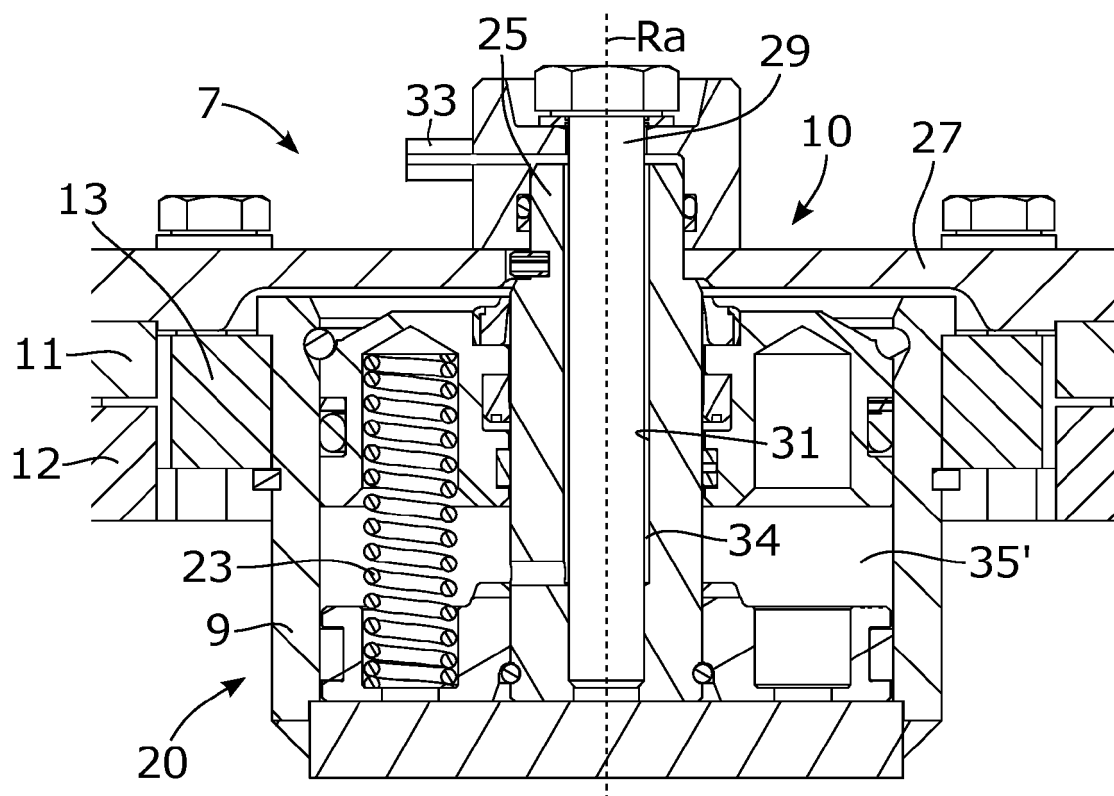


Fig. 8

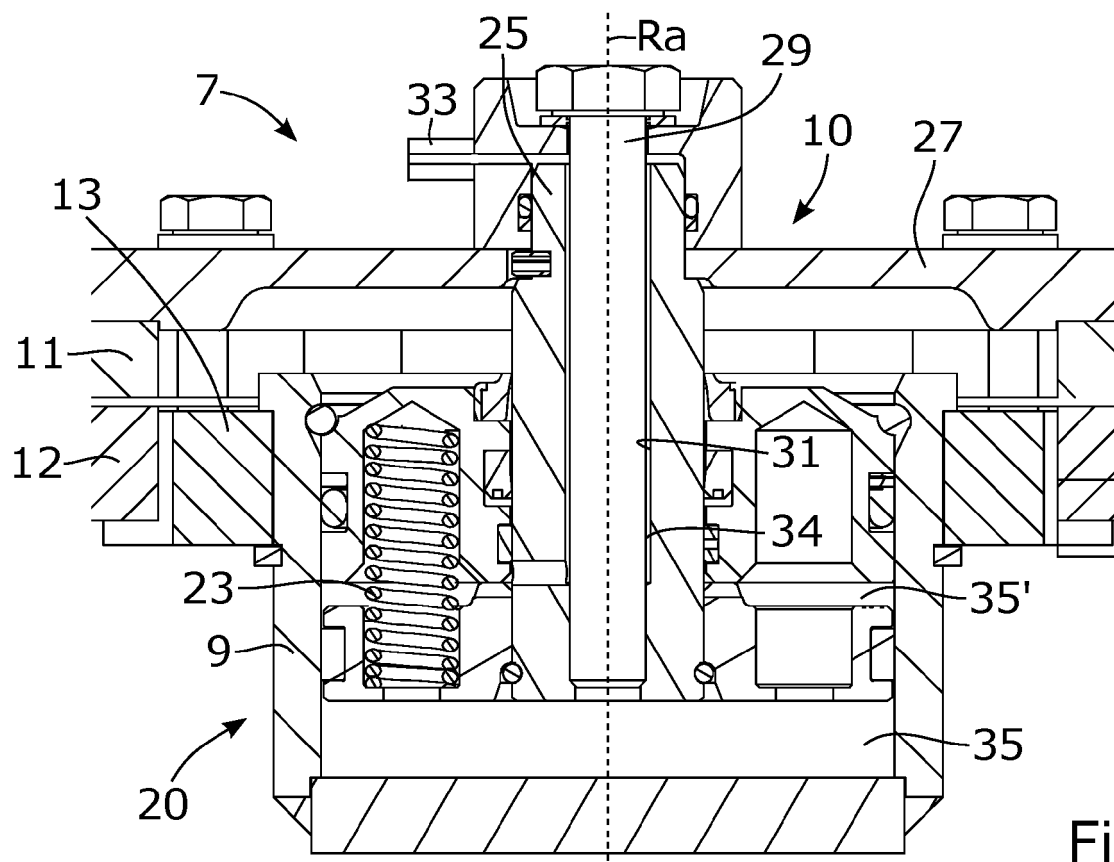


Fig. 9

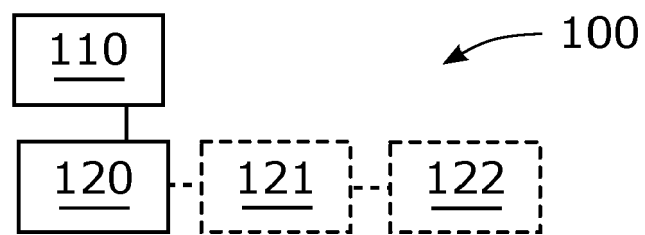


Fig. 10

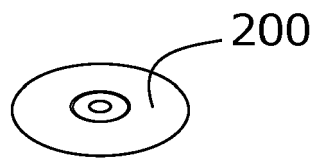


Fig. 11



EUROPEAN SEARCH REPORT

Application Number

EP 23 16 1533

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EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 1 587 991 B1 (KLAC INDUSTRIE [FR]) 2 April 2008 (2008-04-02)	1, 2, 9, 10, 12-15	INV. E02F3/36
A	* paragraphs [0011] - [0023]; figures 1-10 *	3-8, 11	

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