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(71) Applicant: **NCMT LIMITED** [GB/GB]; Ferry Works, Summer Road, Thames Ditton, Surrey KT7 0QJ (GB).

(72) Inventors: **MAUGHAN, Adrian**; NCMT Limited, Ferry Works, Summer Road, Thames Ditton, Surrey KT7 0QJ (GB). **TAYLOR, Ian**; NCMT Limited, Ferry Works, Summer Road, Thames Ditton, Surrey KT7 0QJ (GB).

(74) Agent: **LEACH, Sean**; Mathys & Squire LLP, The Shard, 32 London Bridge Street, London SE1 9SG (GB).

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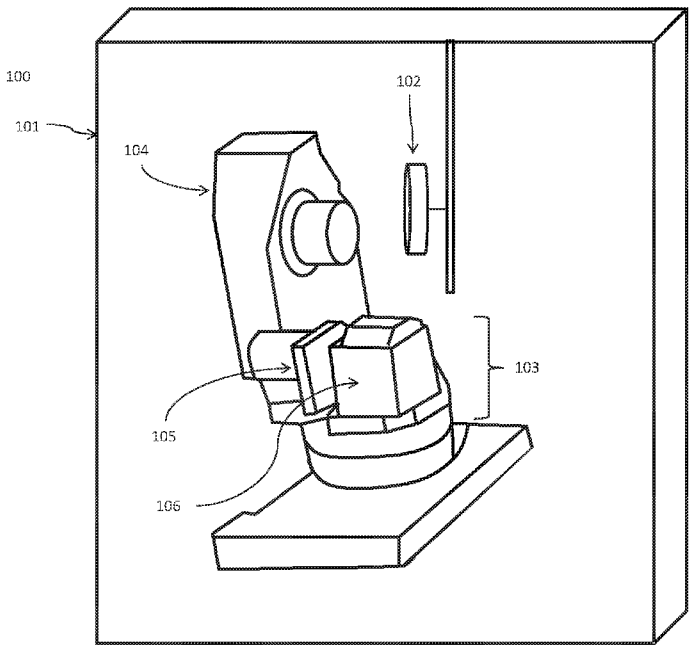
(54) Title: METHODS AND APPARATUS

Fig. 1



(57) Abstract: A dresser apparatus for dressing a grinding wheel, the apparatus comprising a dresser cradle unit for holding a dresser roll, and a rotary drive for driving the dresser roll, wherein the dresser cradle unit is removable from the rotary drive.

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Method and Apparatus

Field of Invention

The present invention relates to methods and apparatus for use with grinding wheels, and more particularly to dresser rolls which may be used to dress a grinding wheel, for example in a grinding machine.

Background

Grinding is a subset of cutting, in which each grain of abrasive functions as a microscopic single-point cutting edge (although of high negative rake angle), and shears a tiny chip that is analogous to what would conventionally be called a "cut" chip (turning, milling, drilling, tapping, etc.). The term “cutting” however is understood to refer to macroscopic cutting operations, as opposed to grinding.

Grinding can produce very fine finishes and can manufacture workpieces to very high precision. For the purposes of mass production, it can also be used to rough out large volumes of metal quite rapidly. Grinding is usually better suited to the machining of very hard materials than is conventional cutting or milling, and is of particular utility in the machining of hardened steels.

Grinding wheels are used extensively in engineering for a variety of abrasive cutting and machining operations. These wheels are generally made from a composite material consisting of a coarse-particle aggregate.

For optimal use grinding wheels often need to be dressed or trued

by the use of a dresser, to remove an outer layer of abrasive material and expose a fresh and sharp surface for grinding. Dressers may also provide grinding wheels with different profiles which may be desirable for performing different types of grinding operations.

In a grinding machine, a grinding wheel may be used as a tool in a computer numerical control (CNC) milling machine

In factories and other manufacturing facilities, the rate at which articles can be manufactured is a key issue. In addition, the ability to reliably maintain that rate of output is also significant. To avoid down-time resulting from a grinding machine being taken offline for maintenance, a second grinding machine might be provided to act as a back-up to ensure the rate of output is not interrupted.

Such machinery may be very large and very heavy and may incorporate large quantities of raw materials which may include non-renewable natural resources. In addition, the transport and installation of such machinery itself consumes energy. To reduce carbon emissions, and the unnecessary use of raw materials, some people have suggested that the only way forward is to accept reduced rate of output in manufacturing processes. Others have suggested that accepting lower reliability would also be an acceptable compromise.

The inventors in the present case however have aimed to address at least some of these problems whilst reducing the environmental impact of high throughput manufacturing processes.

Summary

Aspects of the invention are as set out in the independent claims

and optional features are set out in the dependent claims. Aspects of the invention may be provided in conjunction with each other and features of one aspect may be applied to other aspects.

In an aspect there is provided a dresser apparatus for dressing a grinding wheel, the apparatus comprising: a dresser cradle unit for holding a dresser roll, and a rotary drive for driving the dresser roll wherein the dresser cradle unit is removable from the rotary drive. For example the dresser cradle unit may be of unitary construction, for example integrated into a housing, built to be lifted off, or otherwise removed from, the rotary drive as an integrated unit. For example it may be built to be lifted, slid, or lowered, away from the drive unit.

In an aspect there is provided a method of changing the dresser roll of a dresser apparatus for dressing a grinding wheel, the method comprising: disengaging a drive linkage between a rotary drive of a dresser apparatus and a first dresser roll held in a dresser cradle unit, wherein the rotary drive is arranged to drive the dresser roll about a rotation axis and a seat is arranged to locate the dresser cradle unit in a selected position along the rotation axis; releasing the dresser cradle unit from the seat; removing the dresser cradle unit from the seat; seating a replacement dresser cradle unit in the seat, wherein the dresser cradle unit carries a second dresser roll; and, reengaging the drive linkage.

In an aspect there is provided a removable dresser roll cradle for a grinding machine, the dresser roll cradle comprising: a dresser roll coupling for coupling a dresser roll mandrel of the cradle to a rotary drive; and a base having a locator configured to locate the cradle in a seat for engagement of the dresser roll coupling with the rotary drive.

In an aspect there is provided a rotary drive unit for a dresser roll cradle of a grinding machine, the rotary drive unit comprising: a drive housing for encapsulating a rotary drive separate from a removable dresser roll cradle unit; and wherein the drive housing carries a drive coupling for coupling the rotary drive to the dresser cradle unit to drive a dresser roll of the removable dresser roll cradle unit.

Each of these foregoing aspects may be further refined as set out in the examples described herein.

The drive linkage may be self-sealing. For example the rotary drive unit and dresser cradle unit may comprise built-in sealing elements which interlock to form a seal when brought together.

The apparatus may comprise a support for holding the dresser cradle unit in engagement with the rotary drive. For example the rotary drive unit may be fixed to in position on the support and a dresser cradle unit may be aligned with the rotary drive when positioned on the support.

The support may comprise a seat for fixing a lateral location of the dresser cradle unit on the support. For example, coupling means, such as a pull-stud, may extend from the base of to secure the dresser cradle unit to the seat on the support. The seat may comprise a chuck and the pull-stud may be configured to engage with an opening in the chuck to secure the position of the dresser cradle unit on the support. The base of the dresser cradle may comprise a recess, for example a circular groove, for a sealing ring of the seat to engage with.

The apparatus may comprise an air supply outlet, for example wherein the dresser cradle unit comprises an air intake and in which seating the dresser cradle unit on the support positions

the air intake for connection with the air supply outlet. The outlet may comprise a nozzle for providing a jet of compressed air to the dresser cradle unit. The nozzle may be resilient.

The dresser cradle unit may comprise a dresser roll coupling for coupling the dresser roll to the rotary drive. The dresser roll may be mounted on a mandrel which can be driven by the dresser roll coupling to cause the dresser roll to rotate. The dresser roll coupling may provide indirect or direct linkage to the mandrel. For example the dresser roll coupling may be provided by an end of the mandrel (e.g. a face), configured for coupling to a rotary drive.

The dresser cradle unit may comprise a dresser housing for housing the dresser roll. For example the dresser housing may house a dresser roll mounted on a mandrel, and may provide an opening to enable a grinding wheel to be brought into contact with a portion of the dresser roll. The dresser housing may also comprise an opening for a face of the mandrel for example to enable coupling between the mandrel and the rotary drive. The dresser roll coupling and/or the drive coupling may be arranged to decouple from each other to allow the dresser cradle unit to be removed as a single unit.

