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- (73) Patenthaver: **Heico Befestigungstechnik GmbH, Ensestrasse 1-9, 59469 Ense-Niederense, Tyskland**
- (72) Opfinder: **VORNWEG, Stefan, c/o Heico Befestigungstechnik GmbH, Ensestraße 1-9, 59469 Ense-Niederense, Tyskland**
- (74) Fuldmægtig i Danmark: **NORDIC PATENT SERVICE A/S, Bredgade 30, 1260 København K, Danmark**
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Description

The invention relates to a multiplex screw driver, also called a torque wrench for multiple bolts or nuts with multiple drive spindles that are arranged around a center and are equipped or able to be equipped at the end with respective torque-applying tools, and a ratchet drive, associated with each drive spindle and driven by means of a hydraulic piston drive, for driving the drive spindles. Such a multiplex screw driver is known from EP 2 288 476.

Torque wrenches for multiple bolts or nuts serve the purpose of applying torque to a plurality of screw connections in a single screwing process and thus, for example, tightening or loosening bolts, which are arranged in a ring arrangement. Simultaneously applying torque to a plurality of screw connections shortens the time otherwise required for applying torque to several screw connections. Furthermore, when applying torque to individual screw connections, which are arranged annularly around a center, care must be taken to ensure that the components to be bolted together do not tilt relative to each other, which is why the screw connections must be tightened according to a predefined screwing pattern. If this is not adhered to, there is a risk that a joint consisting of multiple bolted connections will not be fastened properly.

Torque wrenches for multiple bolts or nuts are used for connecting risers in oil or water wells, for example. At their ends, these pipes have connecting flanges protruding outward in the radial direction. To connect two such pipes, the adjacent connecting flanges are bolted together with several screw connections. A torque wrench for multiple bolts or nuts suitable for this purpose is known from EP 2 288 476 B1. With this previously known torque wrench for multiple bolts or nuts, a number of torque-applying devices corresponding to the number of screws to be tightened or loosened is provided, for example six torque stations. The torque stations are arranged around a center. This previously known torque-applying device is designed in an annular shape and leaves a central opening through which the pipes with their flanges can be pulled. Each torque station is displaceable in the radial direction, such that it can be adjusted from a non-operating position, in which a riser with its flange can be passed through a central opening of the torque wrench for multiple bolts or nuts, into an operating position for applying torque to the screw bolts. In order to apply torque to the screw connections of two adjacent connecting flanges of second risers, the torque stations are displaced in the radial direction to their operating position. Each torque station has a drive spindle, which drives a socket as a torque-applying tool. The socket has an inner contour, which is complementary to the outer

contour of the head of a screw bolt that is meant to be tightened or loosened by means of the torque station.

Each drive spindle is driven by its own hydraulically operated ratchet drive. For this purpose, the piston rod of a hydraulically actuated piston is connected to the ratchet lever of the ratchet drive. The ratchet lever has a pawl, which drives a drive spindle that is rotatably supported in the ratchet lever. The drive spindle has a square opening, into which the square drive, which has a complementary geometry to one end of a socket as a torque-applying tool, can be inserted. The pawl is under spring preload and interacts with the outer splines of the drive spindle under the spring preload. With a forward stroke of the piston rod, the drive spindle is advanced by at least one tooth, proportional to the executed stroke, relative to the pawl. With the return stroke, the ratchet lever is returned to its initial position, while the bolt does not turn back. This alternation between the forward and return stroke is carried out until the bolt is tightened with the intended torque.

Sometimes it is not possible to apply a sufficiently high torque to the screw connection, specifically when, during the return stroke of a ratchet lever following the execution of a forward stroke movement, for example of a screw bolt, for moving the drive spindles, the drive spindle springs back due to the torsion introduced into the screw bolt and also into the drive spindle. In that case, the pawl can no longer be moved back by at least one tooth of the teeth of the drive spindle when executing a return stroke movement acting on the ratchet lever. Although the forward stroke and return stroke movement of the actuating cylinder is carried out correctly, a higher torque is not introduced into the screw connection.

A single screw driving tool is known from US 7,146,880 B1, in which, in addition to the ratchet drive, a safety ratchet acts on the drive spindle. This safety ratchet blocks a springing back of the drive spindle as a consequence of torsion introduced in the same and/or the screw connection, for example, in the screw bolt. However, such a device is not suitable to prevent a reverse-rotation of the drive spindles of torque wrenches for multiple bolts or nuts, as the torque-applying tools are bound with the respective bolts to be tightened, or their heads, due to the reaction forces present while torque is applied, which means that pulling the torque wrench for multiple bolts or nuts from the bolt heads is no longer possible.

Based on this state of the art as discussed above, the problem underlying the invention therefore is to refine a torque wrench for multiple bolts or nuts with multiple drive spindles of the type mentioned above, which are arranged around a center, such that it can be used to tighten screw

connections with high torques without having to accept a springing back of the drive spindles, wherein the torque wrench for multiple bolts or nuts can nevertheless be detached easily from the tightened screw fasteners after torque has been applied.

According to the invention, this problem is solved by a generic torque wrench for multiple bolts or nuts as described above, in which, in addition to the ratchet drive, a locking ratchet for locking the drive spindle acts on each drive spindle to keep it from turning back when performing a return stroke movement of the drive ratchet, which locking ratchets are arranged in an annular locking bracket penetrated by the drive spindles, and in which the locking bracket has means for loosening the locking ratchets.

Preferred embodiments of the multiplex screw driver are subject of the dependent claims. In this torque wrench for multiple bolts or nuts, a locking ratchet acts on each drive spindle, in addition to the ratchet drive. The ratchet of the ratchet drive, as well as the locking ratchet, respectively act on the drive spindle in the same direction. Both the pawl of the ratchet drive and the locking pawl of the locking ratchet are in engagement with outer splines of the drive spindle. The pawl of the ratchet drive and the locking pawl of the locking ratchet engage with the teeth of the drive spindle in equal measure. This means that, when performing a return stroke of the ratchet lever of the ratchet drive, the locking ratchet prevents the drive spindle from springing back, for example due to a previously induced torsional force of the drive spindle. The locking ratchets of this torque wrench for multiple bolts or nuts are arranged in a locking bracket, which is penetrated by the drive spindles. The locking bracket thus follows the arrangement of the drive spindles arranged around a center. Typically, the locking bracket is annular. However, an embodiment in which it only extends across a circular segment also is possible. Even in such an embodiment, the drive spindles are arranged around a center, however, not in a ring structure but only in a circular segment structure. Providing a locking bracket in which the locking ratchets are arranged makes it possible that said locking bracket has means for loosening the locking ratchets. With these means, the locking pawls can be moved out of their position engaging with outer splines of the drive spindle. For this purpose, the locking pawls are typically held in the locking bracket translationally against the force of a return spring, against which spring force the locking pawls are moved out of their locking position, in which their hooks engage with outer splines of the drive spindle. The guiding of a locking pawl within the locking bracket typically is provided by the walls of the locking chamber inside which such a locking pawl is mounted. Such a locking chamber represents an expansion in the radial direction to a drive spindle opening.

