



(86) Date de dépôt PCT/PCT Filing Date: 2015/10/02

(87) Date publication PCT/PCT Publication Date: 2016/04/14

(85) Entrée phase nationale/National Entry: 2017/03/24

(86) N° demande PCT/PCT Application No.: EP 2015/072851

(87) N° publication PCT/PCT Publication No.: 2016/055383

(30) Priorité/Priority: 2014/10/06 (EP PCT/EP2014/071334)

(51) Cl.Int./Int.Cl. *E21D 9/12* (2006.01),
E21C 27/24 (2006.01), *E21C 35/20* (2006.01),
E21D 9/10 (2006.01)

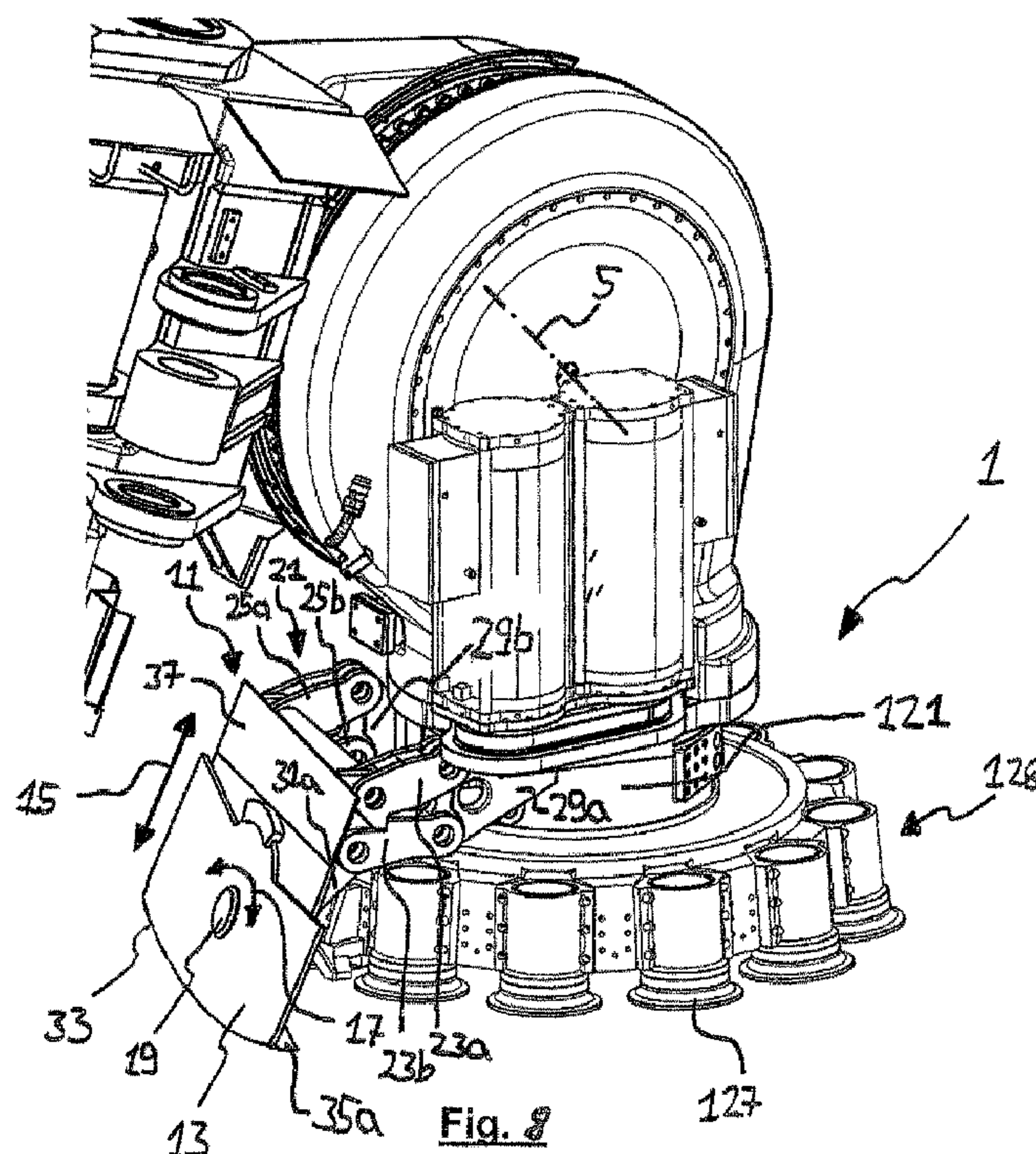
(71) Demandeur/Applicant:
SANDVIK INTELLECTUAL PROPERTY AB, SE

(72) Inventeurs/Inventors:
BRANDL, ERICH, AT;
EBNER, BERNHARD, AT

(74) Agent: GOWLING WLG (CANADA) LLP

(54) Titre : UNITE DE COUPE UTILISANT UN SYSTEME DE DEBLAIEMENT

(54) Title: CUTTING APPARATUS USING A CLEARING ARRANGEMENT



(57) Abrégé/Abstract:

The invention relates to a cutting unit (1) for use with a cutting apparatus (100) suitable for creating tunnels or subterranean roadways and the like, comprising a cutting arm (121) configured for pivotal movement around at least one pivot axis (5), a cutting

(57) **Abrégé(suite)/Abstract(continued):**

head (128) mounted to the cutting arm (121), the cutting head (128) comprising at least one rotatable cutting element (127) for detaching material from a rock face, and a clearing arrangement (11) mounted to the cutting arm (121), wherein the clearing arrangement (11) comprises a clearing blade (13) for pushing detached rock material onto a loading table (41) of the cutting apparatus (100), wherein the clearing blade (13) is guided by a first guiding mechanism allowing for a free movement of the clearing blade (13) in a first direction (15).

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property

Organization

International Bureau

(43) International Publication Date

14 April 2016 (14.04.2016)



(10) International Publication Number

WO 2016/055383 A1

(51) International Patent Classification:

E21D 9/10 (2006.01) E21C 35/20 (2006.01)

E21C 27/24 (2006.01) E21D 9/12 (2006.01)

(21) International Application Number:

PCT/EP2015/072851

(22) International Filing Date:

2 October 2015 (02.10.2015)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

PCT/EP2014/071334

6 October 2014 (06.10.2014)

EP

(71) Applicant: SANDVIK INTELLECTUAL PROPERTY

AB [SE/SE]; S-811 81 Sandviken (SE).