The apparatus may comprise a drive housing which encapsulates the rotary drive separate from the dresser cradle unit.

The drive housing may carry a drive coupling for coupling the rotary drive to the dresser cradle unit to drive the dresser roll. For example, the rotary drive may comprise a drive head and the drive coupling may be provided by a face of rotary drive. The drive head may be operable move axially along the axis of rotation of the rotary drive. This may enable the drive coupling to engage to the dresser roll coupling, which may provide a drive

linkage.

The dresser housing and the drive coupling may cooperate to provide the sealed drive linkage between the dresser cradle unit and the rotary drive.

The sealing of the drive linkage may protect the dresser roll from the ingress of liquid. For example when a grinding wheel is being dressed by the dresser roll, a stream of liquid coolant may be provided around the contact point between the dresser roll and grinding wheel. The sealing of the drive linkage may prevent the ingress of liquid coolant to the drive linkage.

The sealing of the drive linkage may be provided by a labyrinth seal. For example the dresser cradle unit and rotary drive unit may comprise labyrinth elements, such as teeth and grooves, which may interlock when the dresser cradle unit and rotary drive unit are brought together to form the drive linkage.

The labyrinth seal may be provided by the drive housing and the dresser housing. For example the dresser housing may comprise a recess wherein the side edges comprise teeth and grooves to provide a 'female' labyrinth element. A portion of the drive housing may protrude from the rest of the drive housing, for example in the direction of the axis of rotation of the rotary drive to provide a 'male' labyrinth element. Two such elements may interlock to provide the labyrinth seal.

The drive coupling may comprise a V-ring seal for coupling to the drive coupling. For example the V-ring seal may couple to the dresser coupling when the drive linkage is formed.

The labyrinth seal may comprise a drainage channel. For example the drainage channel may extend around the edge of the labyrinth

seal. It may be provided by a gap between a tooth and a groove of two interlocking labyrinth elements. It may enable liquid between the two labyrinth elements to drain away.

The apparatus may comprise a disengager configured to disengage the drive linkage thereby to enable the dresser cradle unit to be removed from the rotary drive.

The disengager may be controllable to retract the drive coupling to disengage the drive linkage. For example the disengager may comprise a pneumatically driven piston which may be operable retract the rotary drive and thereby to decouple the drive coupling from the dresser coupling.

The rotary drive may comprise a motor coupling for providing rotary force, about a rotation axis, to the drive coupling, and the drive coupling may be movable along the rotation axis relative to the motor coupling. For example the motor coupling may be provided by a pulley that couples to the rotary drive and is driven by a motor. For example the rotary drive may be pneumatically retracted and the drive coupling may be spring loaded such that the drive coupling may move axially along the axis of rotation of the rotary drive. For example the drive coupling may travel up to 7mm along the axis of rotation.

The disengager may be controllable to retract the dresser roll coupling to disengage the drive linkage.

The air intake may be coupled to an airflow system arranged to pass a flow of air through the dresser roll. For example the air intake may be provided by an opening in the base of the dresser cradle unit, through which the air supply outlet positioned on the support may be inserted.

The apparatus may comprise a manipulator arm operable to engage with the dresser cradle unit and remove the dresser cradle unit from the rotary drive. For example the manipulator arm may be configured to couple and decouple to a manipulator arm interface provided by the dresser cradle unit housing.

The apparatus may comprise an inter-lock configured to inhibit the manipulator arm from operating to move the dresser cradle unit unless the drive linkage is disengaged.

The apparatus may comprise at least one replacement dresser cradle unit; for example wherein the at least one replacement dresser cradle unit holds a dresser roll. For example the at least one replacement dresser cradle unit may be stored in a dresser cradle storage unit. Dresser cradle units can be placed in and removed from the dresser cradle storage unit, for example by the manipulator arm

The manipulator arm may be configured to replace the dresser cradle unit with the replacement dresser cradle unit. For example a computer may provide instructions to the manipulator arm to remove a dresser cradle unit from the dresser apparatus, place it in the dresser cradle storage unit, and disengage from the dresser cradle unit. The manipulator arm may also be provided with instructions to engage with a replacement dresser cradle unit in the dresser cradle storage unit and transport it to the dresser apparatus for positioning on the support. For example the instructions may be provided to the manipulator arm by an external computer.

The manipulator arm may be configured to disengage with the removed dresser cradle unit and engage with the replacement dresser cradle unit.

The dresser roll may be mounted on a mandrel. For example the mandrel may be inserted into a cylindrical hole that extends through the centre of the dresser roll to support the dresser roll.

The mandrel may be removable from the dresser cradle unit. For example the dresser housing may comprise bearing caps configured to couple and decouple to the top surfaces of opposing walls of the dresser housing. This may provide circular gaps within which two portions of the mandrel are enclosed, for example to secure the mandrel in place within the dresser cradle unit. The bearings caps may be decoupled from the dresser housing wall to enable the mandrel to be lifted out of the dresser cradle unit.

Seating the replacement dresser cradle unit may position a drive coupling of the rotary drive for sealing engagement with the dresser cradle unit for sealing the drive linkage.

The dresser roll may be housed in a dresser housing and the dresser housing may cooperate with a drive coupling of the rotary drive to seal the drive linkage.

The dresser cradle unit may comprise a dresser roll coupling which cooperates with the drive coupling to form the drive linkage, and sealing the drive linkage may protect the dresser roll coupling from the ingress of liquid.

The drive linkage may be sealed by a labyrinth seal.

The replacement dresser cradle unit may position an air intake of the dresser cradle for connection with an air supply outlet of the dresser apparatus.

The method may comprise retracting a drive coupling of the rotary

drive to disengage the drive linkage.

Retracting the drive coupling may comprise moving the drive coupling along the rotation axis relative to a motor coupling of the rotary drive.

The method may comprise retracting the dresser roll coupling to disengage the drive linkage.

The dresser roll coupling may comprise a sealing adapter, configured to engage with a rotary drive to provide a sealed drive linkage.

The drive coupling may be configured to cooperate with a housing of a dresser roll cradle to provide a sealed drive linkage between the dresser roll cradle and the rotary drive.

The sealing of the drive linkage may be provided by a labyrinth seal.

The rotary drive unit may comprise a disengager configured to disengage the drive coupling from a dresser roll cradle, thereby to enable the dresser roll cradle to be removed from the rotary drive.

The disengager may be controllable to retract the drive coupling.

The rotary drive may comprise a motor coupling for providing rotary force, about a rotation axis, to the drive coupling, wherein the drive coupling may be movable along the rotation axis relative to the motor coupling.

Brief Description of Drawings

Embodiments of the disclosure will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 illustrates a machine and a dresser apparatus;

Figure 2 illustrates a dressing apparatus for a grinding wheel;

Figures 3A & 3B illustrate an example dresser cradle unit;

Figure 4 illustrates an example rotary drive unit;

Figure 5 shows an example coupling arrangement between a rotary drive unit and a dresser cradle unit; and

Figures 6A-C illustrate a sealing arrangement between a rotary drive unit and a dresser cradle unit.

Specific Description

A dresser apparatus for dressing a grinding wheel is described with reference to Figure 1. The dresser apparatus comprises a dresser cradle unit for holding a dresser roll, and a rotary drive for driving the dresser roll. The dresser apparatus is configured to enable the dresser cradle to be removed from the rotary drive, and to be replaced with another cradle unit whilst leaving the rotary drive intact. For example the dresser cradle unit may be arranged to be removed from the rotary drive as an integrated unit. This may enable one dresser cradle unit to be easily and quickly replaced with another whilst reducing the delay or interruption associated with maintenance.

Figure 1 shows a machine 100 comprising a grinding wheel 102, and a dresser apparatus 103 for dressing the grinding wheel 102. The machine comprises a machine housing 101 housing the grinding wheel and the dresser apparatus 103. The housing 101 also encloses a work unit 104 for holding a workpiece to be ground by the grinding wheel.