In one exemplary embodiment, each locking ratchet is associated with a return lever by means of which the locking pawl can be moved out of the position in which its teeth are engaged with those of the drive spindle. For this purpose, the locking pawl has at least one actuating area, with which such a return lever engages for moving the locking pawl out of the position in which its teeth engage with those of the drive spindle. In one embodiment, two actuating areas are provided, which are arranged on both sides of a center part supporting the teeth of the locking pawl. In one design of such an embodiment, the respective return levers engage with a return lever accommodation of the locking bracket, which return lever accommodation is arranged in the radial direction of the locking bracket on the outer side with respect to the locking pawl. The other end of the return lever protrudes beyond the locking bracket in the radial direction on the inner side and engages with a return lever accommodation of an actuating element arranged in the radial direction on the inner side toward the locking bracket, which actuating element can be adjusted by a certain angular amount about the center of the arrangement of the drive spindles. In one embodiment, in which the locking bracket is annular, the actuating element is also annular. The actuating element is adjustable relative to the locking bracket about the axis of the center of the arrangement of the drive spindles by at least some angular degrees, wherein the range of adjustment is sufficiently large, such that, when a rotational angle of the actuating element relative to the locking bracket is adjusted, the return lever accommodation of said locking bracket and the end section of a return lever engaging with said return lever accommodation can be displaced to such an extent that the locking pawl is moved out of its position in which it engages with the outer splines of the drive spindle because the return lever is supported on an actuating area of said locking pawl. Typically, the return lever is designed in an angle shape, wherein the outside of the angle acts against the actuating area of the locking pawl. If two actuating areas are provided on the locking pawl, two return levers are used accordingly for moving the locking pawl.

An adjusting movement of the actuating element, which for example can be designed as an actuating ring, can be brought about by an actuating cam, which engages with a cam recess of the actuating ring. Such an actuating cam is positioned transverse to the center axis of the arrangement of the drive spindles in a rotatable manner and typically is located on the end section of an actuating rod penetrating the locking bracket, which actuating rod has a handle, for example a rotary knob, via which handle a rotating movement can be transferred onto the actuating rod, thus adjusting the actuating cam.

Before actuating the actuating rod for loosening the locking ratchets, the drive spindles are slightly tightened by means of the drive ratchets in order to somewhat relieve the locking ratchets, which makes it possible to then perform the loosening process by adjusting the actuating element.

- 5 In a compact design of the drive block of the torque wrench for multiple bolts or nuts, the locking ratchets, along with the locking bracket, are typically arranged in a different plane than the ratchet drives with respect to the longitudinal extension of the drive spindles. In one version of the torque wrench for multiple bolts or nuts, in which the ratchet drives are arranged in two or multiple planes on top of each other, nevertheless, the locking ratchets and the locking bracket
- 10 supporting said locking ratchets may be arranged on the same plane. In one design of the torque wrench for multiple bolts or nuts, in which the locking ratchets are arranged in a different plane than the ratchet drives with respect to the longitudinal extension of the drive spindle, outer splines extending into both planes or two outer spline sections.

- In a refinement of this torque wrench for multiple bolts or nuts as described above, it is provided
- 15 that the torque wrench for multiple bolts or nuts comprises an actuator unit for inducing a rotary movement in the drive spindles, having an actuating wheel mounted rotatably about the axis of the center of the annular drive spindles as drive wheel, which drives respective output wheels fitted on the drive spindles, wherein the driving movement of the actuating wheel is transmitted to the drive spindle via respective torque limiters.

- 20 This torque wrench for multiple bolts or nuts has an actuator unit, which is actuated before the actual tightening or loosening process begins. The drive spindles can be moved with this actuator unit. For this purpose, the actuator unit has an actuating wheel, which is mounted rotatably about the axis of the center of the annular drive spindles. This actuating wheel is a drive wheel and drives respective output wheels that are seated on the drive spindles. In this manner, a driving
- 25 movement of the actuating wheel can be transferred to the drive spindles. A particular property of the actuator unit is that the transfer of the driving movement of the actuator wheel to the drive spindles is performed by means of respective torque limiters. The purpose of these is to ensure that the screw connections to be tightened can be tightened with equal torque by means of the actuator unit on a first pass. The actuating wheel can be operated manually, for example with a
- 30 ratchet as a drive tool or with an electric screw tool. Of course, it can also be operated hydraulically or pneumatically. The torque introduced into the actuating wheel is limited. Due to the rotational movement of the actuator wheel and the resulting rotational movement of the

drive spindles at the torque transmitted via the slip couplings, the torque-applying tools seated on the drive ends of the drive spindles are rotated. The torque-applying tools are typically spring-loaded torque-applying tools, which can be adjusted in the longitudinal axial direction by a certain amount against the force of a return spring on the drive spindle. If, when actuating the actuator device, the torque-applying tool for multiple bolts and nuts is held against the fastening elements, for example, the bolts, the torque-applying tools executed in this embodiment as sockets snap onto the bolt heads when their respective, complementary contours are aligned with each other. Thus, by operating the actuator unit with a low, in particular manually transferred, torque, the torque-applying tools can easily mate to the respective complementary contours of a fastening element and thus engage with them.

In the following, the invention is described on the basis of an exemplary embodiment with reference to the attached drawings. The drawings show:

Fig. 1: A longitudinal-section view through a torque wrench for multiple bolts or nuts

Fig. 2: A cross-section along line A-B of the torque wrench for multiple bolts or nuts of Fig. 1

Fig. 3: Another cross-section along the line C-D through the torque wrench for multiple bolts or nuts of Fig. 1 to represent a locking device for locking the drive spindles in a locking position

Fig. 4: The representation of Fig. 3 with unlocked locking devices

In the exemplary embodiment shown in the drawings, a torque wrench for multiple bolts or nuts 1 is of a modular design and comprises a drive block 2 as the first module, a locking unit 3 as the second module and an actuator unit 4 as the third module. The individual modules 2, 3, 4 are explained below. Even if, within the context of these explanations, these are combined for forming the torque wrench for multiple bolts or nuts 1, the individual modules 2, 3, 4 can also be used independently of each other together with differently designed components of a torque wrench for multiple bolts or nuts. For example, the functionality achieved with the locking unit 3 can also be combined in connection with another drive block or also without actuator unit or with a differently formed actuator unit. The same applies to the actuator unit 3.

The drive block

In the exemplary embodiment shown here, eight drive spindles 5 are provided in the drive block 2. These are arranged annularly around a center. These are rotatably supported and held in the

drive block 2. The drive block 2 has a cylindrical outer lateral surface. In the sectional representation of Fig. 1, two drive spindles 5 are shown in a sectional view, while three others, positioned behind them, are recognizable in a front view or partial view. The drive spindle 5 shown on the left in Fig. 1 and its drive are described in more detail in the following. These explanations also apply equally to the other drive spindles 5, which are designed in the same way as the drive spindle and its drive described below.

