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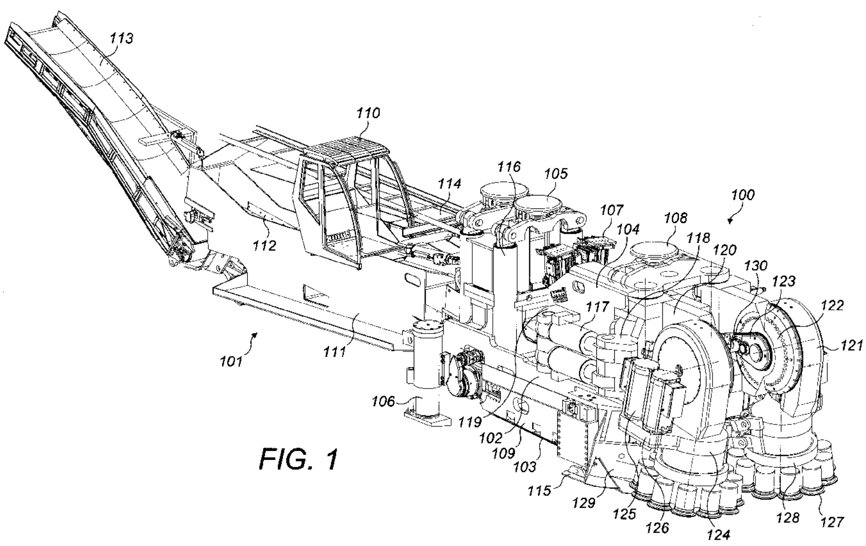

FIG. 1

(57) Abstract: A cutting apparatus suitable for creating tunnels and subterranean roadways. The apparatus comprises independently pivoting supports that each carry a respective independently pivoting arm and a rotatable cutting head. Each cutting head via the supports and arms, is configured to slew laterally outward in a sideways direction and to pivot in a vertical upward and downward direction. The supports and arms are mounted on a linear moving sled carried by a main frame.

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Cutting Apparatus

Field of invention

The present invention relates to rock cutting apparatus suitable for creating tunnels or subterranean roadways and in particular, although not exclusively, to undercutting apparatus in which a plurality of rotating heads are capable of being slewed laterally outward and raised in the upward and downward direction during forward cutting. Furthermore, the present invention relates to a modular cutting apparatus drive train kit, in particular for the aforementioned cutting apparatus.

Background art

A variety of different types of excavation machines have been developed for cutting drifts, tunnels, subterranean roadways and the like in which a rotatable head is mounted on an arm that is in turn movably mounted at a main frame so as to create a desired tunnel cross-sectional profile. WO2012/156841, WO 2012/156842, WO 2010/050872, WO 2012/156884, WO2011/093777, DE 20 2111 050 143 U1. All described apparatus for mill cutting of rock and minerals in which a rotating cutting head forced into contact with the rock face as supported by a movable arm. In particular, WO 2012/156884 describes the cutting end of the machine in which the rotatable heads are capable of being raised and lowered vertically and deflecting in the lateral sideways direction by a small angle in an attempt to try enhance the cutting action.

WO 2014/090589 describes a machine for digging roadways tunnels and the like in which a plurality of cutting heads are movable to dig into the rock face via a pivoting arcuate cutting path. US 2003/0230925 describes a rock excavator having a cutter head mounting a plurality of annular disc cutters suitable to operate in an undercutting mode.

It has been observed that it is particularly challenging to provide the necessary power transmission to the cutter gear while maintaining a compact build. Furthermore, it has been observed that in addition to the high cutting forces needed for the cutter head, in addition to providing sufficient torque, the drive train has to withstand significant axial forces. Still further, it has been observed that it is difficult to supply sufficient quantities of water to the peripheral region of the cutting head without compromising overall build size and complexity of the cutting head and gear.

Furthermore, it has been observed that conventional cutting machines are not optimised to cut hard rock having a strength typically beyond 120 MPa whilst creating a tunnel or subterranean cavity safely and reliably of desired cross-sectional configuration. Accordingly, what is required is a cutting machine that addresses these problems.

Summary of the Invention

It is an objective to provide a cutting apparatus which is built as compact as possible in order to enable operation in tight quarters. In particular, it is an objective to provide such a cutting apparatus without compromising the available torque for the cutting head. Still further, it is a particular objective of the invention to provide such a cutting apparatus while at the same time providing water supply to the cutting head and also to maintain such small sized apparatus.

It is a further objective of the present invention to provide a cutting apparatus which can more easily be adapted for operation in different geographic and geological environments.

It is a further objective of the present invention to provide a cutting machine suitable to form tunnels and subterranean roadways being specifically configured to cut hard rock beyond 120 MPa in a controlled and reliable manner. It is a further specific objective to provide a cutting machine capable of creating a tunnel with a variable cross-sectional area within a maximum and a minimum cutting range. It is a further specific objective to provide a cutting (excavator) machine operable in an '*undercutting*' mode according to a two stage cutting action.

The invention achieves the objective by suggesting a cutting apparatus suitable for creating tunnels or subterranean roadways and the like comprising: at least one arm pivotally mounted to the apparatus and adapted to pivot in an upward and downward direction; at least one arm actuator to actuate pivoting movement of the at least one arm about an arm pivot axis; a rotatable cutting head mounted at the at least one arm, the head rotatable about a head axis oriented to extend substantially transverse to the arm pivot axis, a drive motor unit for supplying a drive power; and a cutter gear drive train coupled between the drive motor unit and the cutting head for transmitting the drive power to the cutting head, wherein the drive motor unit comprises a plurality of drive motors, each drive motor being coupled to the drive train and supplying a portion of the drive power. The invention in this aspect is based upon the realization that not one singular, but instead a plurality of distinct drive motors can be used to provide respectively only a partial amount of the power required by the cutting head. The accumulated build size of the plurality of drive motors is not necessarily smaller in volume as compared to a singular drive motor. However, splitting up the drive unit into a plurality of separate motors allows for much more flexible allocation and positioning of each drive motor, thus making an important contribution to a reduced build size of the cutting head drive as a whole. The power output for the cutting head is beneficially achieved by coupling all of the plurality of drive motors to the same drive train.

Preferably, the cutter gear drive train comprises an input shaft, and all drive motors are coupled to the input shaft. Using a single input shaft for all drive motors to be coupled to allows for a simplification of the design of the drive train.

In a preferred embodiment, the cutter gear drive train comprises an input gear wheel on the input shaft, and all drive motors are coupled to the input gear wheel. Using a single input gear wheel for receiving the output torque of all drive motors synergistically enhances the modular system of the drive motor unit.

It is preferred if at least some of the drive motors, and preferably all drive motors are identical. AC motors have been identified as particularly preferred types.

The drive motors preferentially are controlled for at least one of: a simultaneous start, or simultaneous end of operation. In a preferred alternative embodiment, the drive motors are controlled for a time-delayed start and/or end of operation. The time delay between two drive motors respectively is preferred to be in the range of 0.1 to 5 seconds. By implementing such a short time delay between the two start events, for example, the electrical power required for the start of the drive motor unit has a much smaller peak. Starting up the drive motor unit with the aforementioned delay improves the stability of the electrical power supply of the cutting apparatus and reduces the risk of failure, e.g. induced by blowing fuses. A start-up or shut-down delay may also be maintained in embodiments wherein the plurality of drive motors has three or more motors. In those embodiments for a higher number than two drive motors, e.g. three motors, there preferably is a first delay between the first and second motor start, a second delay between the second and third motor start, and so forth. The second, third etc. delay may be identical to or distinct from the first delay.

According to a further preferred embodiment, the cutter gear drive train comprises a first stage gearbox and a second stage gearbox coupled in series to the first stage gearbox, wherein the input gear wheel is part of the first stage gearbox. In this preferred embodiment, the first stage can specifically be dimensioned and designed for receiving the input torque from the drive motors, while the second stage gearbox can specifically be designed for providing the required transmission ratio necessitated by the cutting head. Also, this embodiment allows for a modular design of the drive train which will be commented on further herein below.

The first stage gearbox preferably is a spur gear. Additionally or alternatively, the second stage gearbox preferably is a planetary drive, particularly preferred a two-stage planetary drive. The particular advantage of having the first stage gearbox being a spur gearbox is that a comparatively high number of drive motors can be accommodated to supply torque to the spur gear without complicated gear structures. At the same time, a spur gear requires very little space in the axial direction. Under “axial direction” the direction parallel to the axes of rotation of the separate spur wheels is understood. A particular advantage of a planetary particularly preferred multiple stage planetary drive is that very high amounts of torque can be transferred while maintaining a very compact design of the drive train. This in turn allows for a very sturdy design able to accommodate very high normal forces. Under “normal forces” again the axial forces in the direction of the axes of rotation of the different wheels is understood.

In a particularly preferred embodiment, which at the same time also is a separate aspect of the invention, the first stage gear box and the second stage gearbox are reversibly coupled to one another. Additionally or alternatively thereto, the first stage gearbox and the second stage gearbox comprise correspondingly shaped male and female positioning means, the positioning means matingly engaging each other in the coupled state. The female positioning means preferably are formed as one or more recesses or grooves, such as annular grooves. the male positioning means preferably are formed as one or more projections, such as tabs, ridges etc. By designing the first and second stages of the gearbox to be reversibly coupleable to one another, maintenance and repair is greatly simplified. In case of a defect of either the first or second stage of the gearbox, it is easily possibly to merely replace the respective defective unit without necessity of disassembling the entire gearbox. Still further, it allows for a modular drive train design which will be commented on further herein below.

According to a preferred embodiment, which is at the same time also a separate aspect of the invention independent of the drive motor unit with its plurality of drive motors, the drive train has a first side facing the cutting head and a second side facing the drive motor unit, and further comprises a water conduit extending from the first side through to the second side for supplying water to the cutting head, wherein preferably the cutting head comprises a water manifold coupled to the conduit at the second side, the water manifold distributing the incoming water to a number of water outlets on the periphery of the cutting head. A major obstacle in the design of the cutting head in terms of keeping the build size as small as possible has been identified to be water supply to the periphery of the cutting head. To this end, it has been realized that it is possible to provide a conduit for water which extends entirely through the second stage gear box.

While perfectly well possible to realize with one arm, it has been found that it is particularly useful if the cutting apparatus of the invention further comprises: a main frame having generally upward, downward and side facing regions; a first and second support pivotally mounted relative to the main frame via respective first and second support axes aligned generally upright relative to the upward and downward facing regions such that each first and second support is configured to pivot laterally in a sideways direction relative to the side facing regions; at least one first and second support actuator to respectively actuate independently movement of each of the first and second supports relative to the main frame; wherein the at least one arm is a first arm, the cutting apparatus further comprising a second arm, the arm pivot axis being aligned in a direction extending transverse including perpendicular to each support pivot axis to enable the first and second arms to pivot independently of one another and to pivot relative to each of the respective first and second supports in an upward and downward direction relative to the upward and downward facing regions; the at least one arm actuator being a first arm actuator, and the cutting apparatus further comprising a second arm actuator, each being adapted to actuate independently pivoting movement of the first and second arms relative to each of the respective first and second support.