The grinding wheel 102 and the work unit 104 are operable to move and rotate relative to one another - e.g. under CNC control. The grinding wheel 102 can thus be brought into contact with a work piece object secured to the work unit in order to grind it into a desired shape. A grinding programme may be supplied to the machine to control the grinding operation and the relative position of the grinding wheel and object. The grinding wheel is operable to translate and rotate along or about multiple axes within the machine.

A dresser apparatus 103 comprises cradle unit 106 having a mandrel for carrying a dresser roll and a drive unit 105 for driving the dresser roll. The grinding wheel 102 may be brought into contact with a dresser roll held on the mandrel to dress or true the grinding wheel e.g. to provide it with a desired profile. The cradle unit is removable from the machine 100.

A manipulator arm (not shown) may also be provided which is operable to couple and decouple to the dresser cradle unit 106, for example to remove the dresser cradle unit from the work unit 104, or to replace the dresser cradle unit 106 with a replacement dresser cradle unit.

Figure 2 shows a dresser apparatus 200 for use in an apparatus such as that illustrated in Figure 1. The dresser apparatus comprises a dresser cradle unit 201, a rotary drive unit 203 and a seat 205. The apparatus further comprises a support 202 for holding the dresser cradle unit 201 in engagement with the rotary drive 203. The rotary drive unit 203 is coupled to the support such that the position of the rotary drive unit 203 is fixed relative to the support 202. The support comprises a seat 205 for fixing the lateral location of the dresser cradle unit 201. For example the seat may comprise a chuck that acts as a zero point location system for fixing the lateral position of the dresser

cradle unit 201 relative to the rotary drive unit 203. This may ensure that the dresser cradle unit is positioned on the support so that a mandrel on which a dresser roll is mounted is aligned with the rotary drive 204. This may enable the rotary drive 204 to form a drive linkage and drive the dresser roll. For example a circular face of the rotary drive may align with a face of the mandrel, upon which the dresser roll may be mounted, such that they share an axis of rotation.

The support also comprises an air supply outlet 206 for supplying air to the dresser cradle unit 201. The air supply outlet 206 is mounted onto the support 202 in a fixed position relative to the seat 205 and rotary drive unit 203. The outlet 206 may comprise a resilient nozzle for providing a jet of compressed air to the dresser cradle unit 201.

Figure 3A and Figure 3B show an example dresser cradle unit 300, for example one that may be used in the apparatus 200 of Figure 2.

The dresser cradle unit 300 comprises a dresser housing 301 which defines an interior space within which a dresser roll (not shown) can be housed. A mandrel 302 extends across a width of the interior space from one face of the dresser housing 301 to an opposing face to define an axis of rotation 303. A dresser roll may be mounted on the mandrel 302 and the mandrel 302 and dresser roll may be operable to rotate about the axis of rotation 303. The dresser cradle unit comprises a dresser roll coupling 304 (304 is not shown on Fig.3 - see 602 in Fig.6 for example) for coupling the mandrel 302 to a rotary drive, for example the rotary drive 204 of apparatus 200.

The dresser housing 301 comprises a base 305, and two parallel opposing walls 306 that extend perpendicular to the base. The top

surfaces of the two opposing walls 306 comprise semi-circular grooves 307 to enable the mandrel 302 to rest in the grooves. A back wall 308 extends perpendicularly between the ends of the two opposing walls 306.

The dresser housing 301 also comprises two bearing caps 309 coupled to the top surfaces of the opposing walls 306 to provide circular openings within which two portions of the mandrel 302 are enclosed, for example so that the mandrel 302 is held securely in place. This may minimise the translational movement of the mandrel 302 and any dresser roll mounted on it, during the dressing operation. The dresser housing 301 also comprises a cover 310 coupled to the tops of the walls and the bearing caps.

A dresser roll mounted on the mandrel 302 fits within the internal space of the dresser housing 301, for example as defined by the walls 306, 308, base 305 and cover 310 of the dresser housing 301. The dresser housing 301 has an opening between an edge of the cover 310 and a portion of the base 305 of the dresser housing 301, to enable the dresser roll mounted on the mandrel 302 to make contact with a grinding wheel during the wheel dressing operation.

Figure 3B shows the dresser cradle unit 300 positioned on a support 311 and aligned with a drive unit 312. The dresser cradle unit 300 further comprises an interface 313 for a manipulator arm. In Figure 3B the interface 313 protrudes from the back wall of the dresser housing 301. A manipulator arm may attach and lock on to the dresser housing 301 at the interface 313. Once attached, the manipulator arm is operable to move the dresser cradle unit 300, for example to extract the dresser cradle unit from the support and rotary drive unit of apparatus 200.

With reference again to Figures 2 and 3, the under-surface of the

base of the dresser cradle unit 200 comprises a locator configured to locate the dresser cradle unit 300 in a seat, for example the seat 205 in Figure 2, to enable the dresser roll coupling to engage with the rotary drive 204. For example, coupling means, such as a pull-stud, extend from the base of the dresser cradle unit 200 to secure the dresser cradle unit 201 to the seat 205 on the support 202. The seat 205 in Figure 2 may comprise a chuck such as an Erowa PowerChuck (RTM), and the pull-stud may be configured to engage with an opening in the chuck to secure the position of the dresser cradle unit 201 on the support. The base of the dresser cradle also comprises a recess, for example a circular groove, for a sealing ring of the seat to engage with. This may assist in securing the dresser cradle unit on the seat 205 and minimises the ingress of liquid between the seat 205 and the dresser cradle unit 201.

The dresser cradle also comprises an air intake, for example a cross drilling through the base of the dresser housing that links to an air supply outlet, such as the air supply outlet 206 mounted on the support 202 in Figure 2. Seating the dresser cradle unit 300 on the support, for example by mounting the dresser cradle unit onto the chuck, positions the air intake of the dresser cradle unit for connection with the air supply outlet mounted on the support. The air intake may be coupled to an airflow system within the dresser cradle unit that is arranged to pass a flow of air through the dresser roll mandrel 302.

The support 202 comprises a set of compressed air control lines that connect air outlets, such as the air supply outlet 206 for the dresser cradle unit, to fittings that extend out from the support and connect to an external air supply. The fittings are protected by a steel cover 207 coupled to an edge of the support. The control lines may be integrated into the support 202, for example one line extends from the air supply outlet through the

interior of the support 202 to a fitting that connects to an external air supply.

The seat 205 may comprise an air-blast ring with openings spaced radially around the seat for cleaning the locator, for example by providing a blast of air through the openings to the surface associated with the mounting features on the base of the dresser cradle unit. The openings connect to an air supply via one of the compressed air control lines.

Figure 4 shows an example of the interior of a rotary drive unit, for example one that could be used in the apparatus 200 of Figure 2. The cover plate in Figure 4 has been removed to show part of the drive mechanism. The cover plate is sealed to a face of the rest of the drive housing 401 with an O-ring seal. The mechanism comprises a driver pulley 402, a driven pulley 403 and a tension pulley 404, which each comprise a toothed outer edge. These are coupled to one another via a toothed belt 405, such that the teeth of the belt interlock with the teeth on the outer edges of the three pulleys. The pulleys 402, 403, 404 are translationally fixed within the drive housing 401 and are configured to rotate about an axis, wherein the rotation axes of the three pulleys are substantially parallel to one another. An electric motor 409 drives the rotation of the driver pulley 402. The rotation of the driver pulley is configured to drive the belt 405 and therefore drive the rotation of the driven pulley 403, and the tension pulley 404. The driven pulley acts as a motor coupling for coupling to and driving the rotary drive 406. The tension pulley may control the tension of the belt for example to ensure it remains in a taut state around the pulleys. The tension of the belt may be controlled by the operation of a belt tension adjuster 412 located on the exterior of the drive housing 401, for example an adjustable screw coupled to the tension pulley 404. In other examples the rotary drive unit does not contain a

tension pulley and the toothed belt couples only to a driver pulley and a driven pulley.

A rotary drive 406 is mounted onto the motor coupling, for example the driven pulley 403, so that they share an axis of rotation 411. The rotary drive may extend through an opening in the cover plate such that a drive coupling 407 (e.g. a circular outer face of the rotary drive) may be located outside of the drive housing 401, enabling it to engage with and drive the rotation of other apparatus, such as a dresser roll (see Figure 2 for example).