(72) Inventors: BRANDL, Erich; Murweg 44A, A-8734

Grosslobming (AT). EBNER, Bernhard; Wehrgasse 11, A-8720 Knittelfeld (AT).

(74) Agent: FLODMAN, Anna; SANDVIK INTELLECTUAL

PROPERTY AB, S-811 81 Sandviken (SE).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

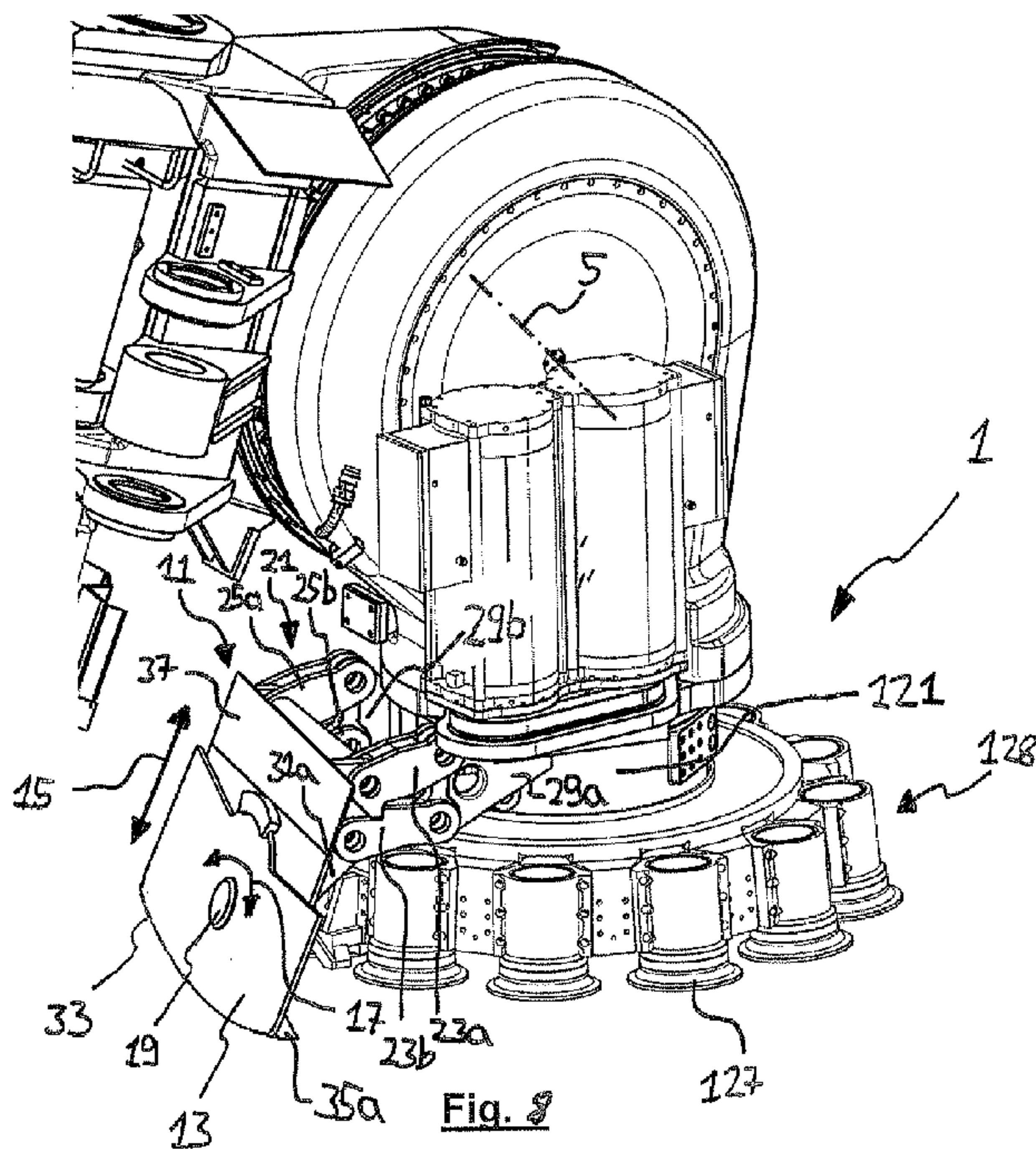
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

[Continued on next page]

(54) Title: CUTTING APPARATUS USING A CLEARING ARRANGEMENT



(57) Abstract: The invention relates to a cutting unit (1) for use with a cutting apparatus (100) suitable for creating tunnels or subterranean roadways and the like, comprising a cutting arm (121) configured for pivotal movement around at least one pivot axis (5), a cutting head (128) mounted to the cutting arm (121), the cutting head (128) comprising at least one rotatable cutting element (127) for detaching material from a rock face, and a clearing arrangement (11) mounted to the cutting arm (121), wherein the clearing arrangement (11) comprises a clearing blade (13) for pushing detached rock material onto a loading table (41) of the cutting apparatus (100), wherein the clearing blade (13) is guided by a first guiding mechanism allowing for a free movement of the clearing blade (13) in a first direction (15).

WO 2016/055383 A1



Published:

— with international search report (Art. 21(3))

— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

CUTTING APPARATUS USING A CLEARING ARRANGEMENT

Field of invention

The present invention relates to a cutting unit for use with a cutting apparatus
5 suitable for creating tunnels or subterranean roadways and the like.

Furthermore, 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
10 capable of being slewed laterally outward and raised in the upward and downward
direction during forward cutting.

Background art

15 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
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
25 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.

Furthermore, it has been observed that conventional cutting machines are not
5 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.

10 It has been observed that clearing the floor of the tunnel from detached rock material requires a considerable amount of time and can lead to a delay in the tunnel generating process. Further, the floor clearing operation needs to be carried out carefully and thoroughly, since the floor of the tunnel is used by various other parts of the cutting apparatus for support purposes.

15 Known cutting units for the use with a cutting apparatus suitable for creating tunnels or subterranean roadway comprise a cutting arm configured for pivotal movement around at least one pivot axis and a cutting head mounted to the cutting arm. The cutting head comprises a rotatable cutting element for detaching material
20 from the rock face.