In the exemplary embodiment shown here, the drive block 2 is provided by two block discs 6, 6.1. The drive spindle 5 penetrates the block discs 6, 6.1, which are connected to each other, and protrudes from them on both ends. These sections of the drive spindle 5 protruding from the drive block 2 are referenced as drive sections 7, 7.1 in the context of these explanations. As torque-applying tool, a socket 8 having an inner contour is seated on the drive section 7 in a torque-transferring manner, which drive section 7 in Fig. 1 protrudes from the bottom of the drive block 2. The socket 8 is detachably held on the drive section 7 in a manner known per se, specifically held by a locking ring 10 pre-tensioned by a compression spring 9. If the locking ring 10 is moved in the direction of the drive block 2, the locking effect caused by a ball not shown in the drawing is released, such that the socket 8 can be detached from the drive section 7. The drive spindle 5 is supported in the drive block 2 by bearings, which can also have seals at their outward-facing sides, which prevent an entry of contamination into the bearings of the drive spindle 5.

A ratchet drive serves for driving the drive spindle 5, as is described more clearly by means of the cross-sectional representation of Fig. 2. In the exemplary embodiment shown here, four ratchet drives are housed in the upper block disc 6.1 and four further ratchet drives in the lower block disc 6. The respective ratchet drives for the individual drive spindles 5 are of the same design.

To provide a drive by means of such a ratchet drive, the drive spindle 5 has circumferential, asymmetrical outer splines 11 in its drive section, as is typical for ratchet drives. The longer spline flanks point in the drive direction of the drive spindle 5. The shorter spline flanks point in the opposite rotational direction. The ratchet drive comprises a piston-cylinder arrangement 12, the piston rod 13 of which acts on a ratchet lever 14. A piston 13.1 supporting the piston rod 13 is located in a cylinder housing provided by a screw-in cylinder 15. The cylinder housing 15 has two fluid connectors, of which a fluid connector 16 is visible in the sectional view of Fig. 2. This fluid connector 16 opens into the bottom area of a hole drilled in the drive block 2, which receives

the screw-in cylinder 15. Hydraulic fluid is fed into the cylinder housing 15 via the fluid connector 16 for moving the piston 13.1 with its piston rod 13 to perform a forward stroke. The hydraulic connector for the return stroke opens radially into the screw-in cylinder 15 at the side of the piston 13.1 opposite to the fluid connector 16. The piston rod 13 is connected to the ratchet lever 14 in a manner transferring both compressive and tensile forces, such that a forward stroke performed by the piston leads to a forward stroke movement by the ratchet lever 14. By performing a return stroke, the ratchet lever 14 is returned to its position shown in Fig. 2. The piston 13.1 is connected to the ratchet lever 14 via a push rod as an extension of the piston rod 13. This push rod penetrates a hole in the ratchet lever 14, which extends in the direction of movement of the piston rod 13. Between the push rod and the piston rod 13 is an actuating tappet with which the piston rod 13 interacts for transferring a forward stroke movement against a bolt of the ratchet lever 14 providing the aforementioned hole that is penetrated by the push rod. The push rod penetrates the hole. A retaining disc, for example a snap ring, is located on the section of the push rod protruding from the hole, by means of which disc the ratchet lever 14 is moved along when the piston rod 13 performs a return stroke movement.

A pawl 17 is inserted in the ratchet lever 14. The teeth of the pawl 17, which is under spring preload (not shown in the drawing), engage with the outer splines 11 of the drive spindle 5. The teeth of the pawl 17 are designed to be complementary to the outer splines 11 of the drive spindle 5. During a forward stroke of the piston rod 13, which leads to a rotation to the right of the ratchet lever 14, the drive spindle 5 is moved clockwise. In the exemplary embodiment shown here, the drive spindle is moved by one tooth when a forward stroke is performed. During a return stroke, the ratchet lever 14, along with the pawl 17, is returned in its position shown in Fig. 2, while the drive spindle 5 remains in its position into which it had been moved by the previously performed drive movement.

The drive block 2 shown in Fig. 1 shows the stacked arrangement of the ratchet drives offset at an angle in the two block discs 6, 6.1. The drive block 2 of the torque wrench for multiple bolts or nuts 1 has a first hydraulic fluid connector for feeding hydraulic fluid from a hydraulic pump for performing the forward stroke and a second hydraulic connector for feeding hydraulic fluid for performing the return stroke. These hydraulic connectors are not visible in the drawing. The hydraulic fluid connector for the forward stroke is connected to a fluid distribution cavity designed as an annular duct 18 by means of a duct extending in the radial direction. The annular duct 18 is located in the wall of a central hole located in the drive block 2. The hole is filled with a cylindrical fluid distributor 19. This distributor is crossed by transverse bores 20 at the height

of the annular duct 18. On both sides of the annular duct 18, sealing rings are provided in slots for sealing the lateral surface of the fluid distributor 19. The annular duct 18 serves for supplying hydraulic fluid required for the forward stroke of the piston-cylinder arrangements 12 of the ratchet drives arranged in the block disc 6.1. Fluid ducts also open into the annular duct 18, which fluid ducts establish a connection between the annular duct 18 and the piston-cylinder arrangements 12 installed in the block disc 6.1 for the forward stroke. A small section 21 of such a line is visible in Fig. 2, as it is inclined relative to a horizontal plane. The transverse bore 22, which is adjacent to the section 21, is used to establish a fluid connection between the radial extension of the section 21 and the fluid connector 16 or the cylinder housing 15. This transverse bore 22 is closed at its end that is opposite to the screw-in cylinder 15. The aforementioned transverse bores 20 serve to also supply the piston-cylinder arrangement of the block disc 6 with hydraulic fluid for the forward stroke. Said bores open into a central fluid duct 23, through which a fluid path is established to the same plane as a second annular chamber 24 in the lower block disc 6. Four fluid ducts also open into the annular chamber 24 for establishing a fluid connection between a first fluid connector of the cylinder housings received in the block disc 6.

The piston-cylinder arrangements 12 of the drive block 2 are all designed identically. Therefore, the same amount of hydraulic fluid is required for performing a forward stroke of each piston-cylinder arrangement.

The hydraulic fluid connection for feeding hydraulic fluid for the return stroke opens into an annular fluid distributor 25 connected to the top of the block disc 6.1. The fluid distributor 25 provides another annular duct 26, into which fluid ducts (not shown in detail in the drawing) open, which fluid ducts are connected to respective backstroke fluid connectors of a screw-in cylinder 15 at their other end. While the fluid ducts for feeding hydraulic fluid to the piston-cylinder arrangements 12 largely extend in the radial direction, the fluid ducts for feeding the hydraulic fluid for performing a return stroke largely extend in the vertical direction and thus in the direction of the longitudinal extension of the drive spindles 5.