The rotary drive 406 is operable to extend and retract along the axis of rotation 411 of the motor coupling, such that for example the axial position of the drive coupling 407 relative to the motor coupling 403 is adjustable. For example the rotary drive may be configured to travel axially between a retracted and extended position. A pneumatic cylinder is located along the axis of rotation 411 of the rotary drive, on the opposite side of the motor coupling 403, which is operable to retract the rotary drive 406. The drive coupling is the interface at which the rotary drive may couple to a dresser roll coupling, for example to enable the rotary drive to drive a dresser roll mounted on a mandrel as shown in Figure 3.

The drive mechanism also comprises switches 408 for monitoring the status of the rotary drive. For example, the switches may monitor: the rotation of the rotary drive, the extent to which the drive coupling is retracted, and whether the drive coupling in an engaged or disengaged state.

The drive housing comprises a compressed air connection point 410 that connects to one of the compressed air control lines in the support to enable compressed air from an external supply to flow

into the interior of the drive housing and increase the pressure.

For the rotary drive to drive the dresser roll, a sealed drive linkage is formed between the dresser cradle unit and the rotary drive. The drive linkage may be self-sealing. For example, the dresser housing of the dresser cradle unit and the drive coupling carried by the drive housing may cooperate to provide the sealed drive linkage between the dresser cradle unit and the rotary drive.

The drive linkage between the rotary drive and the dresser roll may be formed by an engagement/disengagement mechanism, such that when the dresser cradle is positioned in the seat, the mechanism brings the drive coupling 407 into contact with the dresser roll coupling (see 602 in Fig.6). As discussed in relation to Figure 4, the drive coupling 407 may travel axially relative to a driven pulley, and the extent to which the drive coupling extends out from the drive housing 401 may be adjusted for it to couple to the dresser roll coupling (see 602 in Fig.6).

Figure 5 shows a schematic view of an example drive linkage between a dresser cradle unit 510 and a rotary drive unit 520. The rotary drive 503 may be moveable, for example it may comprise control springs 502 such that the drive coupling 501 is spring loaded in order to extend and engage with the dresser roll coupling (see 602 in Fig.6). The mechanism may comprise a disengager configured to disengage the drive linkage and thereby enable the dresser cradle unit 510 to be removed from the rotary drive 503. For example the rotary drive 503 comprises a splined shaft 505 that may be controlled by a pneumatically driven piston 506, such that the drive coupling 501 is retracted to disengage the drive linkage. In another example the disengager is controllable to retract the dresser roll coupling (see 602 in Fig.6) to disengage the drive linkage. It will be appreciated

that the region 504, 510 indicated on Figure 5 may enable a dresser roll coupling such as that illustrated in Figure 6A (see element 602) to be brought into engagement with the rotary drive 503.

The drive linkage may be sealed to protect the coupling arrangement from the ingress of liquid. The sealing may be provided by a labyrinth seal between the dresser housing and the drive housing. The labyrinth seal is comprised of several tooth-like elements on one component that interlock with grooves in another component. For example the drive housing may carry a 'male' labyrinth element that extends outwards from the drive housing, and the dresser housing may comprise a recess which provides a 'female' labyrinth element. When the rotary drive is brought into engagement with the dresser cradle unit, these two elements may be brought together to interlock and form the labyrinth seal.

Figure 6A shows an example of a portion of a dresser cradle unit 601 for coupling to a rotary drive unit. An end face of the mandrel is exposed through a hole in a face of the dresser housing to provide a dresser roll coupling which cooperates with a drive coupling, for example an end face of the rotary drive, to form a drive linkage. The face of the dresser housing comprises a recess for forming a seal with the drive housing. The recess provides a female labyrinth element 603 comprising a set of teeth and grooves around the edge of the recess, between which the teeth and grooves of a male labyrinth element can interlock to form a seal.

Figure 6B shows an example of a portion of a rotary drive unit 610 for coupling to a dresser cradle unit. The drive housing provides a male labyrinth element 611 which extends from the cover plate of the drive housing along the axis of rotation of

the rotary drive. The male labyrinth element comprises a set of teeth for interlocking with the grooves a female labyrinth element such as the one provided by the dresser housing in Figure 6A. When the dresser cradle unit and rotary drive unit are brought together, for example by positioning the dresser cradle unit on a seat as described above, the interlocking labyrinth elements form a labyrinth seal for protecting the dresser roll drive linkage from the ingress of liquid. For example, during the grinding operation of a grinding machine in which the dresser apparatus is situated, liquid coolant may be injected into an area around the grinding wheel. The seal provided may prevent liquid from seeping into the drive linkage and disrupting the operation of the dresser apparatus. When the drive linkage is formed there is a gap between the male and female labyrinth elements; the interlocked teeth and grooves of the two labyrinth elements do not contact one another.

The drive housing further comprises a drain channel 612 to enable liquid between the rotary drive unit 610 and dresser cradle unit 601 to drain away from the drive linkage. For example the drain channel 612 is provided by a groove in the male labyrinth element 611 that extends from the opening for the drive coupling 613 in the drive housing to the base of the rotary drive unit where it meets the support 614.

Figure 6C shows an example of a sealed drive linkage 620 formed between a dresser cradle unit 600 and a rotary drive unit 610. Teeth and grooves from the male labyrinth element 611 of the rotary drive unit 610 and female labyrinth element 603 of the dresser cradle unit 600 are shown interlocking with one another to form a labyrinth seal around the drive linkage. The formation of the labyrinth seal may provide a labyrinth drainage channel 621. For example forming the labyrinth seal may provide a passage between the two labyrinth elements along the length of the

labyrinth seal. Figure 6C shows a gap between a tooth of the female labyrinth element and a groove in the male labyrinth element for example that provides the labyrinth drainage channel 621. This may enable liquid between the two labyrinth elements to drain away when the sealed drive linkage is formed.

As shown in Figures 6B and 6C, the drive coupling further comprises a V-ring seal 615 for sealing the drive linkage between the dresser roll coupling and the drive coupling, for example to protect the drive linkage from the ingress of liquid. The V-ring seal comprises a ring, of elastomer for example, mounted to the drive coupling 613. The V-ring seal 615 comprises a tapered lip that extends from the drive coupling at an oblique angle for sealing against the surface of the dresser roll coupling. During the dressing operation the V-ring seal rotates as the rotary drive rotates, maintaining a seal between the dresser coupling 613 and the drive coupling 602.

A manipulator arm may be provided configured to load and unload the dresser cradle unit from the seat on the support. An example method of loading and unloading a dresser cradle unit using a manipulator arm is described herein. A computer programme may provide the manipulator arm with instructions to perform the actions described herein. In order to load a dresser cradle, the manipulator arm engages with the manipulator arm interface on the dresser cradle and moves the dresser cradle to approach the support in a ‘pre-load’ position in proximity to the support. The manipulator arm then laterally aligns the dresser cradle with the drive housing, by aligning the labyrinth seal arrangement on the dresser cradle with the labyrinth seal arrangement on the drive housing. Once aligned the manipulator arm lowers the dresser cradle onto the seat until that the pull-stud on the under-surface of the base of the dresser cradle unit engages with the

chuck. When the dresser cradle unit is secured in position, manipulator arm disengages from the manipulator arm interface. In order to unload the dresser cradle unit, the steps above may be performed in reverse. The manipulator arm may be configured, however, to only remove the dresser cradle unit from the seat if the drive linkage is disengaged. For example an interlock may inhibit the manipulator arm and prevent it from removing the dresser cradle unit when the drive linkage is engaged.

The apparatus may further comprise at least one replacement dresser cradle unit. These may be stored in a dresser cradle storage unit. The replacement dresser cradle units hold a dresser roll, so that a dresser roll can be replaced by replacing the dresser cradle unit.

A manipulator arm may also be operable to replace the dresser cradle unit with a replacement dresser cradle unit. For example, the manipulator arm may configured to engage with a dresser cradle unit, such as a dresser cradle unit positioned on a seat for engagement with a rotary drive, at its manipulator arm interface. If the drive linkage is disengaged the manipulator arm may remove the dresser cradle unit from the seat and transport it away from the support, for example to the dresser cradle storage unit. The manipulator arm disengages with the removed dresser cradle unit and engages with the manipulator arm interface of the replacement dresser cradle unit. It may then transport the replacement dresser cradle unit to the support, position it on the seat and disengage from the manipulator arm interface.