The detached material accumulates on the floor of the tunnel and needs to be removed before the cutting apparatus can move forward in order to proceed with detaching material from the rock face.

25 From GB 2 153 876 A a clearing arrangement is known, which is mounted to the cutting arm. The clearing arrangement comprises a clearing blade for pushing detached rock material in the direction of a transfer conveyor for transferring the detached material away from the working area.

However, the front edge of the clearing blades of the known cutting units are spaced from the front edge of the cutting head in order to prevent that the clearing blade interferes with an obstacle in the rock face such as protruding rock material not yet being detached by means of the cutting element.

5

Due to the distance that known clearing blades have with respect to the rock face and to the front edge of the cutting head, such clearing blades cannot be used for scraping loose material from the rock face after material has been detached by means of the cutting elements of the cutting head. Further, the distance between the front edge of the clearing blade and the rock face leads to the fact that only a small amount of the detached and accumulated rock material on the floor of the tunnel is pushed in direction of the transport conveyor resulting in a time consuming and effortful clearing operation.

15 Summary of the Invention

It is an objective of the present invention to provide a cutting apparatus and a cutting unit allowing for a quicker and more effective transport of detached rock material away from the floor of the tunnel.

20

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.

25

The objective is achieved by providing a cutting unit for use with a cutting apparatus suitable for creating tunnels or subterranean roadways and the like, wherein the cutting unit comprises a cutting arm configured for pivotal movement

30

around at least one pivot axis and a cutting head mounted to the cutting arm. The cutting head comprises at least one rotatable cutting element for detaching material from a rock face. The cutting unit according to the invention also comprises a clearing arrangement mounted to the cutting arm, wherein the clearing arrangement comprises a clearing blade for pushing detached rock material onto a loading table of the cutting apparatus. The clearing blade is guided by a first guiding mechanism allowing for a free movement of the clearing blade in a first direction.

Due to the fact that the clearing blade is guided by a first guiding mechanism allowing for a free movement of the clearing blade in a first direction, the interference of the front edge of the clearing with an obstacle, such as a protruding rock material, is prevented. In case the clearing blade gets in contact with an obstacle the first guiding mechanism allows for a movement of the clearing blade away from the obstacle and thereby prevents a mechanical damage of the clearing arrangement. Since the clearing blade is freely moveable in a first direction preventing interference with protruding rock material, the clearing blade can be arranged such that the front edge of the clearing blade is in close proximity to the rock face. This allows for scraping the rock face and for pushing the majority of accumulated detached rock material onto the loading table of the cutting apparatus with a single pushing action of the clearing blade.

Preferably, the first guiding mechanism comprises one or more slide shoes allowing for a free linear movement of the clearing blade in the first direction. By using slide shoes to guide the clearing blade of the clearing arrangement the front edge of the clearing blade can follow the shape of the tunnel's roof during pivotal movement of the cutting arm and the cutting head. The slide shoes prevent the clearing blade from hooking into grooves or protrusions in the rock face created during the cutting process.

Optionally, the clearing arrangement comprises a guiding plate and the first guiding mechanism allows for a relative movement between the clearing blade and the guiding plate. It is preferred that the first direction in which the clearing blade is freely movable, is basically in radial direction with respect to the pivot axis of the cutting arm. The first direction may also deviate up to 20 degrees, preferably 10 degrees, from this radial direction.

Preferably, the clearing blade is guided by a second guiding mechanism allowing for a free movement of the clearing blade in a second direction. Optionally, the second guiding mechanism comprises a pivot bearing allowing for a free rotational movement of the clearing blade in the second direction. In a preferred embodiment, the cutting unit further comprises a locking mechanism for locking the clearing blade in a desired rotational orientation. Due to the possibility to lock the clearing blade of the cutting unit the orientation of the clearing blade can be adapted to the cutting head configuration or to the position and/or configuration of the loading table of the cutting apparatus, on which the detached rock material is pushed by the clearing blade.

Preferably, the clearing arrangement of the cutting unit according to the invention comprises a blade actuator mechanism connecting the clearing blade and the cutting arm. The blade actuator mechanism is configured for moving the clearing blade between a parking position and an operating position. The parking position is to be considered as a retracted position, wherein the distance between the rock face and the front edge of the clearing blade is maximized, wherein the distance between the front edge of the clearing blade and the rock face is minimized in the operating position.

It is preferred that the clearing blade is in the parking position and therefore retracted from the rock face during the cutting process. Generally, the cutting process and thereby the process of detaching rock material is performed while the cutting arm and the cutting head are pivotally moved in an upward direction from

the bottom of the tunnel to the top of the tunnel. Since the clearing blade is in the retracted parking position during the cutting process the detached rock material can fall through to the floor of the tunnel.

5 It is further preferred that the clearing blade is moved from the parking position into the operating position when the cutting arm and the cutting head are in their highest position, such that the front edge of the clearing blade follows the shape of the tunnel profile while the cutting arm and the cutting head are pivotally moved in a downward direction. By following the shape of the tunnel profile loose rock
10 material that remained on the rock face is detached by the clearing blade. In case of obstructing protruding rock material that cannot be detached by means of the clearing blade, the first guiding mechanism allows for a free backward movement of the clearing blade preventing damage of the clearing arrangement.

15 During the downward pivotal movement of the cutting arm and the cutting head, the detached rock material accumulated on the floor of the tunnel is pushed onto a loading table of the cutting apparatus by means of the clearing blade. Since the clearing blade is in the operating position during downward movement of the cutting arm and the cutting head, the majority of rock material accumulated on the
20 floor of the tunnel has been pushed onto the loading table after the downward pivotal movement of the cutting arm and the cutting head is completed.

Preferably, the blade actuator mechanism is configured such that a movement of the clearing blade between the parking position and the operating position
25 comprises a linear movement and a rotational movement of the clearing blade. It is further preferred that the clearing blade is rotated by an angle in the range of 5 to 20 degrees during the movement between the parking position and the operating position. The movement on the clearing blade between the parking position and the operating position is dominated by the linear movement.
30 Thereby, a space-saving configuration for the movement of the clearing blade between the parking position and the operating position is provided.