In the exemplary embodiment shown here, the annular duct 26 is provided by two annular bodies 27, 28 arranged concentrically to each other. The geometry of the annular duct 26 is located in the inner wall of the annular body 27 located on the outer side as seen in the radial direction. The inner side of the annular duct 26, as seen in the radial direction, is closed by the outer lateral surface of the second annular body 28. Ring seals arranged adjacent to the annular duct 26 ensure

the necessary tightness. The annular body 28 is penetrated by the drive spindles 5, as is visible in Figs. 1 and 3.

The locking unit

In the exemplary embodiment shown here, the inner annular body 28 at the same time represents a locking bracket. The drive spindles 5 penetrate the annular locking bracket 28. The locking bracket 28 bears respective locking ratchets 29 associated with each drive spindle 5 for locking the respective drive spindle 5 against turning back or springing back when the drive ratchet performs a return stroke movement, i.e., when the pawl with its teeth is moved away from the outer splines 11 of the drive spindle 5. Each locking ratchet 29 comprises a locking chamber 30 as an extension of the opening 31, which is penetrated by the drive spindle 5. A locking pawl 32 is located in the locking chamber 30, the teeth of which locking pawl 32 under spring-load (not shown in the drawings) engage with the outer splines 33, which also are present at this section of the drive spindle 5. The outer splines 33 and the outer splines 11 of the drive spindle 5 are asymmetrical with the same orientation and are designed with the same number of teeth. The same applies to the operational direction of the locking pawl 30 and the pawl 17. The locking ratchet 29 has the effect that the locking ratchet 29 remains in its locking position when a return stroke of the drive ratchet is performed. This makes possible an application of torque to the drive spindle 5 and thus to the torque-applying tool, designed as a socket 8 in the exemplary embodiment shown here, and to a bolt to be tightened in such a measure that torsional force is exerted onto the bolt and/or the drive spindle 5. Due to the blocking effect of the locking ratchet 29, an otherwise unavoidable springing back of the torsion introduced into the drive spindle 5 and/or the bolt is effectively prevented when a return stroke is performed.

The locking pawl 32 is designed T-shaped in its cross section, wherein the middle portion bears the locking teeth interacting with the outer splines 33 of the drive spindle 5. The sections adjacent to both sides each have an actuating area with which an actuating lever 34 makes contact. The actuating lever 34 serves the purpose of moving the locking pawl 29 out of the position in which its teeth engage with the outer splines 33 of the drive spindle 5, when it is to be unlocked. The actuating lever 34 is held with its radially outward end in a return lever accommodation 35 of the locking bracket 28. Although the locking lever 34 is designed as an angle, as shown in Fig. 3, it penetrates the locking bracket 28 in an essentially radial direction and with an actuating section 36 protrudes from the locking bracket 28 toward the inside, as seen in the radial direction. The actuating lever 34 is routed in an actuating lever channel 37 of the locking bracket 28. The

locking channel 37 has sufficient clearance in the circumferential direction of the locking bracket 28 to allow a movement of the actuating lever 34 to move the locking pawl 29 away from the drive spindle 5, specifically move it far enough away that the engagement of teeth of the locking pawl 29 with the outer splines 33 of the drive spindle 5, which otherwise is effected by the spring load, can be released. Further inward, as seen in the radial direction, from the locking bracket 28 is an actuating ring 38, which in turn has a return lever accommodation 39 for the actuating section 36 of the actuating lever 34. The actuating ring 38 can be rotationally displaced relative to the locking bracket 28, as indicated by an arrow in Fig. 3. An actuating rod 40 serves for displacing the actuating ring 28, which rod bears an actuating cam 41 at its end portion engaging with the actuating ring 38. The actuating rod 40 is routed outward through the locking bracket 28, the outer annular body 27 and through a housing 42, and bears a handle 43 at its end protruding from the outer housing 42, via which handle 43 the actuating rod 40 can be rotated for displacing the actuating ring 38. Fig. 3 shows the locking bracket 28 with its locking ratchets 29 and the actuating ring 38 in the tightening position of the torque wrench for multiple bolts or nuts 1, in which position the locking ratchets 29 engage with the outer splines 33 of the drive spindle 5 in a manner that locks the latter.

To push back the locking pawls 30 from their position in which they engage with the outer splines 31 of the drive spindles 5, the actuating rod 40 is rotated by means of the handle by about 180 degrees. Due to the engagement of the eccentrically designed actuating cam 41 with an actuating cam recess 44 of the actuating ring 38, the actuating ring 38 is adjusted counterclockwise, whereby the actuating levers 34 fitted against the actuating areas move the locking pawls 32 away from the respective drive spindle 5. If a torsional force acts on the locking pawls 32 via the drive spindles 5 and it is not easily possible to release the locking mechanism by turning the actuating rod 40, as previously described, the piston cylinder arrangements 12 are controlled to perform a forward stroke, such that the torsional force acting on the locking pawls 32 is reduced. The torque wrench for multiple bolts or nuts 1 can then easily be removed from the tightened bolts.

The locking unit 3 thus makes it possible to tighten screw connections with a particularly high torque using the torque wrench for multiple bolts or nuts 1, in particular with such a torque at which the screw connection remains tight even when exposed to a certain torsion of the components that were fastened together.

The actuator unit

The actuator unit 4 acts on the drive sections 7.1 of the drive spindles 5 opposite to the torque-applying tools (see Fig. 1). The actuator unit 4 serves for inducing a rotational movement in the drive spindles 5, in order to bring the inner contour of the sockets 8 seated on the drive sections 7 into alignment with the outer contour of the individual bolts. In addition, the actuator unit 4 serves the purpose of bringing the bolts to be tightened by means of the torque wrench for multiple bolts or nuts 1 to a uniform preload before the hydraulic tightening process.

The actuator unit 4 comprises a central actuating wheel 45 with a drive contour 46 located centrically within said wheel, into which contour, for example, the square shaft of a ratchet or another manual or electrical tool can be inserted. By turning the actuating wheel 45, the drive spindles 5 can be driven via respective torque limiters. The actuating wheel 45 bears outer splines 47, which mesh with an output wheel 48 that is seated on the drive section 7.1. The output wheel 48 has corresponding, complementary teeth 49 and acts on two coupling rings 50, 50.1 with its radial inner side having two coupling surfaces. The inside of the output wheel 48 is conically tapered for this purpose and acts against complementary inclined coupling surfaces of the coupling rings 50, 51. The upper coupling ring 50 in Fig. 1 acts in the direction of the longitudinal axis of the drive spindle 5 against a counter bearing plate 51. The lower coupling ring 50.1 is under the preload of a compression spring 52 acting on it, which spring is supported on a counter bearing with its other end; through this compression spring 52, the coupling ring 50.1, via the output wheel 48, acts in the direction of the other coupling ring 50. Thus, the force transfer from the output wheel 48 to the coupling rings 50, 50.1 seated on the drive section 7.1 of the drive spindle 5 in a torque-transferring manner is limited by the compression spring 52.