In an embodiment the dresser cradle unit is configured to be loaded and unloaded onto a seat, and when in position to form a drive linkage between the rotary drive and a dresser roll carried by the cradle unit. To load a dresser cradle unit into the dresser apparatus the dresser cradle unit is brought in line with

a rotary drive unit. A dresser roll coupling, which drives a mandrel carrying the dresser roll, is aligned with the rotary drive. The dresser cradle unit is lowered onto a seat, such as a chuck, that a pull-stud on the base of the dresser cradle engages with to secure the dresser cradle unit onto the support. The dresser cradle unit and drive unit both have sealing elements such that as the dresser cradle unit is positioned on the chuck a seal is formed around the rotary drive and mandrel. The rotary drive may extend from the drive unit to couple to the mandrel and form a drive linkage for driving the rotation of the dresser roll. The aforementioned steps may be performed in reverse order to disengage the drive linkage between the rotary drive and the dresser roll, and remove the dresser cradle unit from the dresser apparatus. In this way one dresser cradle unit may be replaced with another.

The above embodiments are to be understood as illustrative examples. Further embodiments are envisaged. It is to be understood that any feature described in relation to any one embodiment may be used alone, or in combination with other features described, and may also be used in combination with one or more features of any other of the embodiments, or any combination of any other of the embodiments. Furthermore, equivalents and modifications not described above may also be employed without departing from the scope of the invention, which is defined in the accompanying claims.

Other variations and modifications of the apparatus will be apparent to persons of skill in the art in the context of the present disclosure.

In an aspect there is provided a dresser roll cradle for a grinding machine, the dresser roll cradle comprising: a dresser roll coupling for coupling a dresser roll mandrel of the cradle

to a rotary drive; and a base having a locator configured to locate the cradle in a seat for engagement of the dresser roll coupling with the rotary drive.

In an aspect there is provided a rotary drive unit for a dresser roll cradle of a grinding machine, the rotary drive unit comprising: a drive housing for encapsulating a rotary drive separate from a dresser roll cradle unit; and wherein the drive housing carries a drive coupling for coupling the rotary drive to the dresser cradle unit to drive a dresser roll.

Claims:

1. A dresser apparatus for dressing a grinding wheel, the apparatus comprising:
a dresser cradle unit for holding a dresser roll, and
a rotary drive for driving the dresser roll, wherein the dresser cradle unit is removable from the rotary drive.

2. The apparatus of claim 1 comprising a sealed drive linkage between the dresser cradle unit and the rotary drive.

3. The apparatus of claim 2 wherein the drive linkage is self-sealing.

4. The apparatus of claim 1, 2, or 3 comprising a support for holding the dresser cradle unit in engagement with the rotary drive.

5. The apparatus of claim 4 wherein the support comprises a seat for fixing a lateral location of the dresser cradle unit on the support.

6. The apparatus of claim 4 or 5 comprising an air supply outlet, wherein the dresser cradle unit comprises an air intake and in which seating the dresser cradle unit on the support positions the air intake for connection with the air supply outlet.

7. The apparatus of any of claims 1 to 6 wherein the dresser cradle unit comprises a dresser roll coupling for coupling the dresser roll to the rotary drive.

8. The apparatus of claim 7 wherein the dresser cradle unit comprises a dresser housing for housing the dresser roll.

9. The apparatus of claim 8, comprising a drive housing which encapsulates the rotary drive separate from the dresser cradle unit.

10. The apparatus of claim 9 wherein the drive housing carries a drive coupling for coupling the rotary drive to the dresser cradle unit to drive the dresser roll.

11. The apparatus of claim 10 wherein the dresser housing and the drive coupling cooperate to provide the sealed drive linkage between the dresser cradle unit and the rotary drive.

12. The apparatus of claim 11 wherein the sealing of the drive linkage protects the drive coupling arrangement and/or the dresser roll coupling from the ingress of liquid.

13. The apparatus of claim 12 wherein the sealing of the drive linkage is provided by a labyrinth seal.

14. The apparatus of claim 13 wherein the labyrinth seal is provided by the drive housing and the dresser housing.

15. The apparatus of any of claims 10 to 14 wherein the drive coupling comprises a V-ring seal for coupling to the dresser roll coupling.

16. The apparatus of claim 13 or 14 wherein the labyrinth seal comprises a drainage channel.

17. The apparatus of any of claims 11 to 16 comprising a disengager configured to disengage the drive linkage thereby to enable the dresser cradle unit to be removed from the rotary drive.

18. The apparatus of claim 17 wherein the disengager is controllable to retract the drive coupling to disengage the drive linkage.

19. The apparatus of claim 18 in which the rotary drive comprises a motor coupling for providing rotary force, about a rotation axis, to the drive coupling, and wherein the drive coupling is movable along the rotation axis relative to the motor coupling.

20. The apparatus of claim 17 wherein the disengager is controllable to retract the dresser roll coupling to disengage the drive linkage.

21. The apparatus of claim 6 wherein the air intake is coupled to an airflow system arranged to pass a flow of air through the dresser roll for example through the mandrel.

22. The apparatus of claim 2, or any preceding claim as dependent upon claim 2, comprising a manipulator arm operable to engage with the dresser cradle unit and remove the dresser cradle unit from the rotary drive.

23. The apparatus of claim 22 comprising an inter-lock configured to inhibit the manipulator arm from operating to move the dresser cradle unit unless the drive linkage is disengaged.

24. The apparatus of claim 22 or 23 comprising at least one replacement dresser cradle unit; for example wherein the at least one replacement dresser cradle unit holds a dresser roll.

25. The apparatus of claim 24 wherein the manipulator arm is configured to replace the dresser cradle unit with the

replacement dresser cradle unit.

26. The apparatus of claim 24 wherein the manipulator arm is configured to disengage with the removed dresser cradle unit and engage with the replacement dresser cradle unit.

27. The apparatus of claim 1 wherein the dresser roll is mounted on a mandrel.

28. The apparatus of claim 27 wherein the mandrel is removable from the dresser cradle unit.

29. A method of changing the dresser roll of a dresser apparatus for dressing a grinding wheel, the method comprising:

disengaging a drive linkage between a rotary drive of a dresser apparatus and a first dresser roll held in a dresser cradle unit, wherein the rotary drive is arranged to drive the dresser roll about a rotation axis and a seat is arranged to locate the dresser cradle unit in a selected position along the rotation axis;

releasing the dresser cradle unit from the seat;

removing the dresser cradle unit from the seat;

seating a replacement dresser cradle unit in the seat, wherein the dresser cradle unit carries a second dresser roll;

and, reengaging the drive linkage.

30. The method of claim 29, wherein seating the replacement dresser cradle unit positions a drive coupling of the rotary drive for sealing engagement with the dresser cradle unit for sealing the drive linkage.

31. The method of claim 30 wherein the drive linkage is self-sealing.

32. The method of claim 30 or 31 wherein the dresser roll is housed in a dresser housing and the dresser housing cooperates with a drive coupling of the rotary drive to seal the drive linkage.

33. The method of claim 32 wherein the dresser cradle unit comprises a dresser roll coupling which cooperates with the drive coupling to form the drive linkage, and wherein sealing the drive linkage protects the dresser roll coupling from the ingress of liquid.

34. The method of claim 33 wherein the drive linkage is sealed by a labyrinth seal.

35. The method of any of claims 31 to 34 wherein the drive coupling comprises a V-ring seal for coupling to the dresser roll drive coupling.

36. The method of claim 30 or 31 in which seating the replacement dresser cradle unit positions an air intake of the dresser cradle for connection with an air supply outlet of the dresser apparatus.

37. The method of any of claims 29 to 36 comprising retracting a drive coupling of the rotary drive to disengage the drive linkage.

38. The method of claim 37 in which retracting the drive coupling comprises moving the drive coupling along the rotation axis relative to a motor coupling of the rotary drive.

39. The method of any of claims 33 to 36 comprising retracting the dresser roll coupling to disengage the drive linkage.

40. A removable dresser roll cradle for a grinding machine, the dresser roll cradle comprising:

a dresser roll coupling for coupling a dresser roll mandrel of the cradle to a rotary drive;

a base having a locator configured to locate the cradle in a seat for engagement of the dresser roll coupling with the rotary drive.