In another preferred embodiment of the cutting unit according to the invention the blade actuator mechanism comprises at least one, preferably two pairs of levers. Each pair of levers comprises a first lever and a second lever, wherein first ends of the first and second levers are rotatably mounted to a mounting plate mounted to the cutting arm. Further, opposite second ends of the first and second levers are rotatably mounted to a supporting structure of the clearing blade. It is preferred, that the supporting structure of the clearing blade is mounted to the guiding plate, such that the guiding plate connects the supporting structure with the clearing blade.

In another preferred embodiment of the cutting unit according to the invention the first lever has a first length and the second lever has a second length different from the first length. By using first and second levers with different lengths a movement of the clearing blade between the parking position and the operating position being partly linear and partly rotational is obtained. It is preferred that first and second levers are basically parallel to each other when the clearing blade is in the parking position. However, it shall be understood that “basically parallel” allows for deviations from the parallel arrangement up to 10 degrees. It is further preferred, that the first and second levers are not parallel (or less parallel) to each other in the operating position.

In an advantageous embodiment of the cutting unit according to the invention, the first and second levers each comprise a stop surface. The stop surfaces of the first and second levers touch each other and limit the movement of the clearing blade, when the clearing blade is in the operating position. It is preferred that the stop surfaces are formed by notches within the surface of the first and second levers.

Preferably, the blade actuator mechanism comprises a hydraulic cylinder configured for moving the clearing blade between the parking position and the operating position. The first end of the hydraulic cylinder is preferably rotatably

mounted to the cutting arm. The second opposite end of the hydraulic cylinder is preferably rotatably mounted to an intermediate lever, wherein the intermediate lever is rotatably mounted to the supporting structure of the clearing arrangement. It is further preferred, that the intermediate lever is rotatably mounted to the supporting structure such that the mount allows for a rotational movement about an axis, about which also one of the first and second levers is rotatable.

Optionally, the clearing blade comprises a curved front edge, wherein the front edge is directed to the rock face when in use. Since the cutting head and its rotatable cutting elements are often configured in a circular arrangement, the generated rock face resulting from the cutting process is curved due to the pivotal movement of the cutting arm and the cutting head around the pivot axis. By providing a clearing blade with a curved front edge, the front edge can follow the shape of the tunnel profile, such that loose material is detached by the clearing blade over its entire width.

In another advantageous embodiment of the cutting unit according to the invention at least one, preferably two or three claws are mounted to the clearing blade. Optionally, the claws are flush-mounted to the front edge of the clearing blade or extend beyond the front edge of the clearing blade. The claws are used to scrape loose material from the rock face or to establish a constant distance between the front edge of the clearing blade and the rock face.

The objective is also achieved by a cutting apparatus suitable for creating tunnels and subterranean roadways and the like, wherein the cutting apparatus comprises a loading table for receiving detached rock material and a cutting unit. The cutting unit of the cutting apparatus is configured according to one of the above described embodiments, wherein the clearing blade of the cutting unit is configured for pushing and detached rock material onto the loading table.

Regarding the advantages of the cutting apparatus according to the invention it is referred to the advantages of the cutting unit according to the invention.

5 In a preferred embodiment of the cutting apparatus according to the invention the loading table and the cutting unit are mounted on a common frame, wherein the common frame is configured for relative movement with respect to a main frame of the apparatus, to which a drive unit for movement of the apparatus is mounted. Further, it is preferred that a transport conveyor for transporting the detached rock material is mounted on the common frame. Thereby a constant distance between
10 the loading table, the transport conveyor and the clearing blade is obtained. Due to this constant distance, it is no longer necessary to perform any re-adjustments of the clearing blade or the loading table in order to maintain a high loading efficiency.

15 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
20 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.

25

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
30 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
5 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
10 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
15 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
20 the first and second arms relative 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.

25 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
30 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
5 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
10 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
15 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
20 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.

25 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
30 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
5 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.

10 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
15 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
20 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
25 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 is 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.

20

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.

25

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.

30

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:

5

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;

10

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;

15 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;

20 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 a cutting unit for use with a cutting apparatus
25 suitable for creating tunnels or subterranean roadways according to a specific implementation of the present invention;

Figure 9a is a side elevation view of the cutting unit of figure 8, wherein the clearing blade is in the operating position;

30

Figure 9b is a side elevation view of the cutting unit of figure 8, wherein the clearing blade is in the parking position;

Figure 10a is a magnified cross-sectional view of the cutting unit of figure 8,
5 wherein the clearing blade is in the operating position;

Figure 10b is a magnified cross-sectional view of the cutting unit of figure 8,
wherein the clearing blade is in the parking position;

10 Figure 11a is a side elevation view of an apparatus suitable for creating tunnels or subterranean roadways having the cutting unit of figure 8, wherein the clearing blade is in the parking position; and

Figure 11b is a side elevation view of the apparatus of figure 11a, wherein the
15 clearing blade is in the operating position.

Detailed description of preferred embodiment of the invention

Referring to figure 1, cutting apparatus 100 comprises a main frame 102 mounting
20 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
25 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
30 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.

10

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 is 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.

15

20

25

30

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 is mounted at main frame 102
5 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
10 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
15 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
20 the first flange 118. A pair of linear hydraulic cylinders 117 is 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
25 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
30 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 by reference 122. Each gear 122 is preferably a Wolfrom type and is coupled to a drive motor 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 motor 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 5 100 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 motor 130. As such, each cutting head 128 and in particular the roller cutters 127 may be raised and 10 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 15 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 20 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 25 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 30 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
5 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.

10

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
15 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.

20 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
25 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
30 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.

- 5 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
10 about axis 401 via motor 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.
15 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
20 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
25 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
30 stabilise the apparatus 100 when sled 104 is advanced in the forward direction via linear actuating cylinder 201.

Referring to figure 8, the cutting unit 1 for use with a cutting apparatus suitable for creating tunnels or subterranean roadways and the like comprises a cutting arm 121 and a cutting head 128. The cutting arm 121 is configured for pivotal
5 movement around the pivot axis 5. The cutting head 128 is mounted to the cutting arm 121 and comprises a plurality of rotatable cutting elements 127. The rotatable cutting elements 127 are configured for detaching material from a rock face.