As the actuating wheel 45 drives all drive spindles 5 in the same manner, a low torque suffices to bring the torque-applying tools seated on the opposite drive section 7 of the drive spindles 5 into the position required for engagement with, for example, the head of a bolt. In addition, the bolts are tightened at the same preload by the drive via the actuating wheel 45. If a screw bolt is tightened with a certain preload, the slip coupling installed on the respective drive spindle 7.1 operates as a torque limiter, such that this drive spindle 5 is not turned further by additional rotary movements of the actuating wheel 45, wherein, on the other hand, the other drive spindles, which can still transfer the torque transferred via the torque limiter, are turned further, specifically until their respective torque limiters formed by the coupling discs 50, 50.1 also are triggered. Thus, a uniform torque limitation of the torque transferred via the actuating wheel 45 to the drive spindles 5 is achieved in a simple manner.

Other operational devices

The torque wrench for multiple bolts or nuts 1 is associated with a hydraulic unit and a control device for controlling the hydraulic unit for its operation. The hydraulic unit comprises a hydraulic pump, a fluid tank for the storage of hydraulic fluid, typically hydraulic oil, as well as a fluid pressure output for the forward stroke and another fluid pressure output for the return stroke. In addition, the hydraulic unit has a flow measurement device for detecting the hydraulic fluid quantity conveyed, which is used to detect said quantity during the operation of the hydraulic unit. According to a preferred operating method of the torque wrench for multiple bolts or nuts, the hydraulic unit is controlled dependent on fluid flow rates, based on information from its flow measurement device. This ensures that a switch from a forward stroke to a return stroke of the hydraulic actuator cylinders of the torque wrench for multiple bolts or nuts takes place only when the predefined hydraulic fluid quantity has been conveyed. This predefined hydraulic fluid flow quantity corresponds to the hydraulic fluid volume required to move the piston arranged in each hydraulic actuating cylinder from its one end position to its other end position. This ensures that a switch from a forward stroke movement to a return stroke movement takes place only when all pistons of the ratchet drives have actually been moved in equal measures. The same applies to a switch from a return stroke movement to a forward stroke movement. When the hydraulic unit is controlled in this manner, it is therefore irrelevant whether the desired stroke is carried out synchronously in all actuator cylinders or with a small time offset. In order to be able to determine the respective quantity of hydraulic fluid, the torque wrench for multiple bolts or nuts is actuated several times to perform of a stroke before it is used to actually tighten or loosen a bolt. The respective fluid volume conveyed is recorded therein. By repeating this process multiple times, a reliable reference value for the fluid volume conveyed is obtained. This fluid quantity conveyed then determines the switching time. If in such an operation of the hydraulic unit of the torque wrench for multiple bolts or nuts the hydraulic fluid flow quantity required for switching from a forward stroke movement to a return stroke movement could no longer be conveyed, because at least one of the screw connections to be tightened is already sufficiently tightened, causing the actuator cylinder not to be moved further by means of the applied hydraulic pressure, the hydraulic unit typically switches off. If no more hydraulic fluid is conveyed, all screw connections are tightened with the same torque, as the hydraulic oil pressure remains constant. In this mode of operation, the force with which the screw connections are tightened is dependent on the pressure with which the hydraulic fluid is conveyed. With such

a torque wrench for multiple bolts or nuts, screw connections can also be tightened with very high torques.

The operation of the hydraulic unit and thus of the torque wrench for multiple bolts or nuts can also be carried out at different pressure levels. It is possible to perform a first tightening step with only a low hydraulic pressure (a few bar). This step of tightening the bolts merely serves for the torque-applying tools to mate their contour to the complementary fastening elements to be driven, for example the head of a bolt, and in that all screw connections are brought into a same initial state with respect to their fastening position. Once this is achieved, the actual tightening of the screw connections takes place. For this purpose, the hydraulic pressure of the hydraulic unit is raised to the pressure corresponding to the torque to be applied. Herein, it is entirely possible to apply pressures from 600 to 800 bar. Of course, it is also possible to provide higher pressures. The tightening process is carried out by means of the fluid control process dependent on fluid quantities conveyed, as already described above.

List of reference numbers

1	Torque wrench for multiple bolts or nuts	26	Annular duct
2	Drive block	27	Ring body
3	Locking unit	28	Annular body/locking bracket
4	Actuator unit	29	Locking ratchet
5	Drive spindle	30	Locking chamber
6, 6.1	Block disc	31	Opening
7, 7.1	Drive section	32	Locking pawl
8	Socket	33	Outer splines
9	Compression spring	34	Actuating lever
10	Locking ring	35	Return lever accommodation
11	Outer splines	36	Actuating section
12	Piston-cylinder arrangement	37	Actuating lever channel
13	Piston rod	38	Actuating ring
13.1	Piston	39	Return lever accommodation
14	Ratchet lever	40	Actuating rod
15	Cylinder housing	41	Actuating cam
16	Fluid connector	42	Housing
17	Pawl	43	Handle
18	Annular duct	44	Actuating cam recess
19	Fluid distributor	45	Actuating wheel
20	Transverse bore	46	Drive contour
21	Section	47	Outer splines
22	Transverse bore	48	Output wheel
23	Fluid duct	49	Teeth
24	Annular chamber	50, 50.1	Coupling ring
25	Fluid distributor	51	Counter bearing disc
		52	Compression spring

Patentkrav

1. Multipel skruetrækker med et antal drivspindler (5), der er anbragt omkring et center og er udstyret eller kan udstyres i enden med et respektivt fastspændingsværktøj (8) og et skraldedrev, der er tildelt til hver drivspindel (5) og drevet ved hjælp af et hydraulisk

5 stempeldrev, til at drive drivspindlerne, **kendetegnet ved, at** ud over skraldedrevet virker en låseskralde (29) på hver drivspindel (5) for at låse drivspindlen (5) mod at dreje tilbage, når der udføres en tilbageslagsbevægelse af drivskralden, hvor låseskralderne (29) er anbragt i en låseholder (28), hvorigennem drivspindlerne (5) passerer, og at låseholderen (28) er forsynet med anordninger til at udløse låseskralderne.

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2. Multipel skruetrækker ifølge krav 1, **kendetegnet ved, at** hver drivspindelpassageåbning (31) i låseholderen (28) omfatter et låsekammer (30), der rummer en låseklo (32), der virker under fjederbelastning på drivspindlerne (5).

15 **3.** Multipel skruetrækker ifølge krav 2, **kendetegnet ved, at** hver låseklo (32) omfatter mindst én justeringsflade, der vender mod drivspindlen (5), med hvilken en nulstillingsløftestang (34) er i kontakt for at flytte låsekloen (32) ud af sin låsestilling i forhold til drivspindlerne (5).

4. Multipel skruetrækker ifølge krav 3, **kendetegnet ved, at** låsekloen (32) omfatter to
20 justeringsplader, der inkluderer en midterdel, der bærer låsekloens (32) tænder.

5. Multipel skruetrækker ifølge krav 3 eller 4, **kendetegnet ved, at** nulstillingsløftestangen (34), der er tildelt til hver låseskralde (29), stikker med én ende ind i en nulstillingsløftestangsmodtager (35) på låseholderen (28) og med den anden ende i den radiale
25 retning over låseholderen (28) og går i indgreb i en nulstillingsløftestangsmodtager (39) i en justeringsindstillingsring (38), der kan drejes for at justere nulstillingsløftestangen (34) koncentrisk i forhold til låseholderen (28).