41. The cradle of claim 40, wherein the dresser roll coupling comprises a sealing adapter, configured to engage with a rotary drive to provide a sealed drive linkage.

42. A rotary drive unit for a dresser roll cradle of a grinding machine, the rotary drive unit comprising:

a drive housing for encapsulating a rotary drive separate from a removable dresser roll cradle unit; and

wherein the drive housing carries a drive coupling for coupling the rotary drive to the dresser cradle unit to drive a dresser roll of said removable dresser roll cradle unit.

43. The rotary drive unit of claim 42 wherein the drive coupling is configured to cooperate with a housing of a dresser roll cradle to provide a sealed drive linkage between the dresser roll cradle and the rotary drive.

44. The rotary drive unit of claim 43 wherein the sealing of the drive linkage is provided by a labyrinth seal.

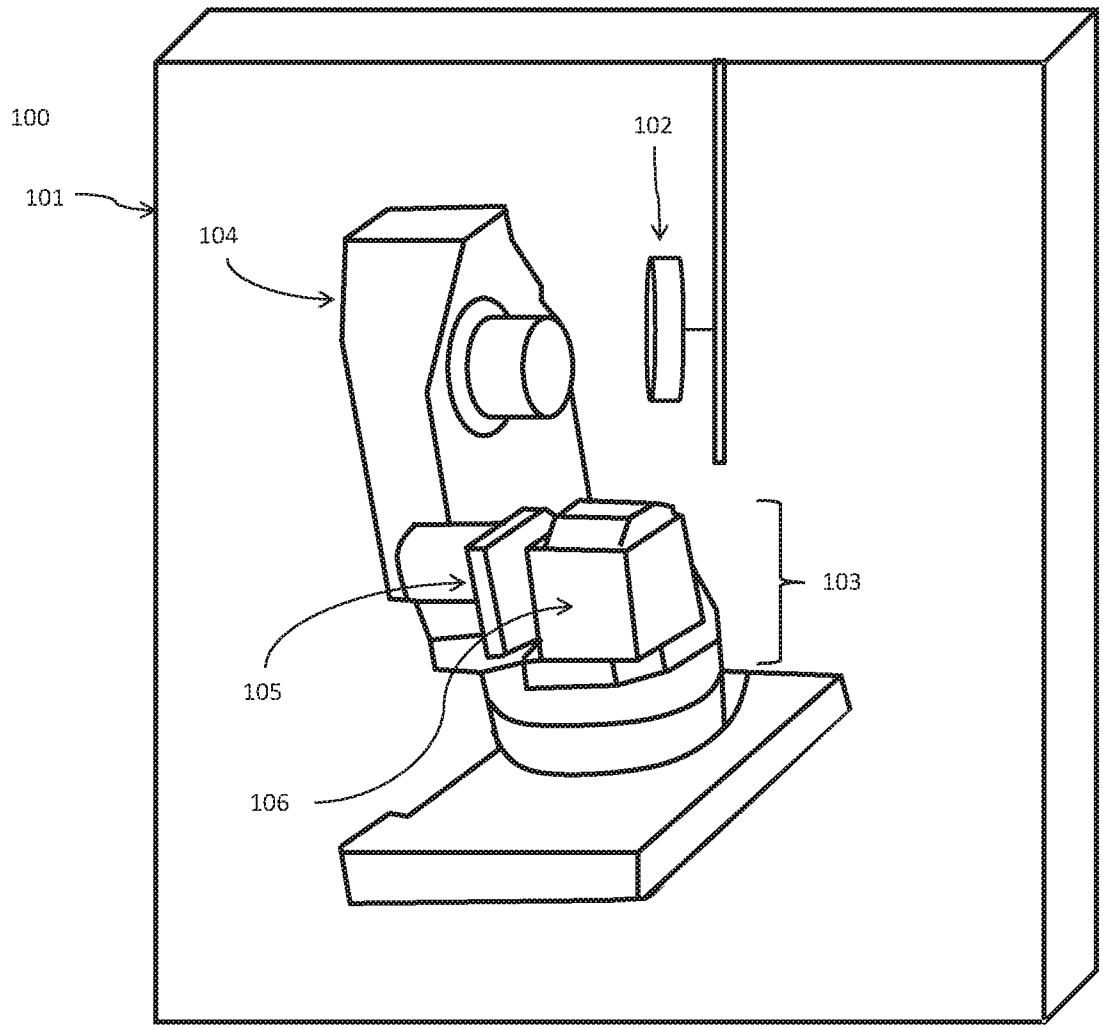
45. The rotary drive unit of any of claims 43 to 44 comprising a disengager configured to disengage the drive coupling from a dresser roll cradle, thereby to enable the dresser roll cradle to be removed from the rotary drive.

46. The rotary drive unit of claim 45 wherein the disengager is

controllable to retract the drive coupling.

47. The rotary drive unit of claim 46 in which the rotary drive comprises a motor coupling for providing rotary force, about a rotation axis, to the drive coupling, and wherein the drive coupling is movable along the rotation axis relative to the motor coupling.