The cutting unit 1 further comprises a clearing arrangement 11, wherein the
10 clearing arrangement 11 is mounted to the cutting arm 121. The clearing arrangement 11 comprises a clearing blade 13 for pushing detached rock material onto a loading table of the cutting apparatus. The clearing blade 13 is guided by a first guiding mechanism allowing for a free movement of the clearing blade 13 in a first direction 15.

15 The first guiding mechanism comprises two slide shoes allowing for a free linear movement of the clearing blade 13. The slide shoes connect the clearing blade 13 with a guiding plate 37 and allow for relative movement between the clearing blade 13 and the guiding plate 37.

20 The clearing blade 13 is further guided by a second guiding mechanism allowing for a free rotational movement of the clearing blade 13 in a second direction 17. The second guiding mechanism comprises a pivot bearing 19. The clearing blade 13 can be locked in a desired rotational orientation by means of a locking
25 mechanism. By using the locking mechanism a free rotational movement of the clearing blade in the rotational direction 17 is prevented.

The clearing arrangement 11 further comprises a blade actuating mechanism 21 connecting the clearing blade 13 and the cutting arm 121. The blade actuating
30 mechanism 21 is configured for moving the clearing blade 13 between a retracted

parking position and an operating position. Figure 8 shows the clearing blade 13 in the operating position.

The blade actuating mechanism comprises a first pair of levers 23a, 23b and a
5 second pair of levers 25a, 25b. Each pair of levers 23a, 23b, 25a, 25b comprises a first lever 23a, 25a and a second lever 23b, 25b. The levers 23a, 23b, 25a, 25b connect mounting plates 29a, 29b that are attached to the cutting arm 121 to supporting structures 31a, 31b of the clearing blade 13.

10 The clearing blade 13 comprises a curved front edge 33, wherein the front edge 33 is directed to the rock face when in use.

Referring to figure 9a, the clearing blade 13 of the clearing arrangement 11 is in the operating position. In the operating position of the clearing blade 13, the front
15 edge 33 of the clearing blade 13 is in close proximity to the rock face and follows the profile of the tunnel while the cutting arm and the cutting head are pivotally moved around the pivot axis 5. By following the profile of the tunnel the clearing blade detaches loose material from the rock face by scraping along the rock face. In case the clearing 13 gets in contact with an obstacle, such as protruding rock
20 material, the first guiding mechanism allows the clearing blade 13 to move in a rearward direction 15, in order to prevent damaging the clearing arrangement.

It is preferred, that the clearing blade 13 is in the operating position when the cutting arm and the cutting head are rotatably moved around the pivot axis in
25 downward direction. Since the front edge of the clearing blade 13 is in close proximity to the rock face, the majority of the detached rock material, which is accumulated on the floor of the tunnel, has been pushed onto the loading table of the cutting apparatus when the cutting arm and the cutting head have completed their pivotal movement around the pivot axis 5 in downward direction.

Referring to figure 9b, the clearing blade 13 is in the retracted parking position. The cutting unit 1 comprises a blade actuator mechanism 21 that is configured such that a movement of the clearing blade 13 between the parking position and the operating position comprises a linear and a rotational movement of the clearing blade 13. However, the movement between the parking position and the operating position is dominated by the linear movement. The clearing blade is, in addition to the linear movement, rotated by an angle of approximately 5 to 20 degrees. The blade actuator mechanism 21 allows therefore for a space-saving movement between the parking position and the operating position.

It is preferred that the clearing blade 13 is in parking position while the cutting is in progress. The cutting takes place while the cutting arm and the cutting head are pivotally moved around the pivot axis in upward direction. Since the clearing blade 13 is in the retracted parking position during the cutting process the detached rock material can fall onto the floor of the tunnel.

Referring to figures 10a and 10b the blade actuator mechanism 21 comprises two pair of levers 23a, 23b, 25a, 25b. Each pair of levers 23a, 23b, 25a, 25b comprises a first lever 23a, 25a and a second lever 23b, 25b. The first ends of the first and second levers 23a, 23b, 25a, 25b are rotatably mounted to mounting plates 29a, 29b. The mounting plates 29a, 29b are mounted to the cutting arm 121. The opposite second ends of the first and second levers 23a, 23b, 25a, 25b are rotatably mounted to supporting structures 31a, 31b of the clearing blade 13.

The first lever 23a, 25a of each pair of levers 23a, 23b, 25a, 25b has a first length and the second lever 23b, 25b has a second length different from the first length. By using first and second levers with different lengths the movement of the clearing blade 13 between the parking position and the operating position comprises a linear movement and rotational movement of the clearing blade 13. The first and second levers 23a, 23b, 25a, 25b each comprise a stop surface, wherein the stop surface of the first and second levers 23a, 23b, 25a, 25b touch

each other and limit the movement of the clearing blade 13, when the clearing blade 13 is in the operating position (see also figures 8 and 9a).

The blade actuator mechanism 21 comprises a hydraulic cylinder 27. The
5 hydraulic cylinder 27 is configured for moving the clearing blade 13 between the parking position and the operating position. The hydraulic cylinder 27 is rotatably mounted to the cutting arm 121 with its first end. The second opposite end of the hydraulic cylinder 27 is rotatably mounted to an intermediate lever 39. The intermediate lever 39 is rotatably mounted to a supporting structure 31a of the
10 clearing blade 13.

Three claws 35a, 35b, 35c are mounted to the clearing blade 13. The claws 35a, 35b, 35c are flush-mounted to the front edge 33 of the clearing blade. However, the claws 35a, 35b, 35c may also mounted such that they extent beyond the front
15 edge 33 of the clearing blade 13.

Referring to figures 11a and 11b, the cutting apparatus 100 suitable for creating tunnels or subterranean roadways comprises a loading table 41 for receiving detached rock material and a cutting unit 1, wherein the cutting unit 1 is
20 configured as described with respect to figures 8 to 10b.

The clearing blade 13 of the cutting unit 1 is configured for pushing detached rock material onto the loading table 41. It is preferred that the clearing blade 13 is in the retracted parking position while cutting is in progress. The cutting takes place
25 while the cutting arm 121 and the cutting head 128 are pivotally moved around the pivot axis 5 in upward direction (figure 11a). It is further preferred that the clearing blade 13 is in the operating position when the cutting arm and the cutting head are rotatably moved around the pivot axis 5 in downward direction (figure 11b). When the rotational movement of the cutting arm 121 and the cutting head
30 128 around pivot axis 5 in downward position is completed, the majority of the

detached rock material accumulated on the floor of the tunnel has been pushed onto the loading table 41 of the apparatus 100.