The invention also achieves its objective in a further aspect by suggesting a modular cutting apparatus drive train kit, in particular for the cutting apparatus of any one of the preceding claims, the kit comprising: a plurality of first stage gearboxes, preferably spur gear drives; a plurality of second stage gearboxes, preferably planetary drives ; wherein each of the first stage gearboxes and second stage gearboxes comprise correspondingly shaped male and female positioning means, the positioning means matingly engaging each other in the coupled state, wherein each one of the first stage gearboxes is adapted for reversible coupling to each one of the second stage gearboxes. The number of first stage gearboxes preferably is two or higher and is defined by spur gearboxes having different transmission ratios. For example, a first spur gearbox would be specifically adapted to be coupled to the drive motors for 50 hz power supply, while a second spur gearbox would be specifically adapted being coupled to drive motors having a 60 hz supply.

The number of second stage gearboxes preferably is two or higher, wherein each second stage gearbox of the kit has a different transmission ratio. For example, the first one of the second stage gearboxes has a transmission ratio specifically designed for a 2 m cutting head, while the second one of the second stage gearbox is specifically designed having a transmission ratio for a 2.5 m cutting head. Herein, “2 m” and “2.5 m” refer to its cutting diameter. Thus, when changing the cutting apparatus from operating with a 2 m cutting head to operating with a 2.5 m cutting head, only the second stage gearbox of the respective arm should preferably need to be replaced. When modifying the cutting apparatus from using a 50 hz power supply to using a 60 hz power supply, only the first stage gearbox of the drive train should simply need to be replaced, while all the remaining components remain in place on the machine.

The further objectives are achieved by providing a cutting apparatus having a plurality of rotatably mounted cutting heads that may be pivoted in an upward and downward direction and a lateral side-to-side direction via a plurality of independently pivoting booms mounted at a main frame. In particular, each boom comprises a support pivotally mounted to the main frame and carrying an arm via a respective additional pivot mounting such that each cutting head is capable of pivoting about two pivoting axes. The desired range of movement of each head is provided as the dual pivoting axes are aligned transverse (including perpendicular) to one another and are spaced apart in the longitudinal direction of the apparatus between a forward and rearward end.

Advantageously, the cutting heads comprise a plurality of disc-like roller cutters distributed circumferentially around a perimeter of each head so as to create a groove or channel into the rock face as the heads are driven about their respective rotational axes. The heads may then be raised vertically so as to overcome the relatively low tensile strength of the overhanging rock to provide breakage via force and energy that is appreciably lower than a more common compressive cutting action provided by cutting picks and the like.

According to a further aspect of the present invention there is provided cutting apparatus suitable for creating tunnels or subterranean roadways and the like comprising: a main frame having generally upward, downward and side facing regions; a first and second support pivotally mounted relative to the main frame via respective first and second support axes aligned generally upright relative to the upward and downward facing regions such that each first and second support is configured to pivot laterally in a sideways direction relative to the side facing regions; at least one first and second support actuator to respectively actuate independently movement of each of the first and second supports relative to the main frame; a first and second arm each pivotally mounted to the respective first and second support via a respective arm pivot axis aligned in a direction extending transverse including perpendicular to each support pivot axis to enable the first and second arms to pivot independently of one another and to pivot relative to each of the respective first and second supports in an upward and downward direction relative to the upward and downward facing regions; at least one first and second arm actuator to actuate independently pivoting movement of the first and second arms relatives to each of the respective first and second support; a rotatable cutting head mounted at each of the first and second arms, each head rotatable about a head axis orientated to extend substantially transverse to each respective arm pivot axis.

Reference within this specification to each head being rotatable about a head axis orientated to extend substantially transverse to each respective arm pivot axis includes (or encompasses) a perpendicular alignment. Such a reference also encompasses the respective pivot axes intersecting or more preferably not intersecting with the rotational axes of the cutting heads. Optionally, the rotational axes of the cutting heads are positioned generally in front of and/or above the respective pivot axes of the pivot arms.

Optionally, each cutting head comprises a generally annular cutting edge or layered cutting edges to provide an undercutting mode of operation. The configuration of each head to provide the undercutting action is advantageous to break the rock with less force and in turn provide a more efficient cutting operation that draws less power.

Preferably, the apparatus comprises a plurality of roller cutters independently rotatably mounted at each rotatable cutting head. Preferably, the roller cutters are generally annular roller cutters each having a generally annular cutting edge or layered cutting edges to provide an undercutting mode of operation. More preferably, the roller cutters are mounted at a perimeter region of each cutting head such that the roller cutters circumferentially surround each cutting head. Such a configuration is advantageous to provide the undercutting action of the apparatus with the roller cutters first creating a channel or groove extending generally horizontally in the rock face. The roller cutters may then be moved upwardly to break the rock by overcoming the tensile forces immediately above the channel or groove. A more efficient cutting operation is provided requiring less force and drawing less power. Preferably, the roller cutters are mounted at generally cylindrical bodies and comprise generally annular cutting edges distributed around the perimeter of the cutting head. Each generally circular cutting edge is accordingly positioned side-by-side around the circumference of the cutting head with each cutting edge representing an endmost part of each pivoting arm. Preferably an alignment of the rotational axes of the roller cutters relative to the rotational axis of the respective cutting head is the same so that the respective cutting edges are all orientated in the same position around the cutting head.

Preferably, each of the first and second arm actuator comprises a planetary gear assembly mounted at the junction at which each arm pivots relative to each support. The subject invention may comprise a conventional planetary gear arrangement such as a Wolfram type planetary gear having a high gear ratio. The planetary gear assembly is mounted internally with each arm such that the cutting apparatus is designed to be as compact as possible. Preferably, the apparatus further comprises at least one first drive motor to drive the pivoting movement of the first and/or second arm relative to the respective first and second support and the main frame. Preferably, the apparatus comprises two drive motors to drive each of the first and second arms about their pivoting axis via the respective planetary gears. Preferably, the respective drive motors are mounted in-board of each arm and are coupled to each arm via the planetary gear assembly and/or an intermediate drive transmission.

Preferably, the apparatus further comprises at least one second drive motor to drive rotation of the cutting head at the first and/or the second arm. Preferably, each head comprises two drive motors mounted at the side of each arm. Such an arrangement is advantageous to pivot each drive motor with each cutting head and to provide a direct drive with minimal intermediate gearing.

Optionally, the first and second support actuator comprises a hydraulic linear actuator. Preferably, each support actuator comprises a linear hydraulic cylinder positioned at the lateral sides of the sled and coupled to extend between the sled and an actuating flange extending laterally outward from each support. Such an arrangement is advantageous to minimise the overall width of the apparatus whilst providing an efficient mechanism for the sideways lateral slewing of each support and accordingly each arm.

Optionally, the sled may be positioned to operate longitudinally between the supports and each of the respective arms. That is, each arm may be configured to slide in the axially forward direction relative to each support via one or a plurality of actuators. Optionally, each arm is connected to each support via a respective sliding actuator such that each arm is configured to slide independently relative to one another. Optionally, each arm may be configured to slide in a forward and rearward direction relative to each support via a coordinated parallel sliding mechanism.

Preferably, the apparatus further comprises a powered sled movably mounted at the main frame to be configured to slide in a forward cutting direction of the apparatus relative to the main frame. The apparatus may further comprise a plurality of '*runners*' or guide rails to minimise the frictional sliding movement of the sled over the main frame. Preferably, the apparatus comprises at least one powered linear actuator to provide the forward and rearward movement of the sled relative to the main frame. As will be appreciated, the sled may be configured to move axially/longitudinally at the machine via a plurality of different actuating mechanisms including rack and pinion arrangements, belt drive arrangements, gear arrangements and the like. Preferably the supports and the arms are mounted at the sled and are all configured to move in the forward and rearward direction collectively.

Optionally, each of the first and second arms is configured to pivot in the upward and downward direction by up to 180°. Optionally, each arm may be configured to pivot over a range of up to 155°. Optionally, the first and second supports are configured to pivot in the lateral sideways direction by up to 90°. Optionally, the supports may be configured to pivot up to 20° in the lateral sideways direction. Such a configuration provides control of the profile shape and avoids any cuts or ridge that would otherwise remain on the roof and floor of the as-formed tunnel.

Preferably, the apparatus comprises tracks or wheels mounted at the main frame to allow the apparatus to move in a forward and rearward direction. The tracks or wheels enable the apparatus to be advanced forwardly and rearwardly within the tunnel both when manoeuvred into and from the cutting face between cutting operations and to be advanced forwardly during cutting operations as part of the cut-and-advance cutting cycle that also utilises the sliding sled.

Preferably, the apparatus further comprises floor and roof engaging members mounted at the main frame, at least the floor engaging members being extendable and retractable to respectively raise and lower the apparatus in the upward and downward direction. The engaging members are configured to wedge the apparatus in position between the roof and floor of the tunnel to provide points of anchorage against which the machine may be braced to allow the cutters to be forced against the rock face.

Preferably, the apparatus further comprises a first material discharge conveyor to convey cut material rearwardly from the first and second cutting head; and a gathering head to direct cut material onto the conveyor, the gathering head positioned rearwardly behind at least one of the first and second cutting heads. The apparatus is accordingly configured to transport rearwardly material from the cut face to provide unhindered forward cutting movement into the rock.

Preferably, the apparatus further comprises a control unit demountably connectable to the apparatus, the control unit comprising operational components to power at least the first and second support and arm actuators, the control unit further comprising a second conveyor to receive material from the first conveyor and to discharge the material at a position rearward of the apparatus and the control unit. Preferably, the control unit is demountably coupled to the apparatus so as to be capable of being advanced and retracted in the forward and rearward directions with the cutting apparatus. Preferably, the control unit is suspended above the tunnel floor by suitable couplings to the apparatus. The control unit may comprise ground engaging support members provided at a rearward and/or forward regions. Optionally, the control unit may be attachable at its rearward end to a material collection and discharge vehicle and to be connectable at its forward end to the cutting apparatus.

According to a further aspect of the present invention there is provided cutting apparatus suitable for creating tunnels or subterranean roadways and the like comprising: a main frame having generally upward, downward and side facing regions; a powered sled movably mounted at the main frame to be configured to slide in a forward cutting direction of the apparatus relative to the main frame; a first and second arm pivotally coupled or mounted to the sled by respective pivot arm axes aligned in a direction extending transverse including perpendicular to a longitudinal axis of the main frame to allow each arm to pivot independently of one another in an upward and downward direction relative to the upward and downward facing region of the main frame; at least one first and second arm actuator to actuate independent pivoting movement of the first and second arms relative to one another and the main frame; a rotatable cutting head mounted at each of the first and second arms so as to be configured to be moved in the upward and downward direction and advanced in the forward cutting direction, each head rotatable about a head axis orientated to extend substantially transverse to respective pivot arm axes.

Optionally, the first and second arm together with the respective pivot arm axes are respectively coupled or mounted to the sled via a first and second support, the first and second supports are slidably mounted relative to the sled via a common or respective slidable means such that each first and second support is configured to slide laterally in a sideways direction relative to the side facing regions. The first and second supports are mounted at the sled and configured to slide laterally cross the sled substantially perpendicular to the forward and backward sliding movement of the sled relative to the main frame.

Optionally, each rotatable cutting head comprises a generally annular roller cutter each having a generally annular cutting edge or layered cutting edges to provide an undercutting mode of operation.

Preferably, the apparatus further comprises a plurality of roller cutters independently rotatably mounted at each rotatable cutting head. Optionally, the plurality of roller cutters are generally annular roller cutters each having a generally annular cutting edge or layered cutting edges to provide an undercutting mode of operation.