6. Multipel skruetrækker ifølge krav 5, **kendetegnet ved, at** indstillingsringen (38) er anbragt
30 radiale på indersiden i forhold til låseholderen (28), og omfatter en indstillingsknastudskæringsåbning (44), hvori en indstillingsknast (41) holdes på en drejelig måde, såsom for at justere indstillingsringen (38) i forhold til låseholderen (28).

7. Multipel skruetrækker ifølge krav 6, **kendetegnet ved, at** indstillingsknasten (41) er monteret på en indstillingsstang (40), der strækker sig i den radikale retning og går i indgreb gennem låseholderen (28), med et håndtag (43) i sin ende, der stikker ud af låseholderen (28) i den radiale retning.

5

8. Multipel skruetrækker ifølge et hvilket som helst af kravene 5 til 7, **kendetegnet ved, at** nulstillingsløftestangen (34) omfatter en kant, der vender mod en indstillingsflade på låsekloen (32), der strækker sig ud af hvilken der er en første arm af nulstillingsløftestangen (34), der strækker sig så langt som ind i nulstillingsholdermodtageren (35) på låseholderen (28), og en anden arm af nulstillingsløftestangen (34) strækker sig så langt som ind i en nulstillingsløftestangsmodtager (39) i indstillingsringen (38).

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9. Multipel skruetrækker ifølge et hvilket som helst af kravene 1 til 8, **kendetegnet ved, at** drivspindlerne (5) er monteret og holdt drejelige i en drivblok (2), og omfatter i hver ende en drivsektion (7, 7.1), der stikker ud af drivblokken (2), hvor drivsektionerne (7, 7.1) af drivspindlerne (5) på den ene side af drivblokken (2) bruges til at holde spændeværktøjerne (8), i hvilken drivblok (2) stemplerne (13.1) i stempeldrevne føres i cylinderhuse (15), således at de kan indstilles på en translationel måde i begge retninger, hvor, for at overføre en fremadgående slagbevægelse og en baglæns slagbevægelse i hvert tilfælde til en skraldearm (14), der omfatter en drivklo (17), hvor stempelstængerne (13) er kinematisk forbundet til skraldearmen (14), og hvilken drivblok (2) omfatter i sin midte mindst ét væskefordelingshulrum (18, 24), hvori flere væskekanaler åbner sig, placeret i drivblokken (2), hvor der gennem hver væskekanal er etableret en væskeforbindelse mellem væskefordelingshulrummet (18, 24) og et første væskeindtag i et cylinderhus (15), og at der på en flad side af drivblokken (2) er anbragt en væskedeler (25), med en ringkanal (26) forbundet til en væskeleveringskanal, som et væskefordelingshulrum, ind i hvilket væskefordelingshulrum flere væskekanaler åbner sig, hvor der gennem hver væskekanal er etableret en væskeforbindelse mellem væskefordelingshulrummet (26) og et andet væskeindløb i et cylinderhus (15).

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10. Multipel skruetrækker ifølge krav 9, **kendetegnet ved, at** væskefordelerhulrummet placeret i det midterste område af drivblokken (2) er udformet som en ringkanal (18, 24).

11. Multipel skruetrækker ifølge et hvilket som helst af kravene 9 til 10, **kendetegnet ved, at** drivblokken (2) er sammensat af mindst to blokskiver, hvor flere skraldedrev er anbragt i hver blokskive (6, 6.1).

5 **12.** Multipel skruetrækker ifølge krav 11, **kendetegnet ved, at** et væskefordelingshulrum (18, 24) er anbragt i hver af de to blokskiver (6, 6.1), og de to væskefordelingshulrum (18, 24) er sat i væskeforbindelse med hinanden ved hjælp af en væskefordeler (19).

10 **13.** Multipel skruetrækker ifølge et hvilket som helst af kravene 1 til 12, **kendetegnet ved, at** den multiple skruetrækker (1) omfatter en justeringsenhed (4) til at inducere en rotationsbevægelse ind i drivspindlerne (5), med et justeringshjul (45) som et drivhjul, monteret således, at det kan drejes om akse i midten af den ringformede konfiguration af drivspindler (5), der i hvert tilfælde driver et kraftudtagshjul (48) placeret i hvert tilfælde på en drivspindel (5), hvor overførslen af justeringshjulets (45) drivbevægelse til drivspindlerne (5)
15 sker i hvert tilfælde med indgreb af en momentbegrænser.

14. Multipel skruetrækker ifølge krav 13, **kendetegnet ved, at,** til den momentbegrænsede kraftoverførsel af drivkraften til drivspindlerne (5), er drivhjulene (48) placeret på drivspindlerne (5) med mellemliggende indgreb af en glidekobling, og med en tandkrans (49) i
20 indgreb med en ydre tandanordning (47) på justeringshjulet (45).

15. Multipel skruetrækker ifølge krav 14, **kendetegnet ved, at** glidekoblingen på hver drivspindel (5) omfatter to koblingsskiver (50, 50.1), der er anbragt momentlåst på drivspindlen (5), med i hvert tilfælde en koblingsflade, der er skråtstillet i forhold til
25 drivspindlernes (5) længdeudstrækning, hvilke koblingsflader hælder mod hinanden for at danne en modtager til kraftudtagshjulet, og også omfatter kraftudtagshjulet, der går i indgreb med dets inderside, udformet til at være komplementær med koblingsfladerne, ind i kraftudtagshjulets modtager, og er i kontakt under foreløbig spænding med koblingsfladerne på koblingsskiverne (50, 50.1).