The loading table 41 and the cutting unit 1 are mounted on a common frame 102,
5 wherein the common frame is configured for relative movement with respect to a main frame of the apparatus 100 to which a drive unit for movement of the apparatus 100 is mounted.

Exemplary embodiments:

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

5 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
10 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);

15 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
20 (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) relative to each of the respective first and second support (120);

25 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
30 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).

5

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.

10

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).

15

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).

20

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).

25 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).

30

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
5 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
10 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
15 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
20 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);
25 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
5 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
10 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
15 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
20 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
25 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 unit (1) for use with a cutting apparatus (100) suitable for creating
5 tunnels or subterranean roadways and the like, comprising:
- a cutting arm (121) configured for pivotal movement around at least one pivot axis (5),
 - a cutting head (128) mounted to the cutting arm (121), the cutting head (128) comprising at least one rotatable cutting element (127) for detaching
10 material from a rock face; and
 - a clearing arrangement (11) mounted to the cutting arm (121), wherein the clearing arrangement (11) comprises a clearing blade (13) for pushing detached rock material onto a loading table (41) of the cutting apparatus (100), characterized in that the clearing blade (13) is guided by a first guiding
15 mechanism allowing for a free movement of the clearing blade (13) in a first direction (15).
2. Cutting unit (1) according to claim 1,
characterized in that the first guiding mechanism comprises one or more slide
20 shoes allowing for a free linear movement of the clearing blade (13) in the first direction (15).
3. Cutting unit (1) according to claim 1 or 2,
characterized in that the clearing blade (13) is guided by a second guiding
25 mechanism allowing for a free movement of the clearing blade (13) in a second direction (17).
4. Cutting unit (1) according to claim 3,
characterized in that the second guiding mechanism comprises a pivot bearing
30 (19) allowing for a free rotational movement of the clearing blade (13) in the second direction (17).

5. Cutting unit (1) according to one of the preceding claims,
characterized in that the clearing arrangement (11) comprises a blade actuator
mechanism (21) connecting the clearing blade (13) and the cutting arm (121),
5 wherein the blade actuator mechanism (21) is configured for moving the clearing
blade (13) between a parking position and an operating position.

6. Cutting unit (1) according to claim 5,
characterized in that the blade actuator mechanism (21) is configured such that a
10 movement of the clearing blade (13) between the parking position and the
operating position comprises a linear movement and a rotational movement of the
clearing blade (13).

7. Cutting unit (1) according to claim 5 or 6,
15 characterized in that the blade actuator mechanism (21) comprises at least one,
preferably two pairs of levers (23a, 23b, 25a, 25b), each pair of levers (23a, 23b,
25a, 25b) comprises a first lever (23a, 25a) and a second lever (23b, 25b), wherein
first ends of the first and second levers (23a, 23b, 25a, 25b) are rotatably mounted
to a mounting plate (29a, 29b) mounted to the cutting arm (121) and wherein
20 opposite second ends of the first and second levers (23a, 23b, 25a, 25b) are
rotatably mounted to a supporting structure (31a, 31b) of the clearing blade (13).

8. Cutting unit (1) according to claim 7,
characterized in that the first lever (23a, 25a) has a first length and the second
25 lever (23b, 25b) has a second length different from the first length.

9. Cutting unit (1) according to one of the claims 6 to 8,
characterized in that the first and second levers (23a, 23b, 25a, 25b) each
comprise a stop surface, wherein the stop surfaces of the first and second levers
30 (23a, 23b, 25a, 25b) touch each other and limit the movement of the clearing
blade (13), when the clearing blade (13) is in the operating position.

10. Cutting unit (1) according to one of the claims 5 to 9,
characterized in that the blade actuator mechanism (21) comprises a hydraulic
cylinder (27) configured for moving the clearing blade (13) between the parking
5 position and the operating position.

11. Cutting unit (1) according to one of the preceding claims,
characterized in that the clearing blade (13) comprises a curved front edge (33),
wherein the front edge (33) is directed to the rock face when in use.