According to a further aspect of the present invention there is provided cutting apparatus configured to create a cutting profile via an undercutting operation to create tunnels and subterranean roadways, the apparatus comprising: a main frame; a first and second arm pivotally mounted to the main frame by respective pivot arm axes aligned in a direction extending transverse including perpendicular to a longitudinal axis of the main frame to allow each arm to pivot independently of one another in an upward and downward direction relative to an upward and downward facing region of the main frame; at least one first and second arm actuator to actuate independent pivoting movement of the first and second arms relative to one another and the main frame; a rotatable cutting head mounted at each of the first and second arms, each cutting head comprising generally annular roller cutters each having a generally annular cutting edge to provide an undercutting mode of operation.

Preferably, the apparatus comprises a first and second support pivotally mounted relative to the main frame via respective first and second support axes aligned generally upright relative to the upward and downward facing regions such that each first and second support is configured to pivot laterally in a sideways direction relative to the side facing regions.

Preferably, the apparatus further comprises a powered sled movably mounted at the main frame, the first and second arms mounted at the sled so as to be capable of longitudinal reciprocating movement to slide in a forward cutting direction of the apparatus to engage the roller cutters into the rock face.

Brief description of drawings

A specific implementation of the present invention will now be described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 is a front perspective view of a mobile cutting apparatus suitable for creating tunnels or subterranean roadways having a forward mounted cutting unit and a rearward control unit according to a specific implementation of the present invention;

Figure 2 is a rear perspective view of the cutting apparatus of figure 1;

Figure 3 is a side elevation view of the apparatus of figure 2;

Figure 4 is a magnified front perspective view of the cutting unit of the apparatus of figure 3;

Figure 5 is a plan view of the cutting apparatus of figure 4;

Figure 6 is a side elevation view of the cutting apparatus of figure 5;

Figure 7 is a front end view of the cutting apparatus of figure 6;

Figure 8 is a perspective view of the cutting gear motor and drive train of the cutting apparatus of figures 1 to 7;

Figures 9a and 9b are side elevation views of the assembly of figure 8;

Figure 10 is a first cross-sectional view of the assembly of figures 8 and 9; and

Figure 11 is a second cross-sectional view of the assembly of figures 8 to 10.

Detailed description of preferred embodiment of the invention

Referring to figure 1, cutting apparatus 100 comprises a main frame 102 mounting a plurality of cutting components configured to cut into a rock or mineral face to create tunnels or subterranean roadways. Apparatus 100 is configured specifically for operation in an undercutting mode in which a plurality of rotatable roller cutters 127 may be forced into the rock to create a groove or channel and then to be pivoted vertically upward so as to overcome the reduced tensile force immediately above the groove or channel and break the rock. Accordingly, the present cutting apparatus is optimised for forward advancement into the rock or mineral utilising less force and energy typically required for conventional compression type cutters that utilise cutting bits or picks mounted at rotatable heads. However, the present apparatus may be configured with different types of cutting head to those described herein including in particular pick or bit type cutting heads in which each pick is angularly orientated at the cutting head to provide a predetermined cutting attack angle.

Referring to figures 1 to 3, main frame 102 comprises lateral sides 302 to be orientated towards the wall of the tunnel; an upward facing region 300 to be orientated towards a roof of the tunnel; a downward facing region 301 orientated to be facing the floor of the tunnel; a forward facing end 303 intended to be positioned facing the cutting face and a rearward facing end 304 intended to be positioned facing away from the cutting face.

An undercarriage 109 is mounted generally below main frame 102 and in turn mounts a pair of crawler tracks 103 driven by a hydraulic (or electric) motor to provide forward and rearward movement of apparatus 100 over the ground when in a non-cutting mode. A pair of rear ground engaging jacking legs 106 are mounted at frame sides 302 towards rearward end 304 and are configured to extend and retract linearly relative to frame 102. Frame 102 further comprises a forward pair of jacking legs 115 also mounted at each frame side 302 and towards forward end 303 and being configured to extend and retract to engage the floor tunnel. By actuation of legs 106, 115, main frame 102 and in particular tracks 103 may be raised and lowered in the upward and downward direction so as to suspend tracks 103 off the ground to position apparatus 100 in a cutting mode. A pair of roof engaging grippers 105 project upwardly from main frame 102 at frame rearward end 304 and are extendable and retractable linearly in the upward and downward direction via control cylinders 116. Grippers 105 are therefore configured to be raised into contact with the tunnel roof and in extendable combination with jacking legs 106, 115 are configured to wedge apparatus 100 in a stationary position between the tunnel floor and roof when in the cutting mode.

A sled 104 is slidably mounted on top of main frame 102 via a slide mechanism 203. Sled 104 is coupled to a linear hydraulic cylinder 201 such that by reciprocating extension and retraction of cylinder 201, sled 104 is configured slide linearly between frame forward and rearward ends 303, 304.

A pair of hydraulically actuated bolting units 107 are mounted at main frame 102 between sled 104 and roof gripping unit 105, 116 relative to a lengthwise direction of the apparatus. Bolting units 107 are configured to secure a mesh structure (not shown) to the roof of the tunnel as apparatus 100 is advanced in a forward cutting direction. Apparatus 100 also comprises a mesh support structure (not shown) mounted generally above sled 104 so as to positionally support the mesh directly below the roof prior to bolting into position.

A pair of supports 120 are pivotally mounted at and project forwardly from sled 104 immediately above frame forward end 303. Supports 120 are generally spaced apart in a lateral widthwise direction of the apparatus 100 and are configured to independently pivot laterally outward from one another relative to sled 104 and main frame 102. Each support 120 comprises a forward end 503 and a rearward end 504 referring to figure 5. A first mount flange 118 is provided at support rearward end 504 being generally rearward facing. A corresponding second mount flange 119 projects laterally outward from a side of sled 104 immediately behind the first flange 118. A pair of linear hydraulic cylinders 117 are mounted to extend between flanges 118, 119 such that by linear extension and retraction, each support 120 is configured to pivot in the generally horizontal plane and in the lateral sideways direction relative to frame sides 302. Referring to figured 4, each support 120 is mounted at sled 104 via a pivot rod 404 extending generally vertically (when apparatus 100 is positioned on horizontal ground) through sled 104 and being suspended generally above the main frame forward end 303. Each support 120 is therefore configured to pivot or slew about pivot axis 400. Referring to figure 5, each support 120 is further coupled to a respective inner hydraulic cylinder 500 mounted at an inner region of sled 104 to cooperate with side mounted cylinders 117 to laterally slew each support 120 about pivot axis 400.

Referring to figures 4 and 5, as the respective pivot axes 400 are space apart in the widthwise direction of apparatus 100, supports 120 are capable of being slewed inwardly to a maximum inward position 501 and to be slewed laterally outward to a maximum outward position 502. According to the specific implementation, an angle between the inner and outer slewing positions 501, 502 is 20°.

Referring to figures 1 to 3, an arm 121 is pivotally mounted generally at the forward end 503 of each support 120. Each arm 121 comprises a cutting head 128 rotatably mounted at a distal end. Each cutting head 128 comprises a disk like (generally cylindrical) configuration. The plurality of generally annular or disc shaped roller cutters 127 are mounted at the circumferential perimeter of each head 128 and comprise a sharp annular cutting edge configured specifically for undercutting the rock. Cutters 127 are rotatably mounted independently relative to one another and head 128 and are generally free to rotate about their own axis. Each roller cutter 127 projects axially beyond a forwardmost annular edge of head 128 such that when arms 121 are orientated to be extending generally downward, roller cutters 127 represent a lowermost part of the entire head 128 and arm 121 assembly. Each arm 121 may be considered to comprise a length such that arm 121 is mounted at each respective support 120 at or towards a proximal arm end and to mount each head 128 at a distal arm end. In particular, each arm 121 comprises an internally mounted planetary gear indicated generally be reference 122. Each gear 122 is preferably a Wolfrom type and is coupled to a drive motor unit 130 via a drive train indicated generally by reference 123. A pair of drive motors 125 are mounted at the lateral sides of each arm 121 and are orientated to be approximately parallel with the rotational axis of each respective cutting head 128 as shown in figure 7. Each arm 121 further comprise an internal drive and gear assembly 124 coupled to a gear box 126 mounted at one end of each of the drive motors 125. Each cutting head 128 is driveably coupled to the drive motors 125 via the respective gear assembly 124 to provide rotation of cutting head 128 about axis 402.

According to the specific implementation, and as shown in figure 7, each arm 121 is coupled to a respective drive motor unit 130 mounted at a forward end of sled 104. Each planetary gear 122 is centred on a pivot rod 405 having a pivot axis 401 referring to figure 4. Each axis 401 is aligned to be generally horizontal when apparatus 100 is positioned on horizontal ground. Accordingly, each arm 121 is configured to pivot (relative to each support 120, sled 104 and main frame 102) in the upward and downward direction (vertical plane) by actuation of each drive motor unit 130. As such, each cutting head 128 and in particular the roller cutters 127 may be raised and lowered along the arcuate path 602 referring to figure 6. In particular, each arm 121, head 128 and roller cutters 127 may be pivoted between a lowermost position 601 and an uppermost raised position 600 with an angle between positions 600, 601 being approximately 150°. When in the lowermost position 601, each roller cutter 127 and in particular head 128 is suspended in a declined orientation such that a forwardmost roller cutter 127 is positioned lower than a rearwardmost roller cutter 127. According to the specific implementation, this angle of declination is 10°. This is advantageous to engage the cutters 127 into the rock face at the desired attack angle to create the initial groove or channel during a first stage of the undercutting operation. Additionally, the extensive range of movement of the cutting heads 128 over the rock face is possible due, in part, to axis 401 being separated and positioned forward relative to axis 400 by a distance corresponding to a length of each support 120.

Referring to figure 4, each support pivot axis 400 is aligned generally perpendicular to each arm pivot axis 401. Additionally, a rotational axis 402 of each cutting head 128 is orientated generally perpendicular to each arm pivot axis 401. A corresponding rotational axis 403 of each roller cutter 127 is angularly disposed relative to cutting head axis 402 so as to taper outwardly in the downward direction. In particular, each roller cutter axis 403 is orientated to be aligned closer to the orientation of each cutting head rotational axis 402 and support pivot axis 400 relative to the generally perpendicular arm rotational axis 401.

Accordingly, each support 120 is configured to slew laterally outward in a horizontal plane about each support axis 400 between the extreme inner and positions 501, 502. Additionally and referring to figure 6, each respective arm 121 is configured to pivot in the upward and downward direction about arm pivot axis 401 to raise and lower the roller cutters 127 between the extreme positions 600, 601.

A gathering head 129 is mounted at main frame forward end 303 immediately rearward behind each cutting head 128. Gathering head 129 comprises a conventional shape and configuration having side loading aprons and a generally inclined upward facing material contact face to receive and guide cut material rearwardly from the cutting face (and cutting heads 128). Apparatus 100 further comprises a first conveyor 202 extending lengthwise from gathering head 129 to project rearwardly from frame rearward end 304. Accordingly, material cut from the face is gathered by head 129 and transported rearwardly along apparatus 100.

Referring to figures 1 to 3, a detachable control unit 101 is mounted to the frame rearward end 403 via a pivot coupling 200. Control unit 111 comprises a personnel cabin 110 (to be occupied by an operator). Unit 111 further comprises an electric and hydraulic power pack 114 to control the various hydraulic and electrical components of apparatus 100 associated with the pivoting movement of supports 120 and arms 121 in addition to the sliding movement of sled 104 and the rotational drive of cutting heads 128.