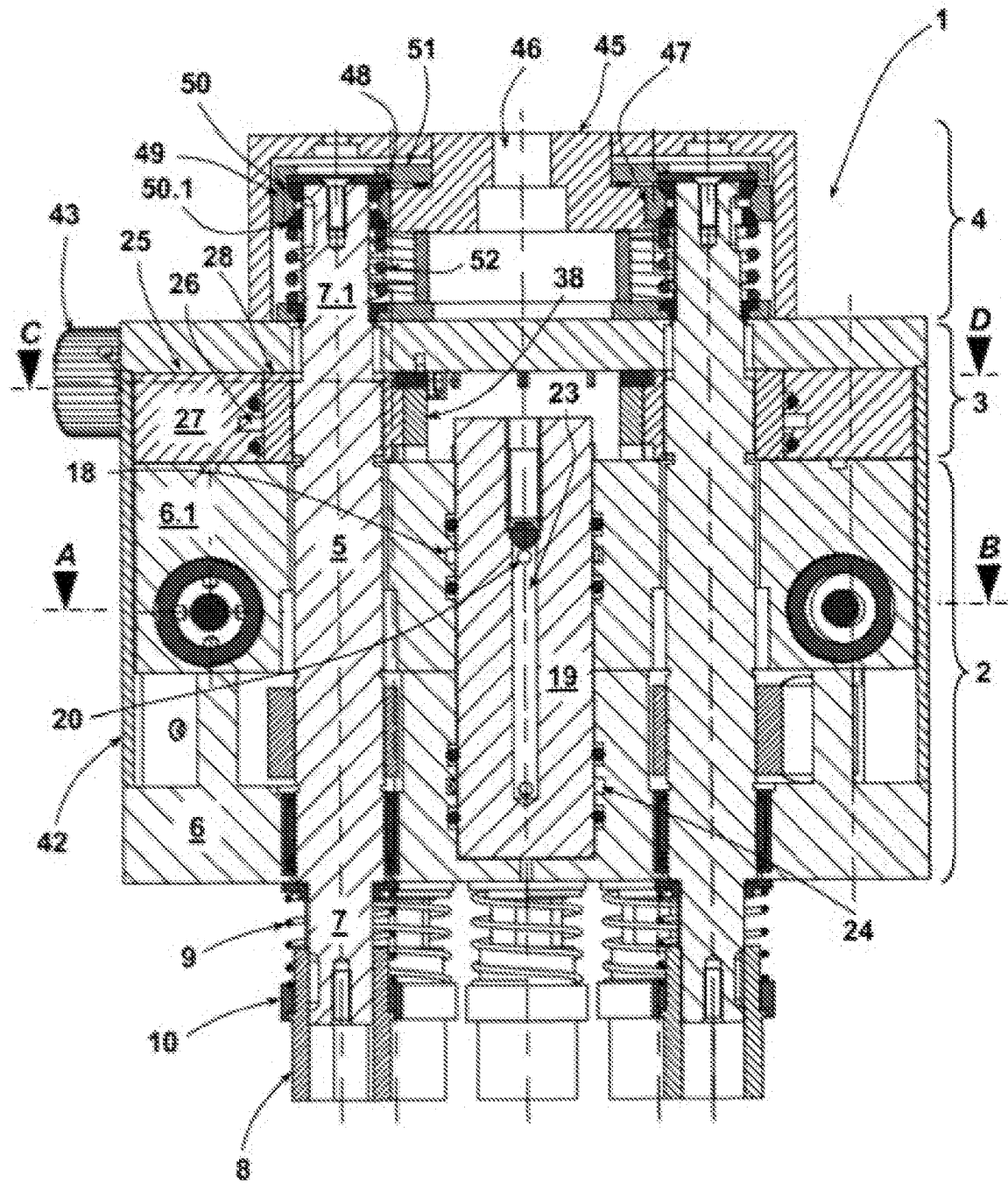
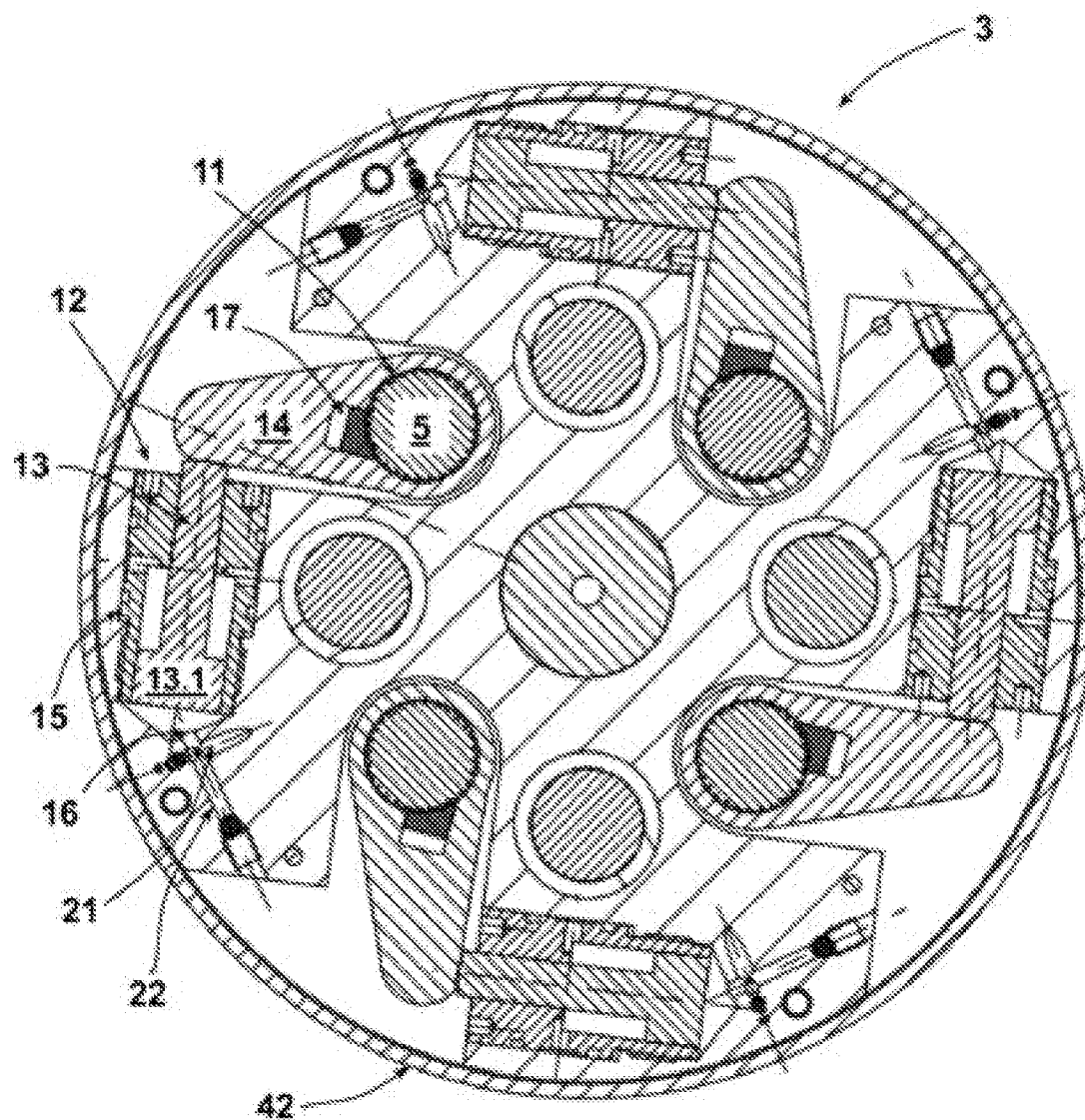
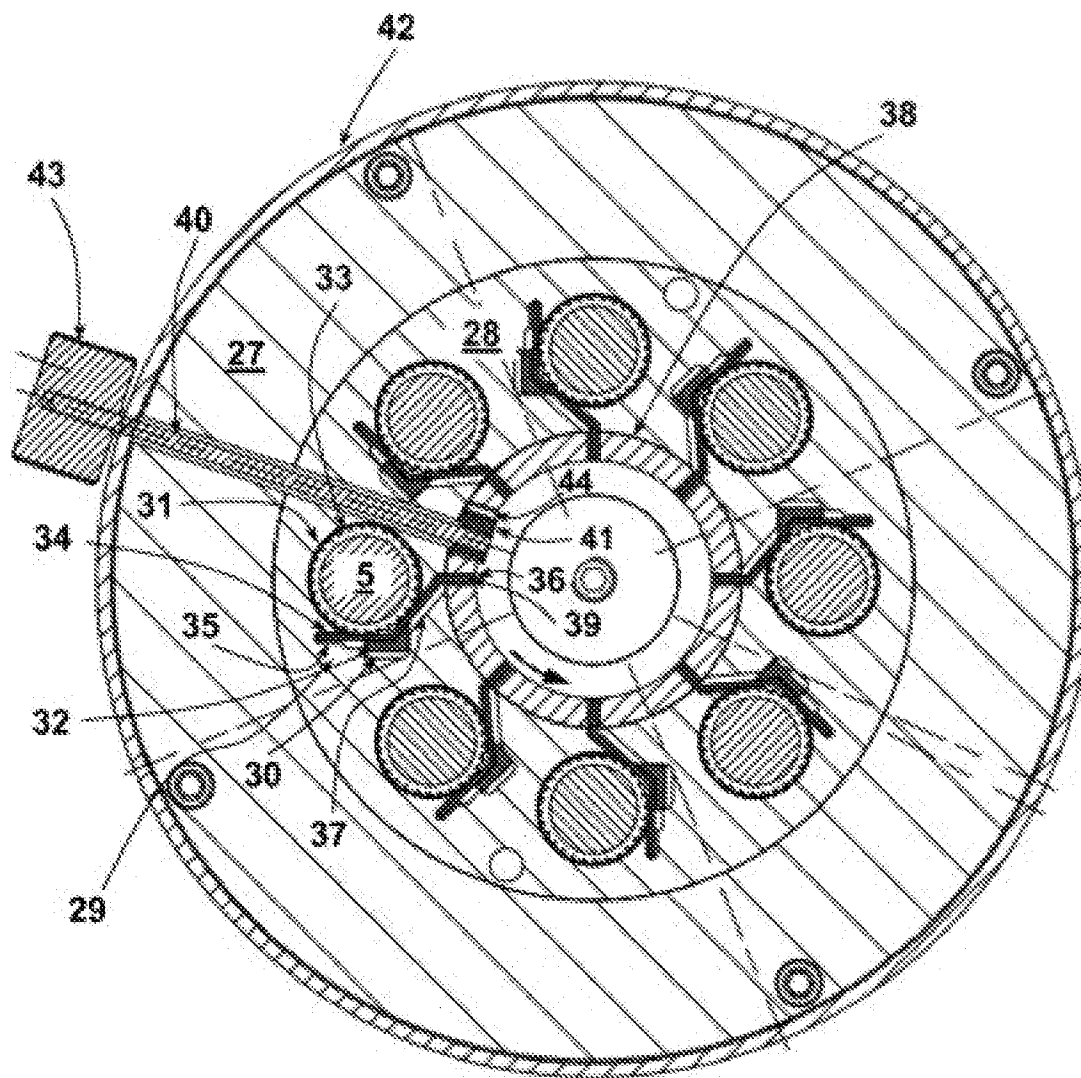