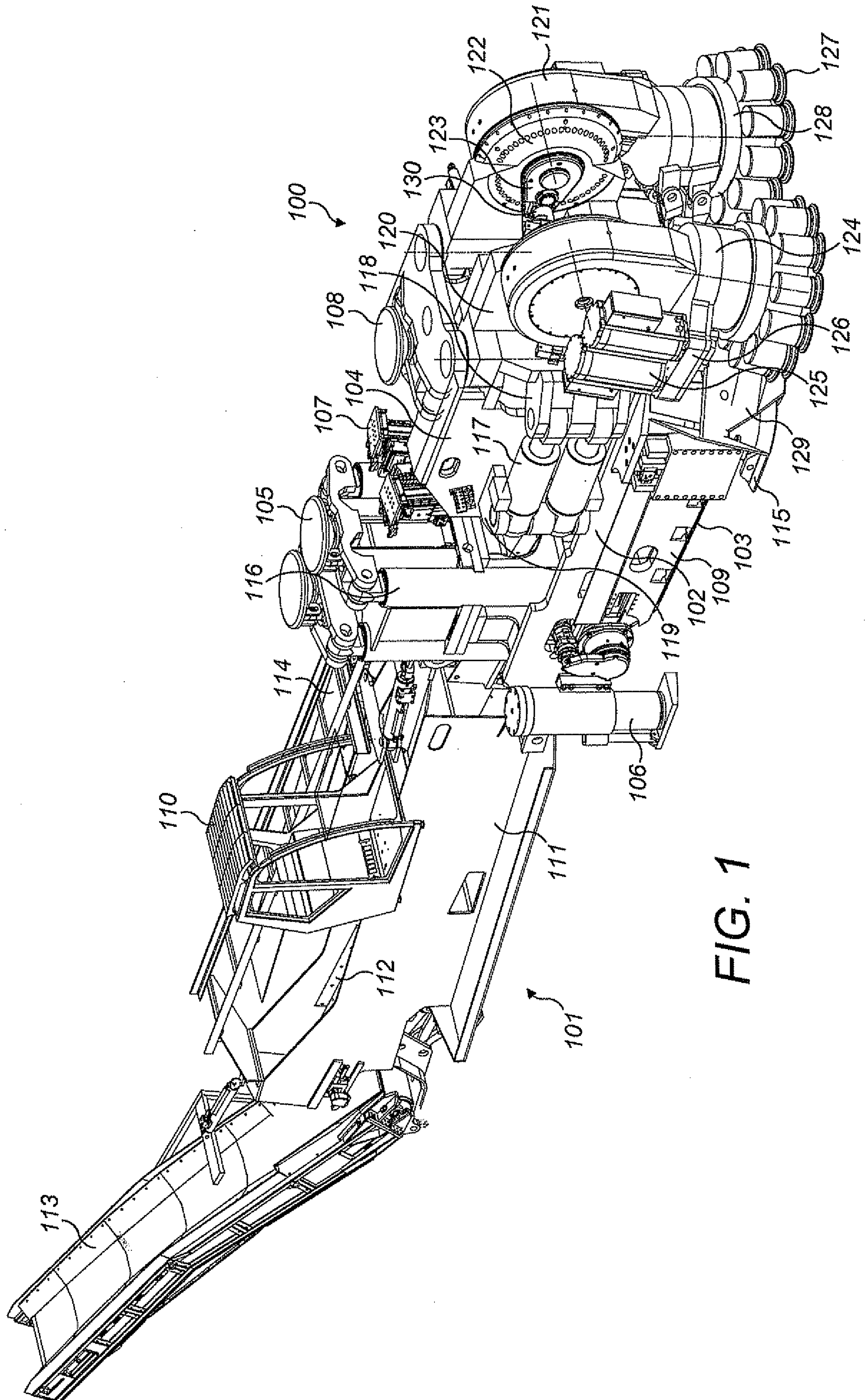
10

12. Cutting unit (1) according to claim 11,
characterized by at least one, preferably two or three claws (35a, 35b, 35c),
wherein the claws (35a, 35b, 35c) are mounted to the clearing blade (13).

13. Cutting unit (1) according to claim 12,
characterized in that the claws (35a, 35b, 35c) are flush-mounted to the front edge
(33) of the clearing blade (13) or extend beyond the front edge (33) of the clearing
blade (13).

14. Cutting apparatus (100) suitable for creating tunnels or subterranean
roadways and the like, comprising:
- a loading table (41) for receiving detached rock material, and
- a cutting unit (1) according to one of the preceding claims, wherein the
clearing blade (13) of the cutting unit (1) is configured for pushing detached rock
25 material onto the loading table (41).

15. Cutting apparatus (100) according to claim 14,
characterized in that the loading table (41) and the cutting unit (1) are mounted on
a common frame (102), wherein the common frame (102) is configured for
relative movement with respect to a main frame of the apparatus (100) to which a
30 drive unit for movement of the apparatus (100) is mounted.