Control unit 101 further comprises a second conveyor 112 extending generally lengthwise along the unit 101 and coupled at its forwardmost end to the rearwardmost end of first conveyor 202. Unit 101 further comprises a discharge conveyor 113 projecting rearwardly from the rearward end of second conveyor 112 at an upward declined angle. Accordingly, cut material is capable of being transported rearwardly from cutting heads 128 along conveyors 202, 112 and 113 to be received by a truck or other transportation vehicle.

In use, apparatus 100 is wedged between the tunnel floor and roof via jacking legs 106, 115 and roof grippers 105. Sled 104 may then be displaced in a forward direction relative to main frame 102 to engage roller cutters 127 onto the rock face. Cutting heads 128 are rotated via motors 125 that create the initial groove or channel in the rock face at a lowermost position. A first arm 121 is then pivoted about axis 401 via drive motor unit 130 to raise roller cutters 127 along path 602 to achieve the second stage undercutting operation. The first support 120 may then be slewed in the lateral sideways direction via pivoting about axis 400 and combined with the raising and lowering rotation of roller cutters 127 creates a depression or pocket within the rock immediately forward of the first arm 121 and support 120. The second arm 121 and associated head 128 and cutters 127 are then actuated according to the operation of the first arm 121 involving pivoting in both the vertical and horizontal planes. This sequential dual pivoting movement of the second arm 121 is independent of the initial dual pivoting movement of the first arm 121. A phasing and sequencing of the pivoting of arms 121 about axes 401 and supports 120 about axes 400 is controlled via control unit 111.

When the maximum forward travel of sled 104 is achieved, jacking legs 106, 115 are retracted to engage tracks 103 onto the ground. Tracks 103 are orientated to be generally declined (at an angle of approximately 10° relative to the floor) such that when ground contact is made, the roller cutters 127 are raised vertically so as to clear the tunnel floor. The apparatus 100 may then be advanced forward via tracks 103. Jacking legs 106, 115 may then be actuated again to raise tracks 103 off the grounds and grippers 105 moved into contact with the tunnel roof to repeat the cutting cycle. A forwardmost roof gripper 108 is mounted above sled 104 to stabilise the apparatus 100 when sled 104 is advanced in the forward direction via linear actuating cylinder 201.

Figure 8 shows an overview of a cutter gear drive train 131 coupled to the drive motor unit of the cutting apparatus according to the figures 1 to 7. The drive motor unit has a plurality of drive motors 125 that are coupled to a first stage gearbox 124. The first stage gearbox 124 comprises a mounting flange 135 which is reversibly coupled to a corresponding mounting flange 137 of a second stage gearbox 126. The second stage gearbox 126 and the first stage gearbox 124 together form the cutter gear drive train 131. At the same time, the first and second stage gearboxes 124, 126 preferably define a modular drive train gearbox kit. A plurality of mounting brackets 133, particularly two opposingly situated mounting brackets, are located on the out periphery of the drive train. In particular, the mounting brackets 133 are located on the peripheral surface of the second stage gearbox 126. The mounting brackets 133 are adapted to support corresponding coupling means of a loading flap (not shown).

In operation, the cutting gear drive unit is coupled to the cutter head 128 as indicated by the arrow on the bottom of figure 8.

Figures 9a and 9b show several side elevation view of the assembly of figure 8. In particular, figure 9a indicates a cross-section shown in more detail in figure 11, whereas figure 9b indicates a cross-section shown in figure 10. The first stage gearbox 124 comprises a number of covers 139a,b. Cover 139a provides access to a spur wheel. Cover 139b is coaxial with respect to the input shaft 141 of the second stage gearbox 126, cf. figure 10.

Figur 10 shows a cross-section perpendicular to the axial direction of the first stage gear box 124. The first stage gearbox 124 has a spur gear drive. The spur gear drive comprises an input shaft 141. Mounted to the input shaft 141, the first stage gearbox 124 comprises an input gear wheel 143. The plurality of drive motors 125 (figures 8, 9a,b) are coupled to the input gear wheel 143 through motor output gear wheels 145.

The input gear wheel 143 engages an intermediate gear wheel 147. The intermediate gear wheel is coupled, through an output gear wheel 149, to a transfer shaft 151. Coupled in series to the first stage gearbox 124, preferably through the transfer shaft 151, is the second stage planetary drive 126, which is shown in more detail in figure 11.

The second stage gearbox 126 comprises a first sun wheel 153 coupled to the output gear wheel 149 of the first stage gearbox 124. The first sun wheel 153 engages a number of first planetary wheels 155. The planetary wheels 155 further engage a first hollow wheel 157 and are supported on a planetary carrier 159, respectively. The planetary carrier 159 is coupled to a second sun wheel 161 associated with a second stage planetary drive within the second stage gearbox 126. The second sun wheel 126 engages a number of second planetary wheels 163. The second planetary wheels 163 rotate by engaging a second hollow wheel 165. In the preferred embodiment shown, the second hollow wheel 165 forms part of the housing of the second stage gearbox 126 and is reversibly coupled to the first hollow wheel 157. The second planetary wheels 163 are supported by a planetary carrier 167 which is adapted to transmit the torqe applied to it to the cutting head 128.

In a separate aspect, figure 11 shows a particulary preferred aspect of the invention. A water conduit 169 is led coaxially through the sun wheels 153, 161 of the planetary drives of the second stage gearbox 126. The conduit 169 leads all the way through the drive train 131 in order to supply water to a manifold (not shown) of the cutting head 128. The conduit 169 is sealingly led through cover 139b on a first side 171 of the drive train 131 and then through a further cover 173 facing a second side 174 of the drive train 131, opposite the first side 171.

The massive expected normal forces in direction of axis A are led from the solid structure of the planetary carrier 167 and a pre-tensioned bearing assemply, preferably comprising two rows of tapered roller bearings, generally indicated by reference signs 175a,b to the second hollow wheel 165. A portion of the normal forces is thus held by the second hollow wheel 165, and another portion by a support ring 177 coupled to the first bearing row 175a and the second planetary carrier 167.

During cutting operation, particularly in undercutting (i.e. upward slewing of the cutting head 128), significant radial forces (i.e. perpendicular with respect to axis A) will act upon the cutting head 128 in addition to the normal forces mentioned hereinabove. In a preferred embodiment such as the one shown, the cutting head 128 is coupled to the drive train 123 by a plurality of screw connections. Particularly preferred, the cutting head 128 is mounted directly to the second planetary carrier 167 of the second stage gearbox 126. The radial forces acting upon the cutting head 128 are led into the second planetary carrier 167. Preferably the second planetary carrier 167 has a material thickness in the radial direction that is dimensioned to withstand the radial forces acting upon the cutting head 128 substantially without elastic deformation, or the deformation of the planetary carrier is so small that there is no negative impact on the bearings or on any other components in the gearbox.

The multi-row pretensioned bearings 175a,b lead the radial forces on to the second hollow wheel 165. From the second wheel 165, the radial forces are led in to the rigid cutting arm 121 of the cutting apparatus 100, and through the support 120 to which the arm 121 is mounted into the main frame 102. As the arm 121 is rotatably linked to the support 120 through an arm actuator 122 having its own drive motor unit 130 and drive train, the radial forces acting upon the cutting head 128 also are borne by the arm actuator drive train, the drive train being supplied with sufficient torque by its drive motor unit 130.

As is evident in particular from figure 11, the invention provides an extremely compact and furthermore modular gearbox design and drive power supply system for the cutting apparatus of the invention. As can further be seen from figure 10 in particular, and also from figure 8, replacing the first or second stage gearbox 124, 126 is easily achieved with the reversible coupling and interfacing means provided between the first and second stages 124, 126 of the cutting head drive train 131.

Exemplary embodiments:

Embodiment 1. Cutting apparatus (100) suitable for creating tunnels or subterranean roadways and the like comprising:

a main frame (102) having generally upward (300), downward (301) and side (302) facing regions;

a first and second support (120) pivotally mounted relative to the main frame (102) via respective first and second support axes (400) aligned generally upright relative to the upward (300) and downward (301) facing regions such that each first and second support (120) is configured to pivot laterally in a sideways direction relative to the side (302) facing regions;

at least one first and second support actuator (117) to respectively actuate independently movement of each of the first and second supports (120) relative to the main frame (102);

a first and second arm (121) each pivotally mounted to the respective first and second (120) support via a respective arm pivot axis (401) aligned in a direction extending transverse including perpendicular to each support pivot axis (400) to enable the first and second arms (121) to pivot independently of one another and to pivot relative to each of the respective first and second supports (120) in an upward and downward direction relative to the upward (300) and downward (301) facing regions;

at least one first and second arm actuator (122, 130) to actuate independently pivoting movement of the first and second arms (121) relatives to each of the respective first and second support (120);

a rotatable cutting head (128) mounted at each of the first and second arms (121), each head (128) rotatable about a head axis (402) orientated to extend substantially transverse to each respective arm pivot axis (401).

Embodiment 2. The apparatus of embodiment 1 wherein each cutting head comprises a generally annular cutting edge or layered cutting edges to provide an undercutting mode of operation.

Embodiment 3. The apparatus of embodiment 1 or 2 further comprising a plurality of roller cutters (127) independently rotatably mounted at each rotatable cutting head (128).

Embodiment 4. The apparatus of embodiment claim 3 wherein the plurality of roller cutters (127) are generally annular roller cutters each having a generally annular cutting edge or layered cutting edges to provide an undercutting mode of operation.

Embodiment 5. The apparatus of any one of the preceding embodiments wherein each of the first and second arm actuator (122, 130) comprises a planetary gear assembly mounted at the junction at which each arm (121) pivots relative to each support (120).

Embodiment 6. The apparatus of any one of the preceding embodiments wherein at least one of the first and second arm actuator (122, 130) comprises at least one first drive motor to drive the pivoting movement of the first and/or second arm (121) relative to the respective first and second support (120).

Embodiment 7. The apparatus of any one of the preceding embodiments further comprising at least one second drive motor (125) to drive rotation of the cutting head (128) at the first and/or the second arm (121).

Embodiment 8. The apparatus of any one of the preceding embodiments wherein the first and second support actuator (117) comprises a hydraulic linear actuator.

Embodiment 9. The apparatus of any one of the preceding embodiments further comprising a powered sled (104) movably mounted at the main frame (102) to be configured to slide in a forward cutting direction of the apparatus (100) relative to the main frame (102).

Embodiment 10. The apparatus of embodiment 9 wherein each of the first and second cutting head (128) is mounted at the sled (104) via the respective first and second arms (121) and supports (120) so as to be configured to advance in the forward cutting direction.

Embodiment 11. The apparatus of any one of the preceding embodiments wherein:

each of the first and second arms (121) is configured to pivot in the upward and downward direction by up to 180°; and

each of the first and second supports (120) is configured to pivot in the lateral sideways direction by up to 90°.

Embodiment 12. The apparatus of any one of the preceding embodiments further comprising tracks (103) or wheels mounted at the main frame (102) to allow the apparatus (100) to move in a forward and rearward direction.

Embodiment 13. The apparatus of any one of the preceding embodiments further comprising floor and roof engaging members (106, 115, 105, 108) mounted at the main frame (102), at least the floor engaging members (106, 115) being extendable and retractable to respectively raise and lower the apparatus (100) in the upward and downward direction.