Fig. 1



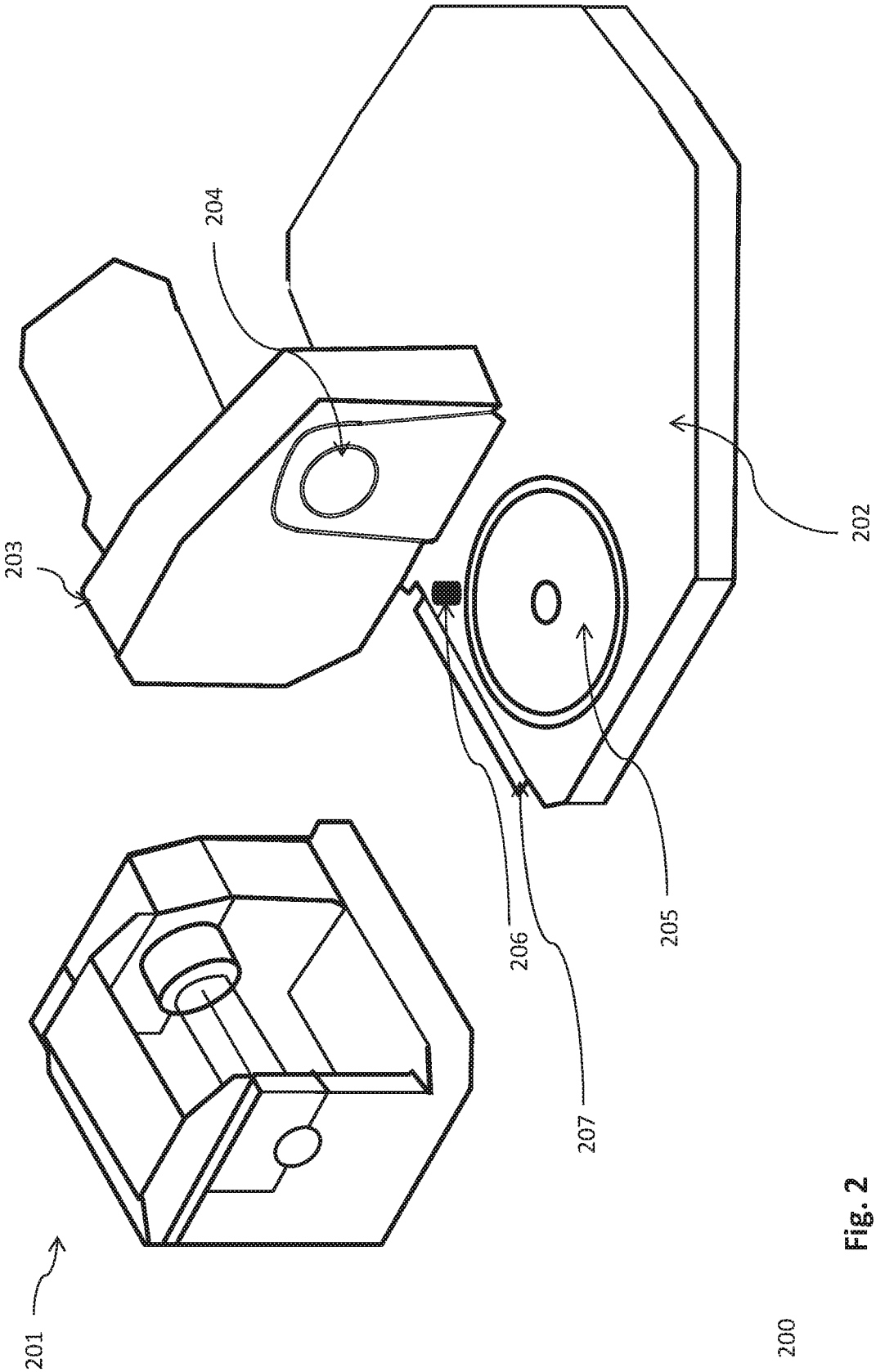


Fig. 2

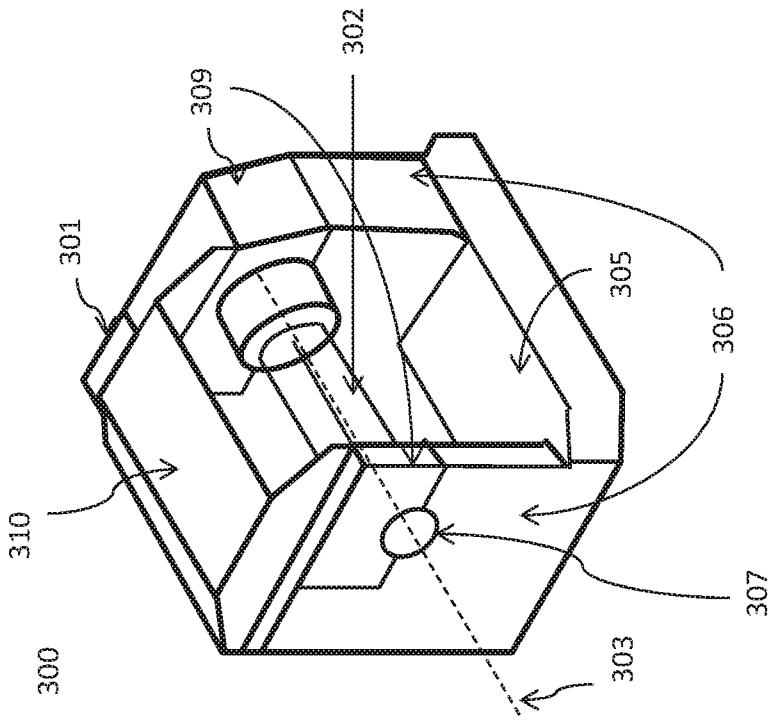


Fig. 3A

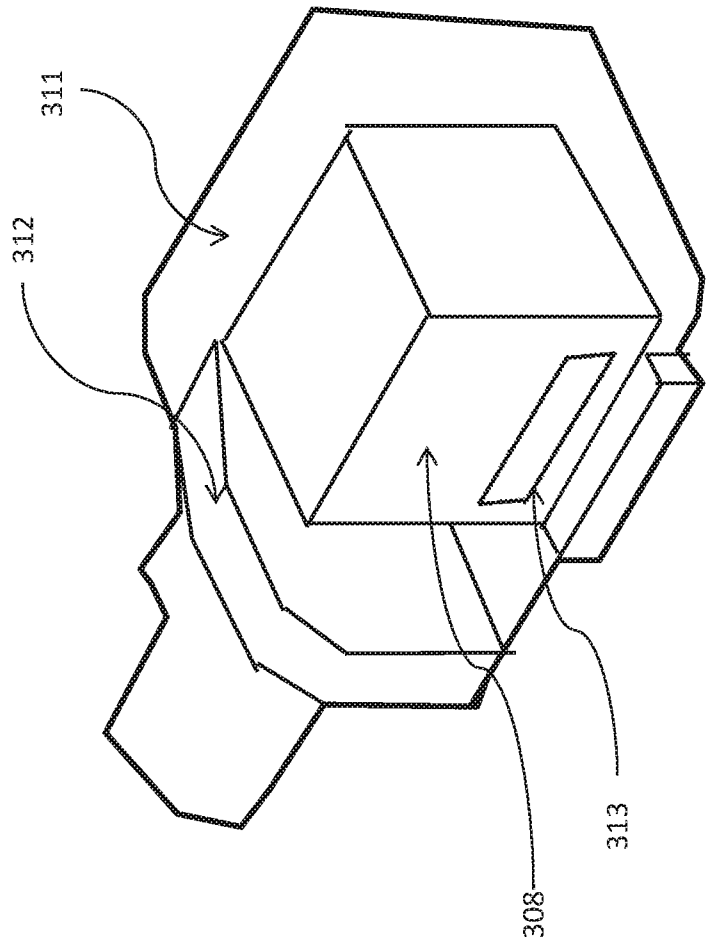


Fig. 3B

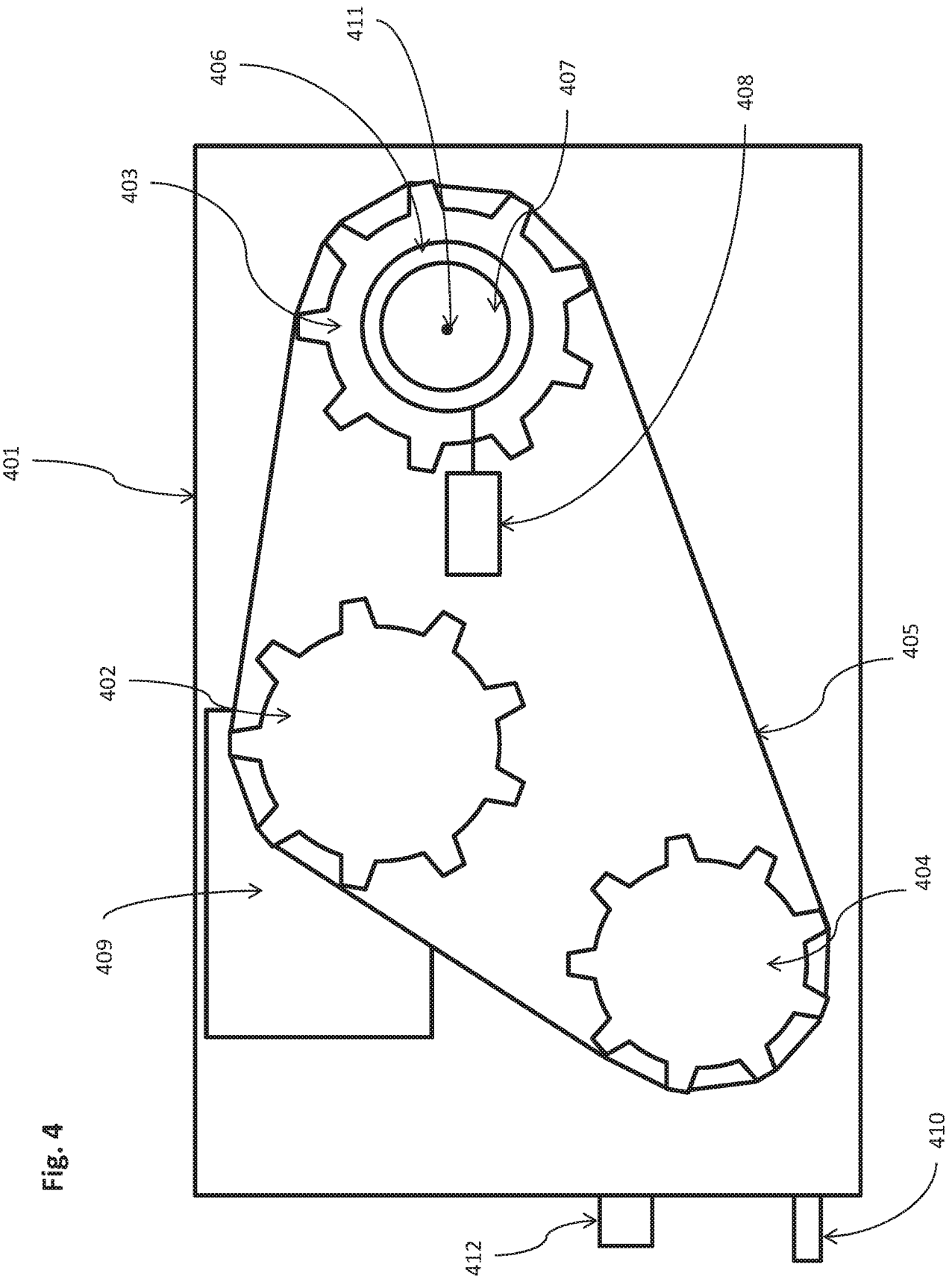
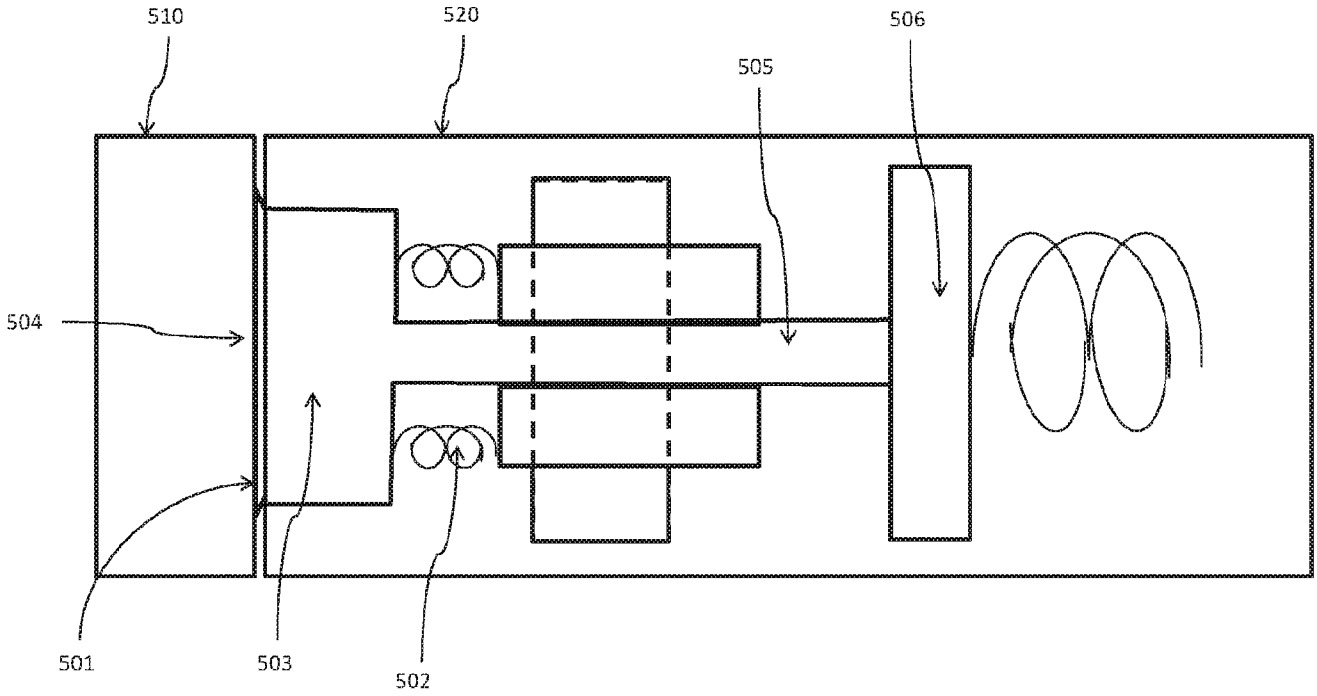