Fig. 1

**Fig. 2**

**Fig. 3**

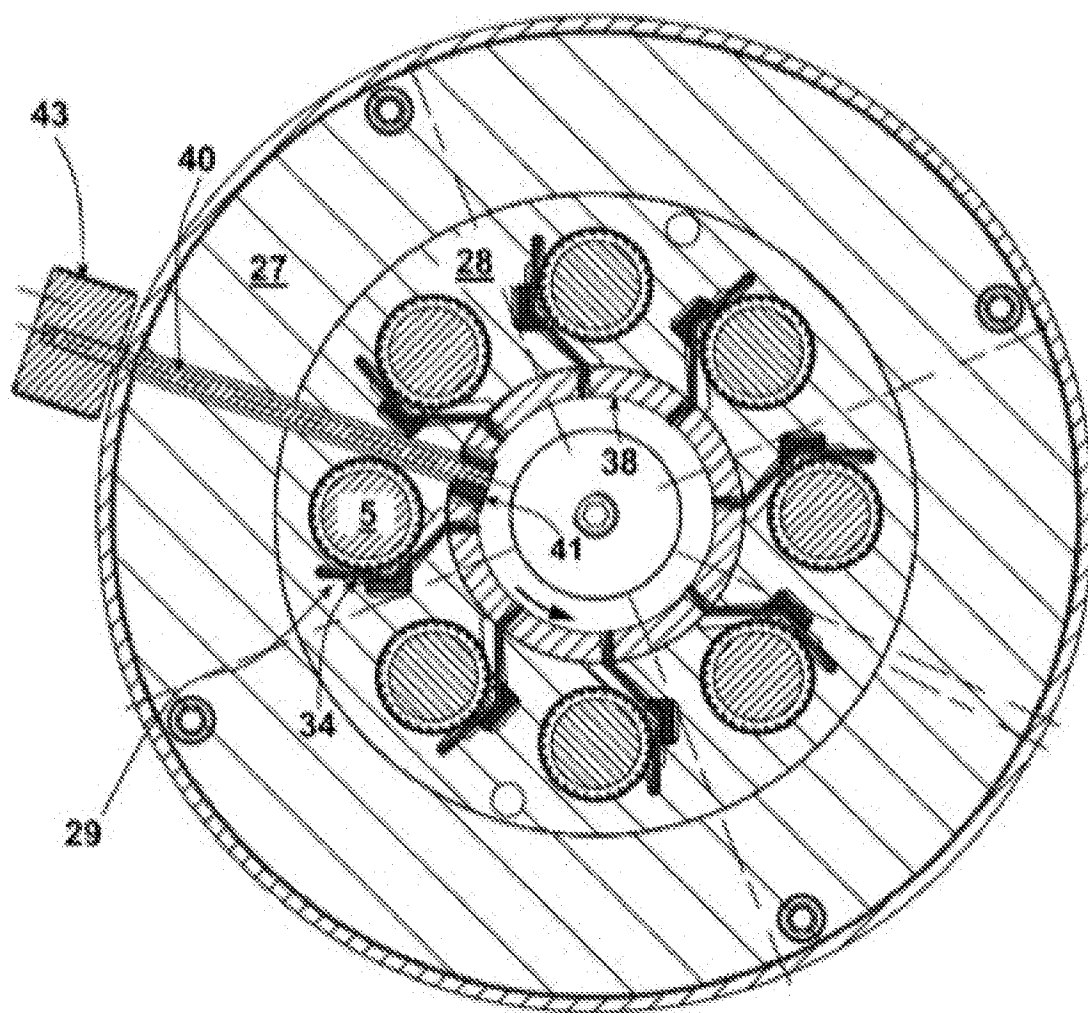


Fig. 4