Embodiment 14. The apparatus of any one of the preceding embodiments further comprising:

a first material discharge conveyor (202) to convey cut material rearwardly from the first and second cutting head (128); and

a gathering head (129) to direct cut material onto the conveyor (202), the gathering head (129) positioned rearwardly behind at least one of the first and second cutting heads (128).

Embodiment 15. The apparatus of embodiment 14 further comprising a control unit (101) demountably connectable to the apparatus (100), the control unit (101) comprising operational components (114) to power at least the first and second support (120) and arm actuators (122, 130), the control unit (101) further comprising a second conveyor (112) to receive material from the first conveyor (202) and to discharge the material at a position rearward of the apparatus (100) and the control unit (101).

Embodiment 16. Cutting apparatus (100) suitable for creating tunnels or subterranean roadways and the like comprising:

a main frame (102) having generally upward (300), downward (301) and side (302) facing regions;

a powered sled (104) movably mounted at the main frame (102) to be configured to slide in a forward cutting direction of the apparatus (100) relative to the main frame (102);

a first and second arm (121) pivotally mounted to the sled (104) by respective pivot arm axes (401) aligned in a direction extending transverse including perpendicular to a longitudinal axis of the main frame (102) to allow each arm (121) to pivot independently of one another in an upward and downward direction relative to the upward and downward facing region of the main frame (102);

at least one first and second arm actuator (122, 130) to actuate independent pivoting movement of the first and second arms (121) relative to one another and the main frame (102);

a rotatable cutting head (128) mounted at each of the first and second arms (121) so as to be configured to be moved in the upward and downward direction and advanced in the forward cutting direction, each head (128) rotatable about a head axis (402) orientated to extend substantially transverse to respective pivot arm axes (401).

Embodiment 17. The apparatus of embodiment 16 wherein each first and second arm (121) together with the respective pivot arm axes is respectively mounted to the sled (104) via a first and second support (120) that is slidably mounted relative to the sled (104) via a common or respective slidable means such that each first and second support (120) is configured to slide laterally in a sideways direction relative to the side facing regions (302).

Embodiment 18. The apparatus of embodiment 16 or 17 wherein each rotatable cutting head (128) comprises a generally annular roller cutter (127) each having a generally annular cutting edge or layered cutting edges to provide an undercutting mode of operation.

Embodiment 19. The apparatus of any one of embodiments 16 to 18 further comprising a plurality of roller cutters (127) independently rotatably mounted at each rotatable cutting head (128).

Embodiment 20. The apparatus of embodiment 19 wherein the plurality of roller cutters (127) are generally annular roller cutters each having a generally annular cutting edge or layered cutting edges to provide an undercutting mode of operation.

Embodiment 21. The apparatus of any one of embodiments 17 to 20 wherein each of the first and second arm actuator (122, 130) comprises a planetary gear assembly mounted at the junction at which each arm (121) pivots relative to each support.

The features of the embodiments presented hereinabove are understood to be, alone or in combination with each other, preferred embodiments of the invention in themselves as well as in combination with what is claimed hereinafter.

Claims

1. Cutting apparatus (100) suitable for creating tunnels or subterranean roadways and the like comprising:
at least one arm (121) pivotally mounted to the apparatus and adapted to pivot in an upward and downward direction;
at least one arm actuator (122, 130) to actuate pivoting movement of the at least one arm (121) about an arm pivot axis (401);
a rotatable cutting head (128) mounted at the at least one arm (121), the head (128) rotatable about a head axis (402) oriented to extend substantially transverse to the arm pivot axis (401),
a drive motor unit (125) for supplying a drive power; and
a cutter gear drive train coupled between the drive motor unit and the cutting head for transmitting the drive power to the cutting head, wherein
the drive motor unit (125) comprises a plurality of drive motors, each drive motor being coupled to the drive train and supplying a portion of the drive power.

2. The cutting apparatus of claim 1,
wherein the cutter gear drive train comprises an input shaft, and all drive motors are coupled to the input shaft.

3. The cutting apparatus of claim 2,
wherein the cutter gear drive train comprises an input gear wheel on the input shaft, and all drive motors are coupled to the input gear wheel.

4. The cutting apparatus of any one of the preceding claims,
wherein at least some of the drive motors, and preferably all drive motors are identical.

5. The cutting apparatus of any one of the preceding claims,
wherein the drive motors are controlled for a simultaneous start and/or end of operation.

6. The cutting apparatus of any one of claims 1 to 4,

wherein the drive motors are controlled for a time-delayed start and/or end of operation.

7. The cutting apparatus of claim 6,
the time delay between two drive motors respectively being in the range of 0.1 to 5 seconds.

8. The cutting apparatus of any one of the preceding claims,
wherein the cutter gear drive train comprises a first stage gearbox and a second stage gearbox coupled in series to the first stage gearbox, wherein the input gear wheel is part of the first stage gearbox.

9. The cutting apparatus of claim 8,
wherein the first stage gearbox is a spur gear.

10. The cutting apparatus of claim 8 or 9,
wherein the second stage gearbox is a planetary drive.

11. The cutting apparatus of claim 10,
the second stage gearbox being a two-stage planetary drive.

12. The cutting apparatus of any one of claims 8 to 11,
wherein the first stage gear box and the second stage gearbox, are reversibly coupled to one another, and/or
wherein the first stage gearbox and the second stage gearbox comprise correspondingly shaped male and female positioning means, the positioning means matingly engaging each other in the coupled state.

13. The cutting apparatus of any one of the preceding claims,
wherein the drive train has a first side facing the cutting head and a second side facing the drive motor unit, and further comprises a water conduit extending from the first side through to the second side for supplying water to the cutting head,

wherein preferably the cutting head comprises a water manifold coupled to the conduit at the second side, the water manifold distributing the incoming water to a number of water outlets on the periphery of the cutting head.

14. The cutting apparatus of any one of the preceding claims, comprising:

a main frame (102) having generally upward (300), downward (301) and side (302) facing regions;

a first and second support (120) pivotally mounted relative to the main frame (102) via respective first and second support axes (400) aligned generally upright relative to the upward (300) and downward (301) facing regions such that each first and second support (120) is configured to pivot laterally in a sideways direction relative to the side (302) facing regions;

at least one first and second support actuator (117) to respectively actuate independently movement of each of the first and second supports (120) relative to the main frame (102);

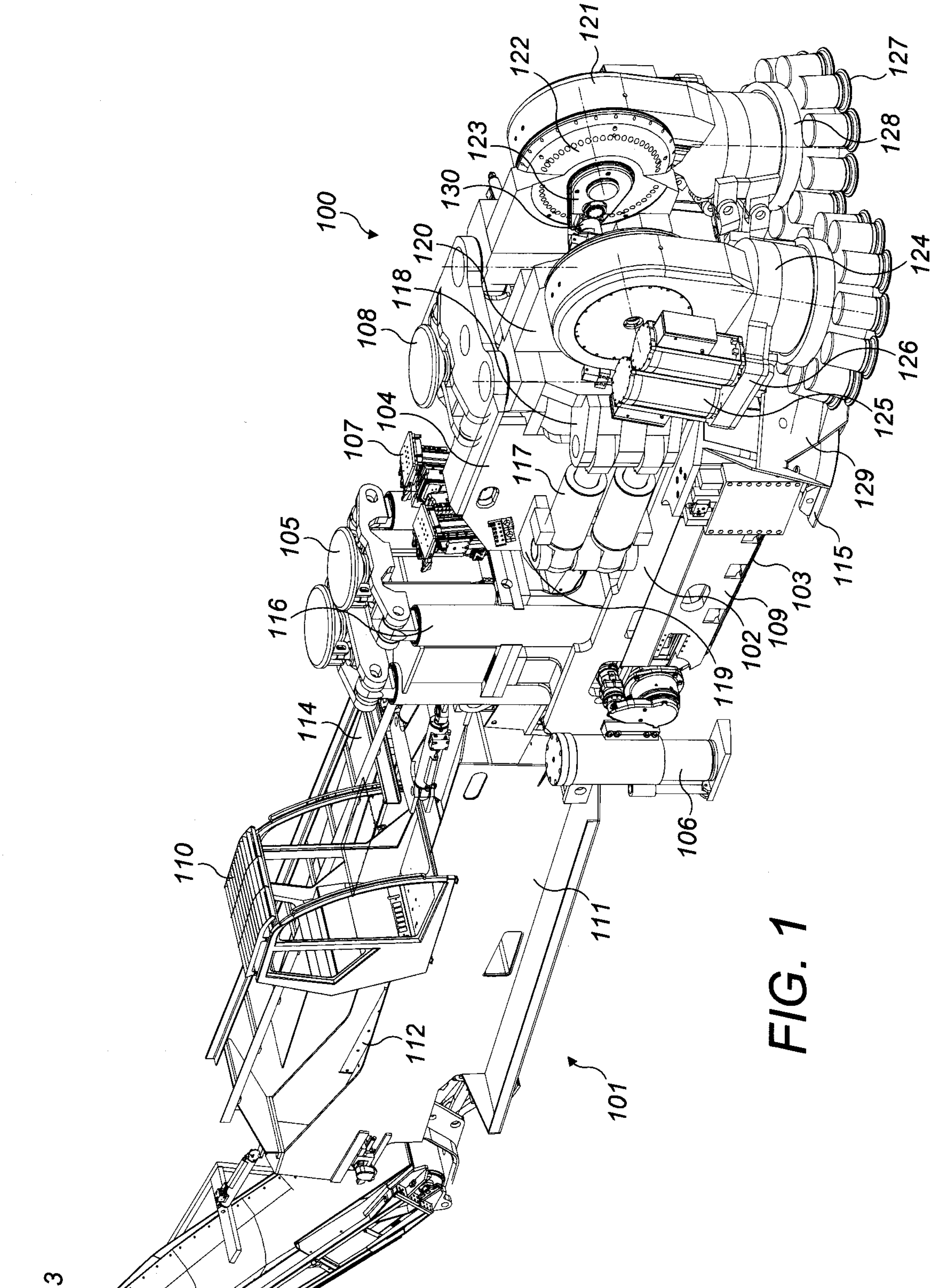
wherein the at least one arm (121) is a first arm, the cutting apparatus further comprising a second arm (121), the arm pivot axis (401) being aligned in a direction extending transverse including perpendicular to each support pivot axis (400) to enable the first and second arms (121) to pivot independently of one another and to pivot relative to each of the respective first and second supports (120) in an upward and downward direction relative to the upward (300) and downward (301) facing regions;

the at least one arm actuator (122;130) being a first arm actuator, and the cutting apparatus further comprising a second arm actuator (122, 130), each being adapted to actuate independently pivoting movement of the first and second arms (121) relative to each of the respective first and second support (120).