Fig. 4

Fig. 5



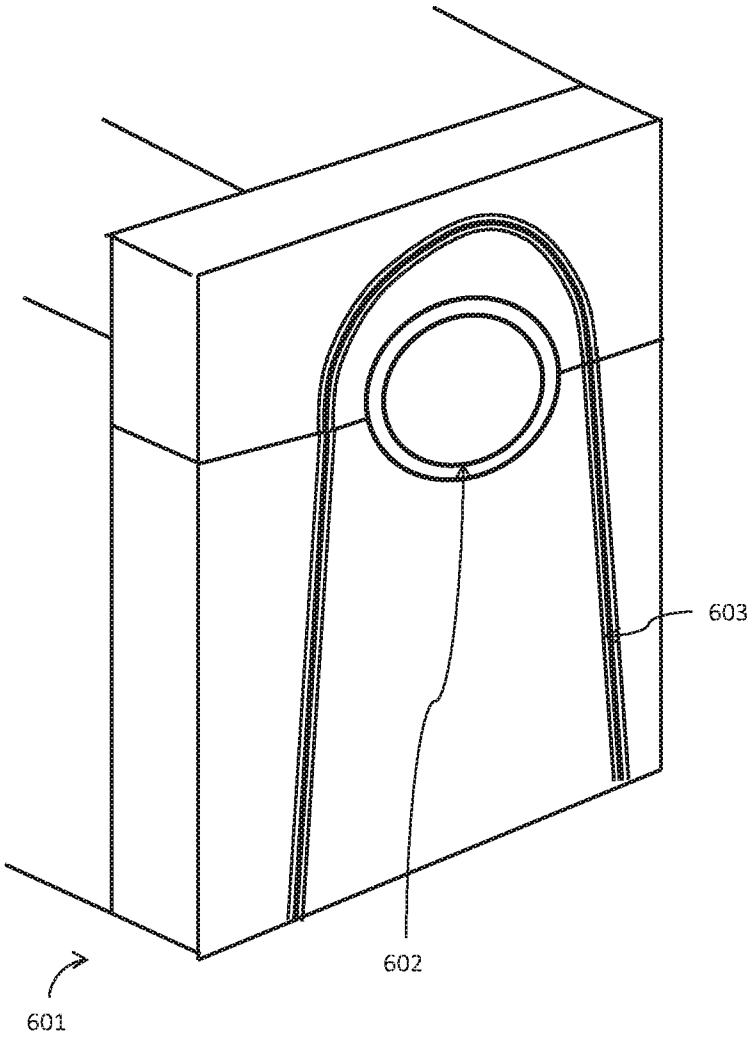


Fig. 6A

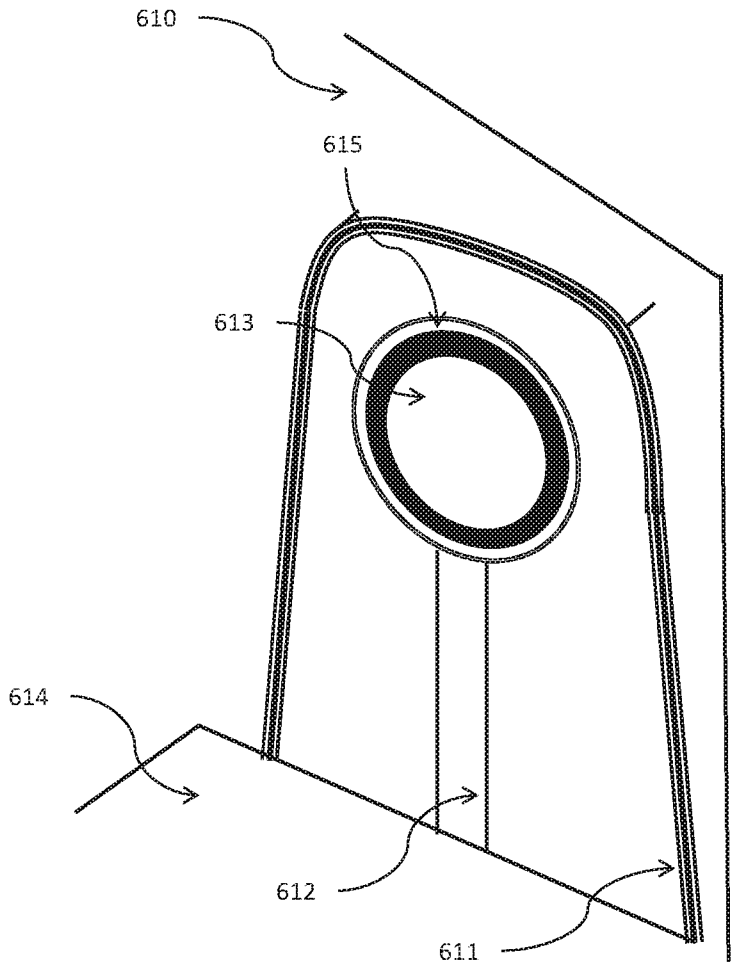


Fig. 6B

Fig. 6C