15. A modular cutting apparatus drive train kit, in particular for the cutting apparatus of any one of the preceding claims, the kit comprising:

- a plurality of first stage gearboxes, preferably spur gear drives;
- a plurality of second stage gearboxes, preferably planetary drives;

wherein each of the first stage gearboxes and second stage gearboxes comprise correspondingly shaped male and female positioning means, the positioning means matingly engaging each other in the coupled state, wherein each one of the first stage gearboxes is adapted for reversible coupling to each one of the second stage gearboxes.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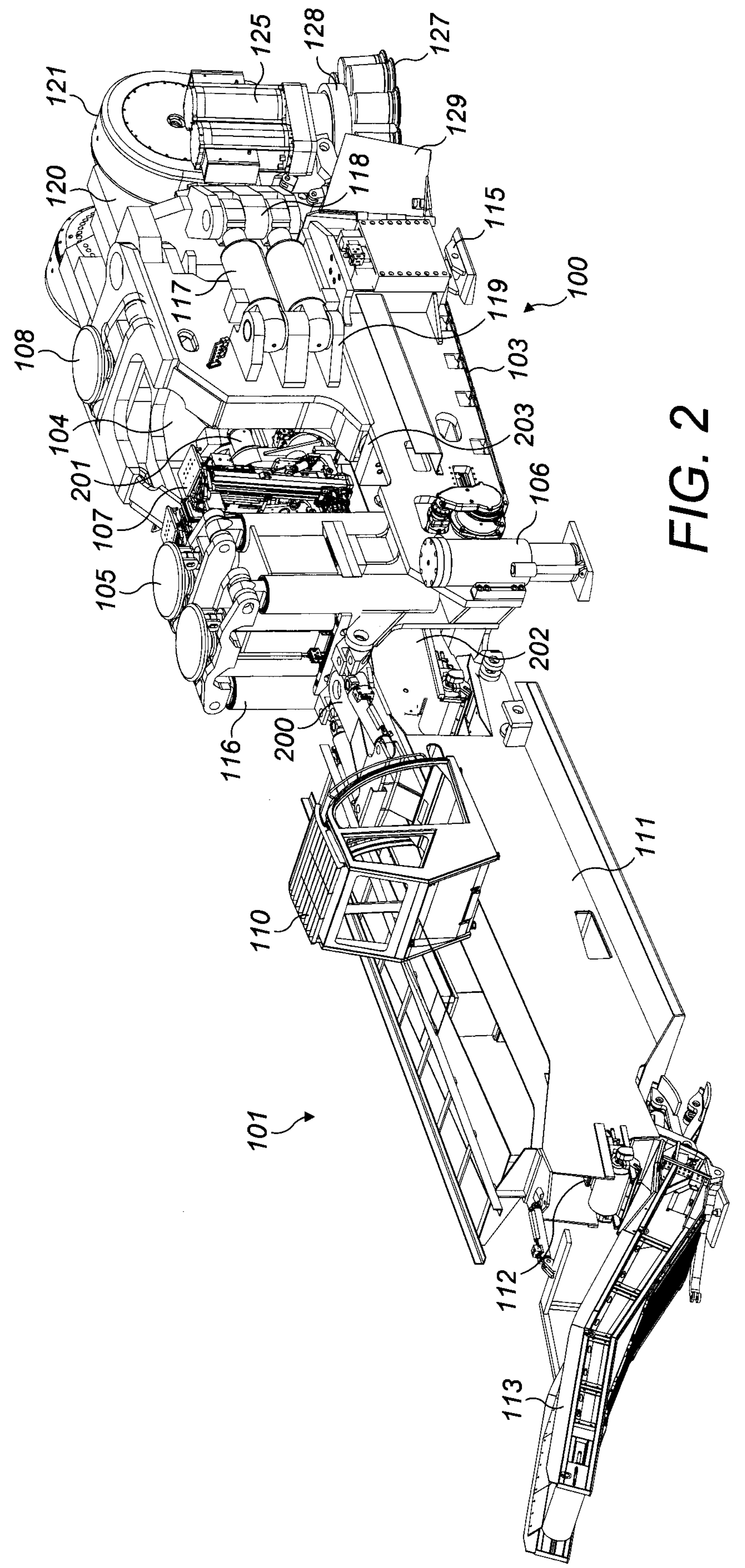
121
122
123
124
125
126
127
128
129
130

FIG. 1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128
127
129
120
118
115
117
100
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201
106
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105
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116
200
111
110
101
112
113

FIG. 2

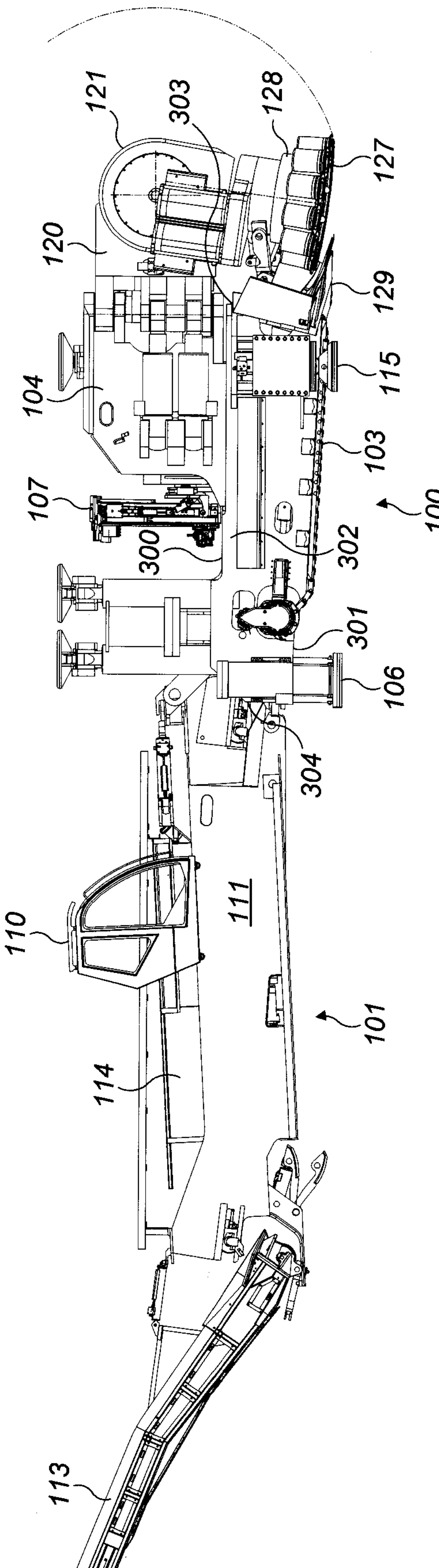
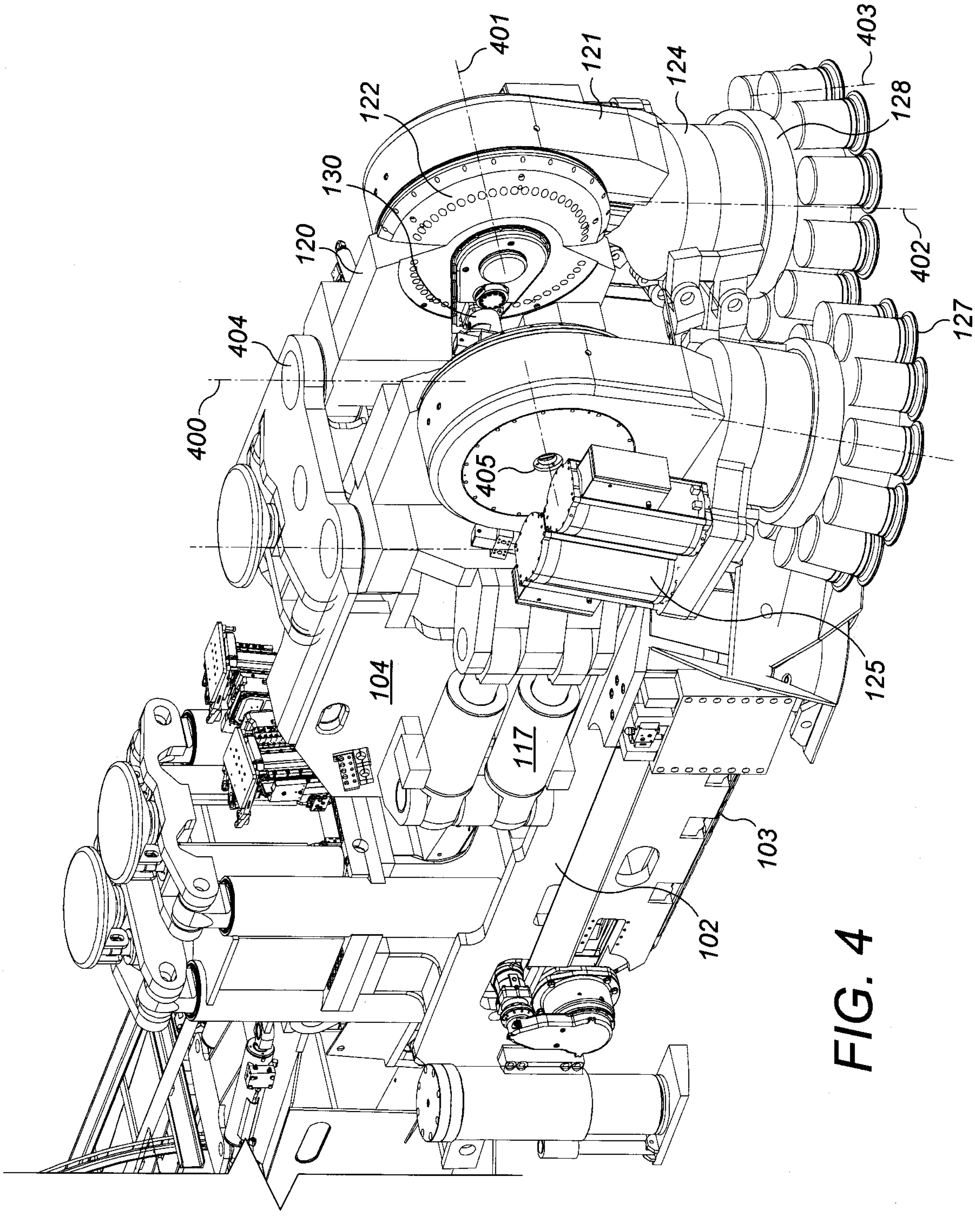

121
303
128
127
120
129
104
115
103
107
100
300
302
301
106
304
110
111
101
114
113

FIG. 3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121
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403
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130
128
120
402
127
404
400
405
125
104
117
103
102

FIG. 4

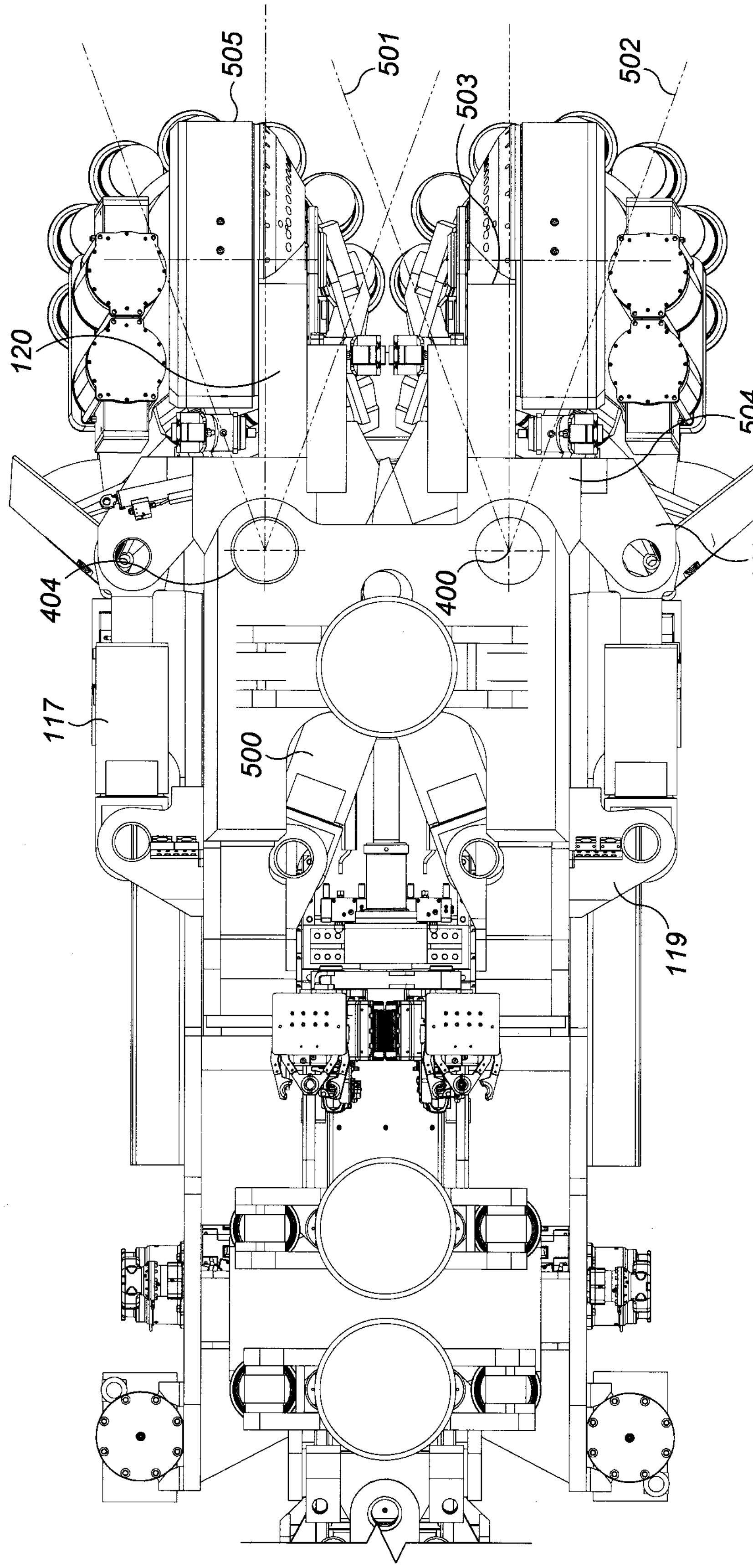

FIG. 5

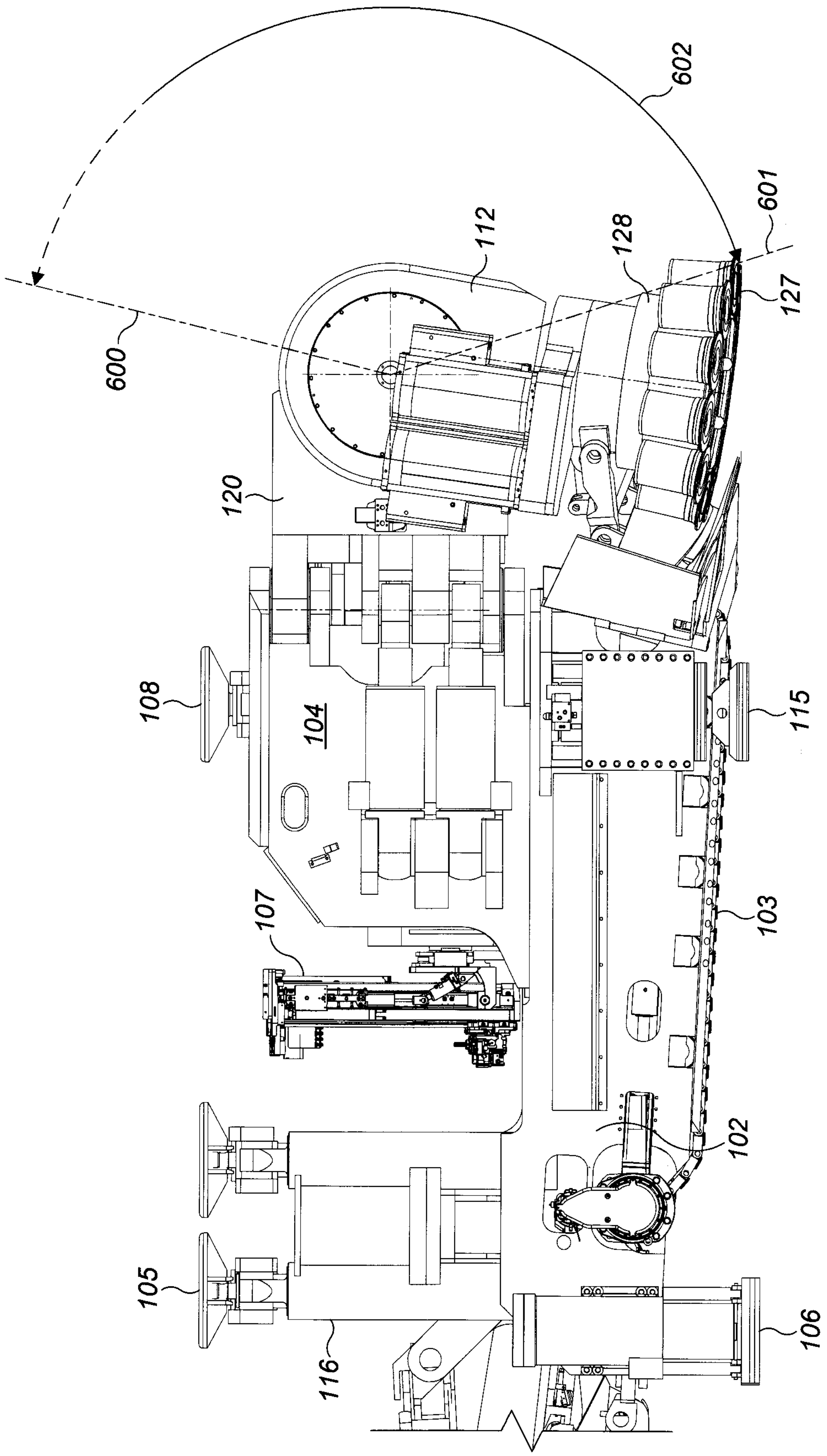

FIG. 6

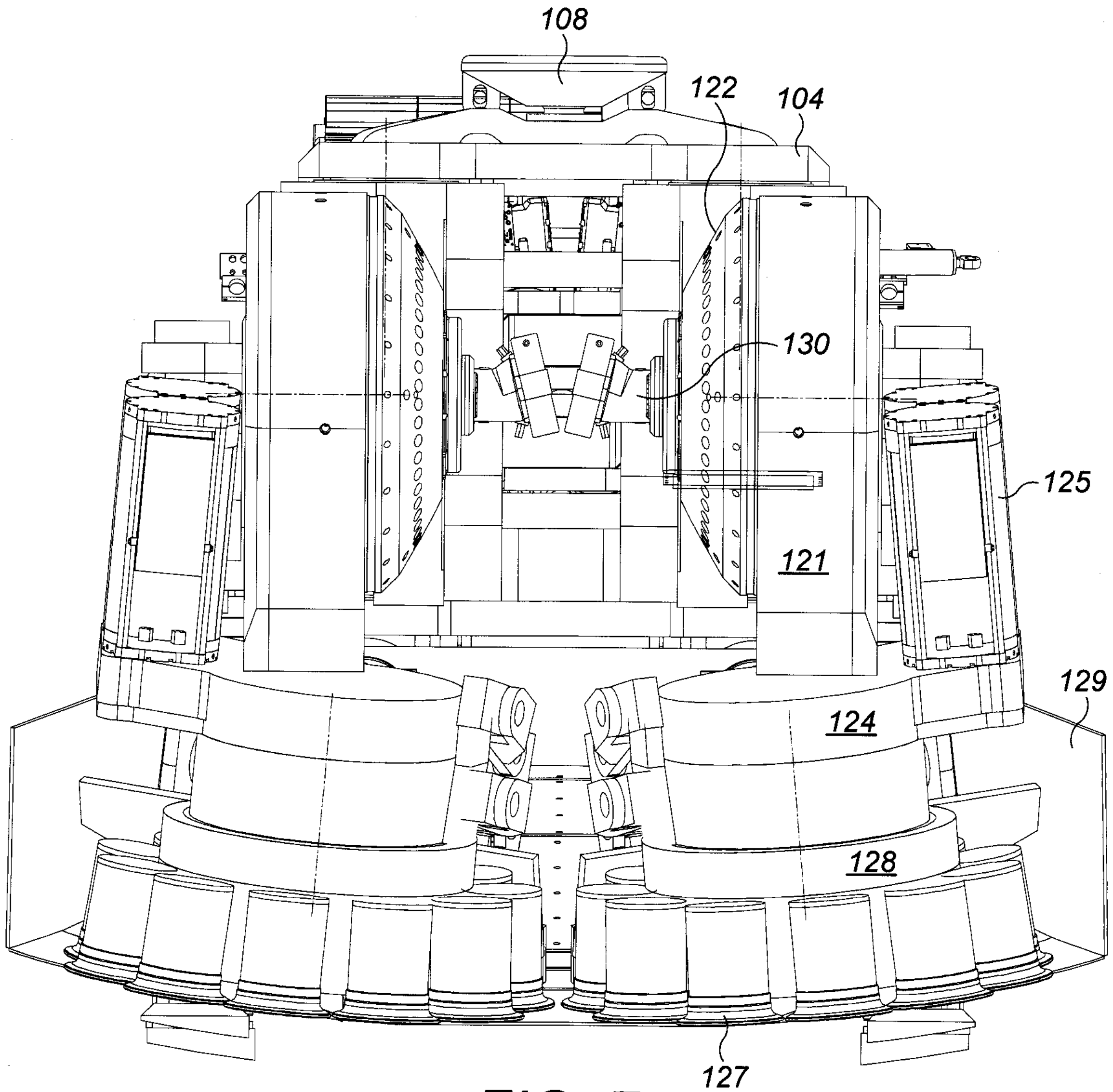

FIG. 7

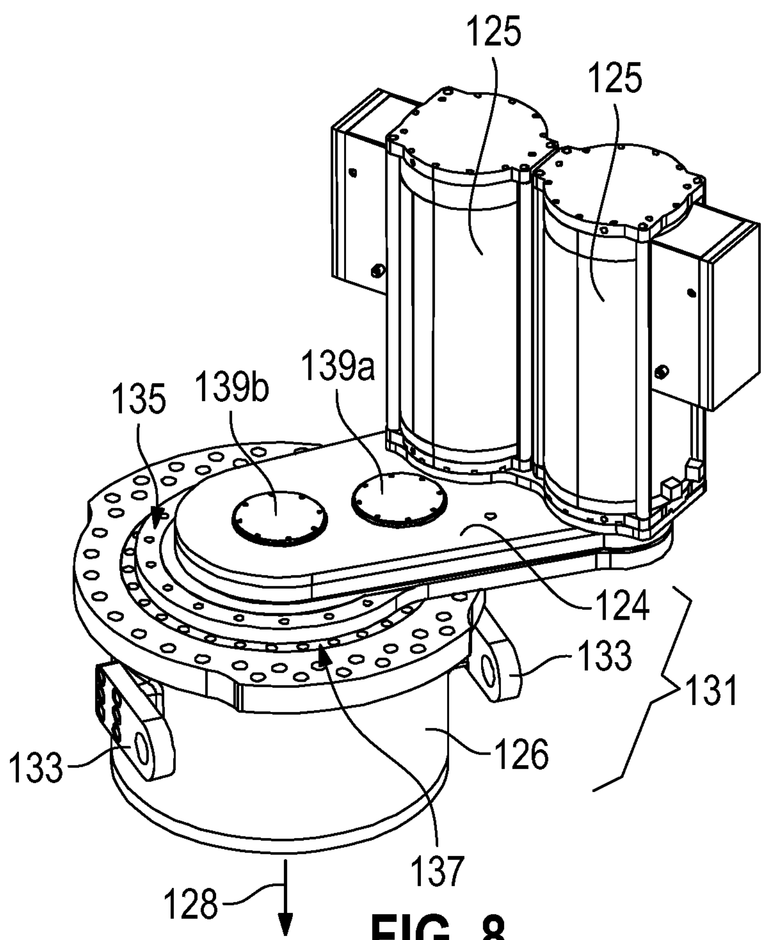
125
125
139b
139a
135
124
133
131
133
126
137
128

FIG. 8

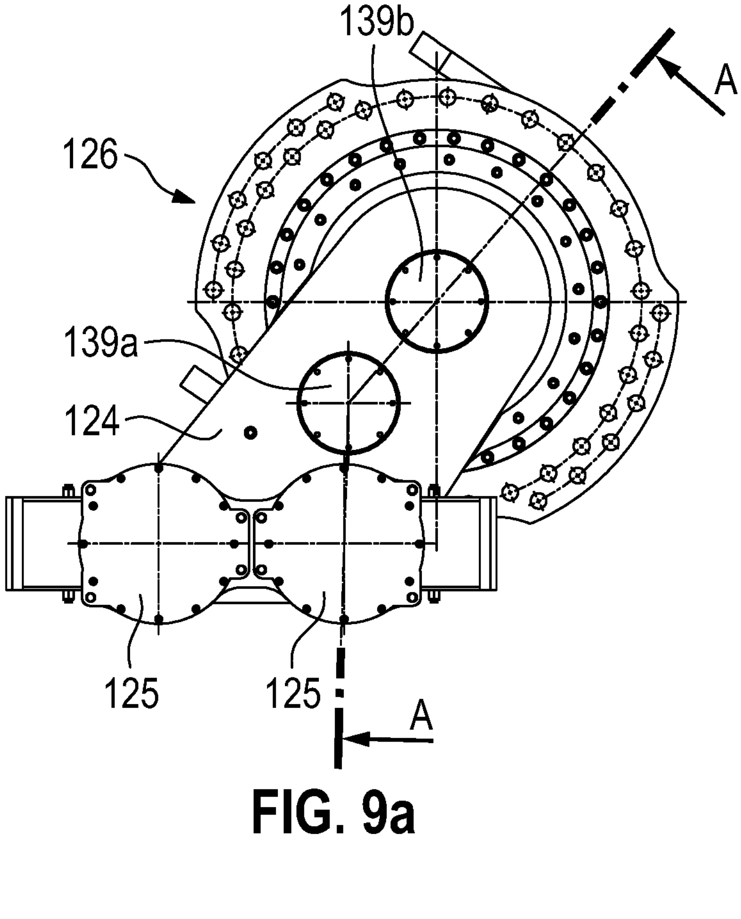
139b
A
126
139a
124
125
125
A

FIG. 9a

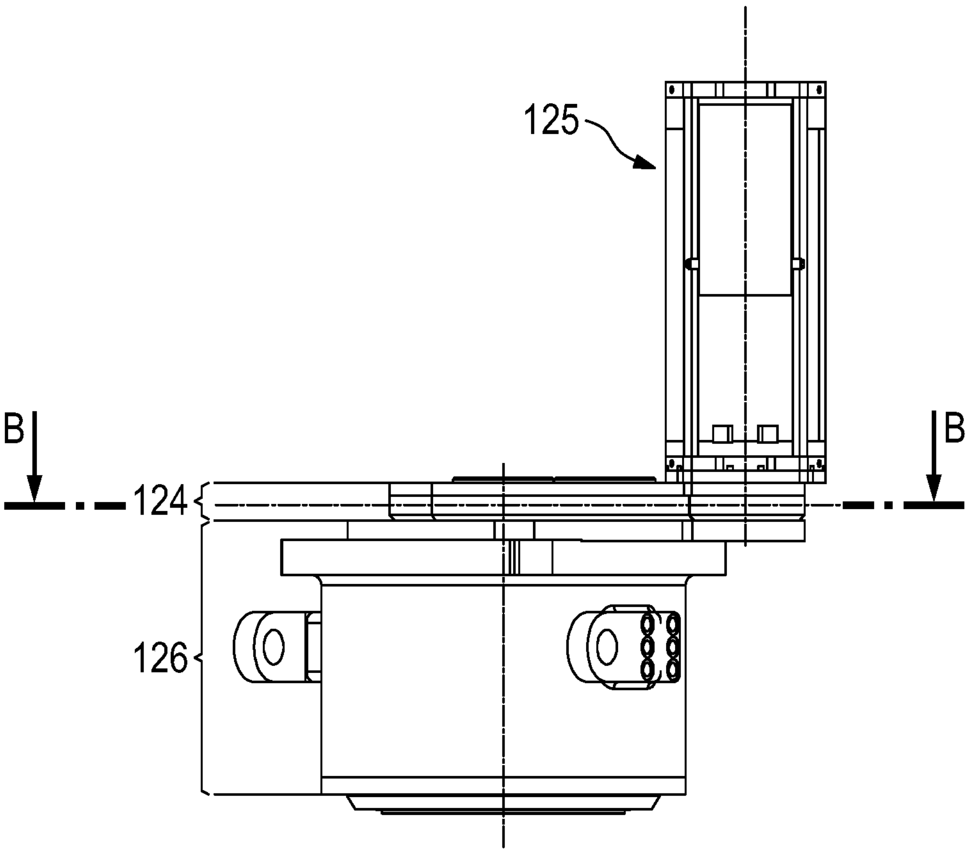

FIG. 9b

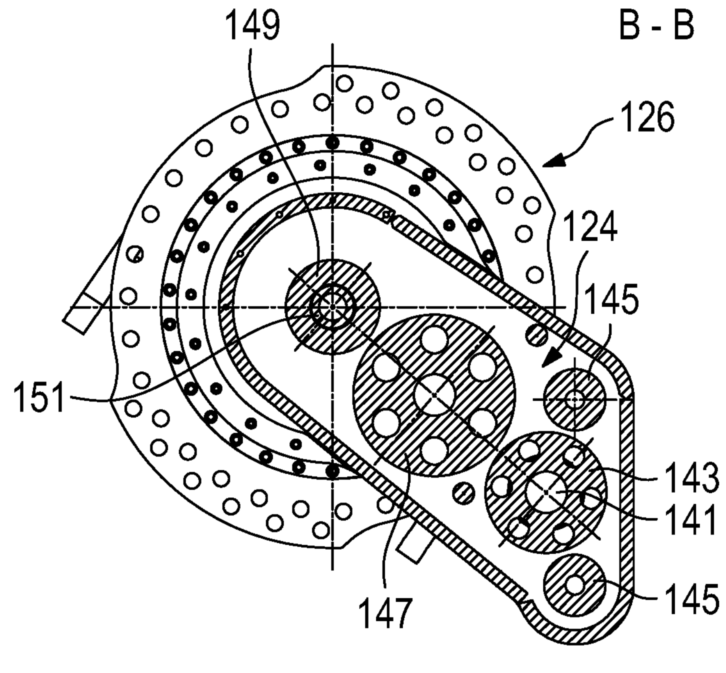

FIG. 10

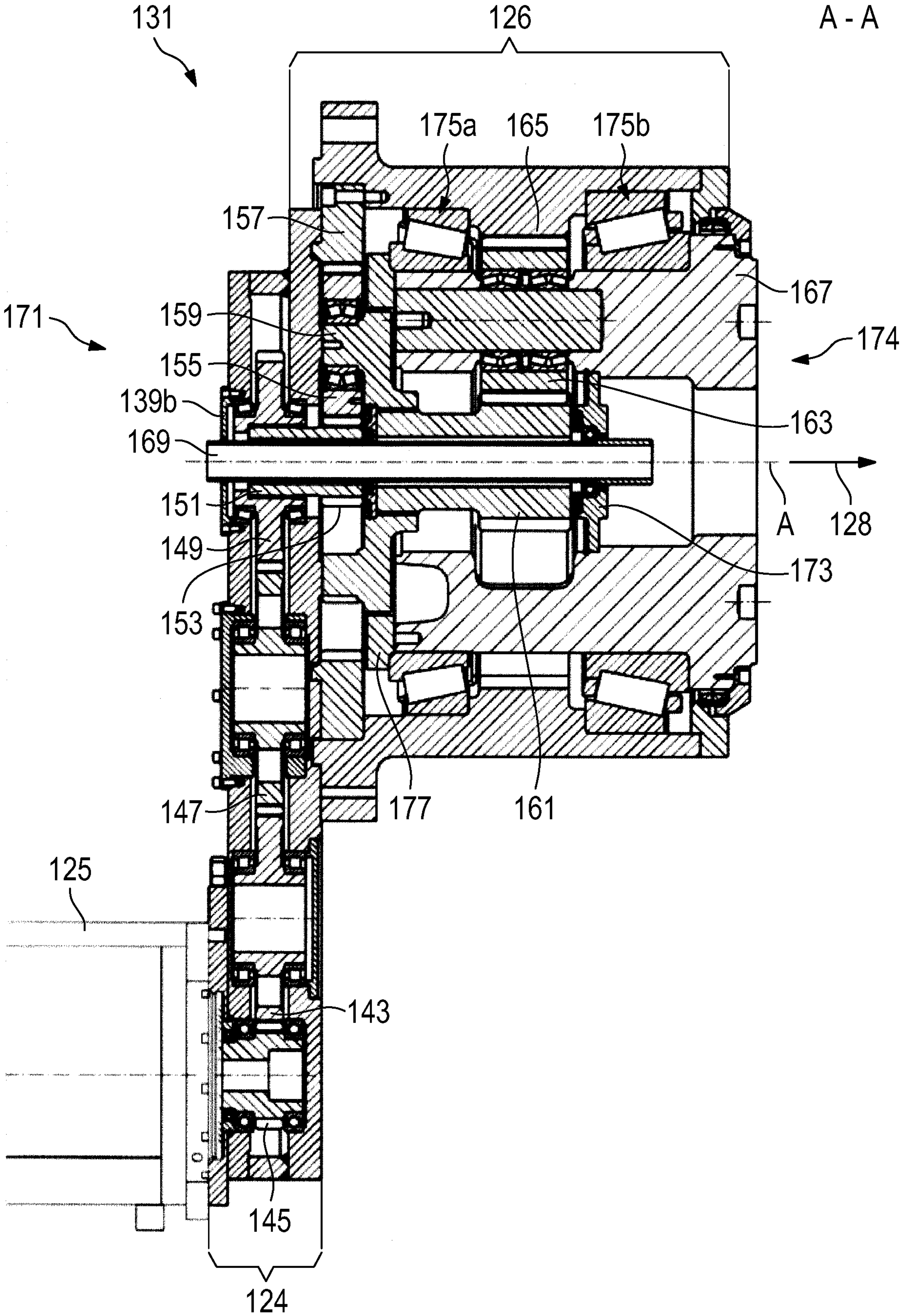
131
126
A - A
175a
165
175b
157
167
171
159
174
155
139b
163
169
151
A
128
149
173
153
147
177
161
125
143
145
124

FIG. 11