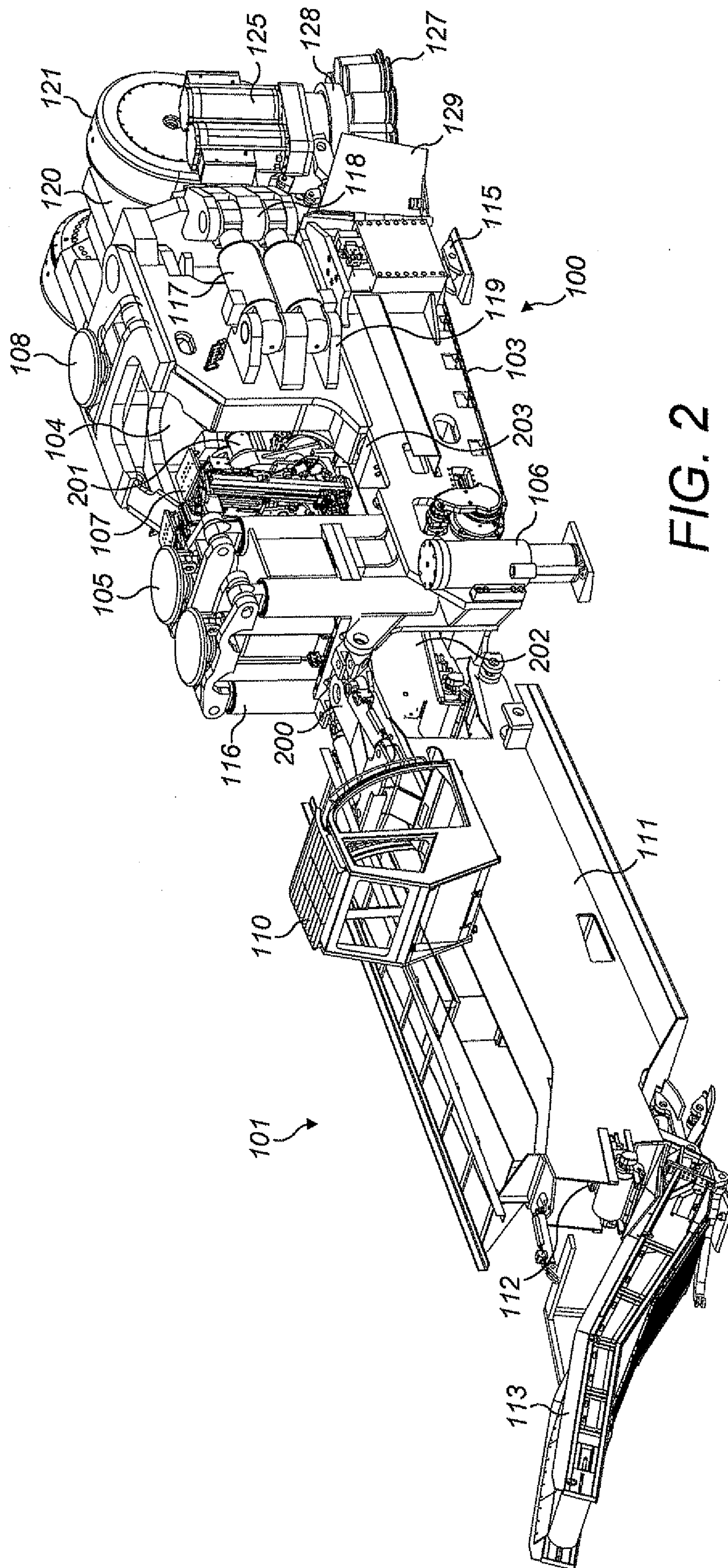


FIG. 2

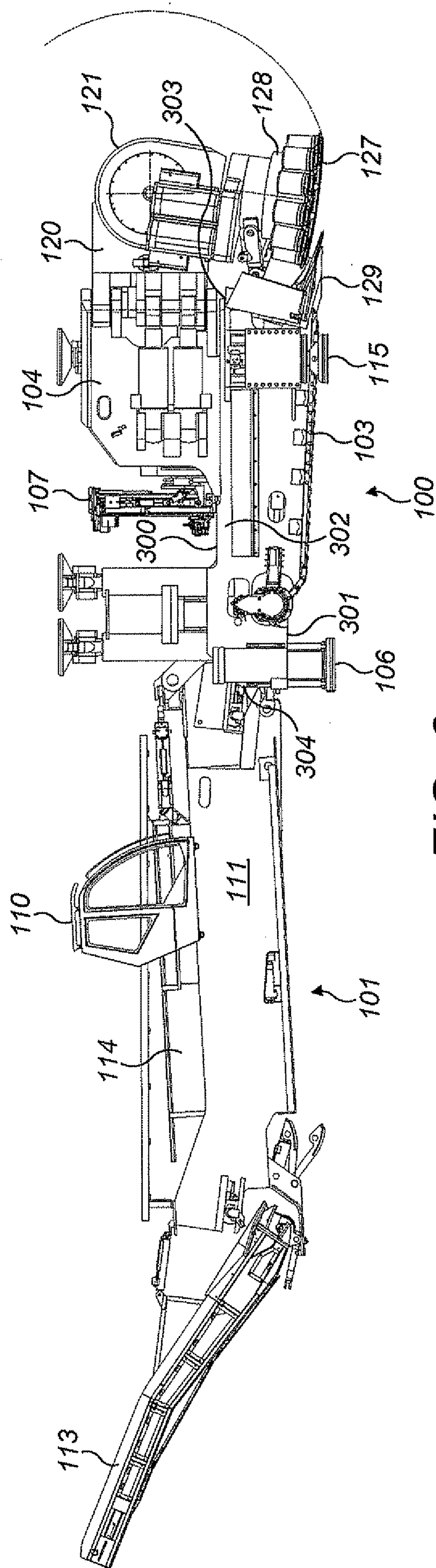
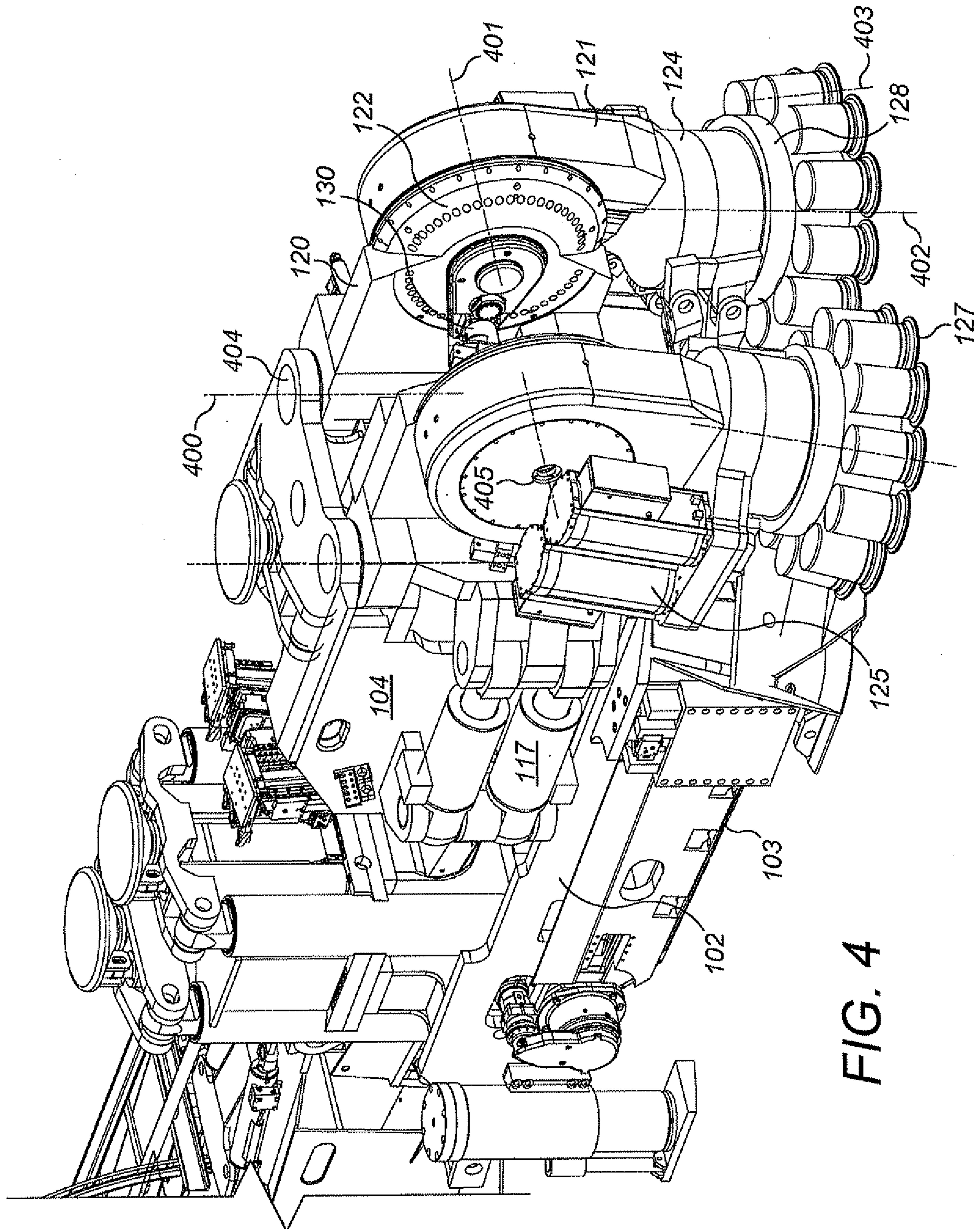


FIG. 3



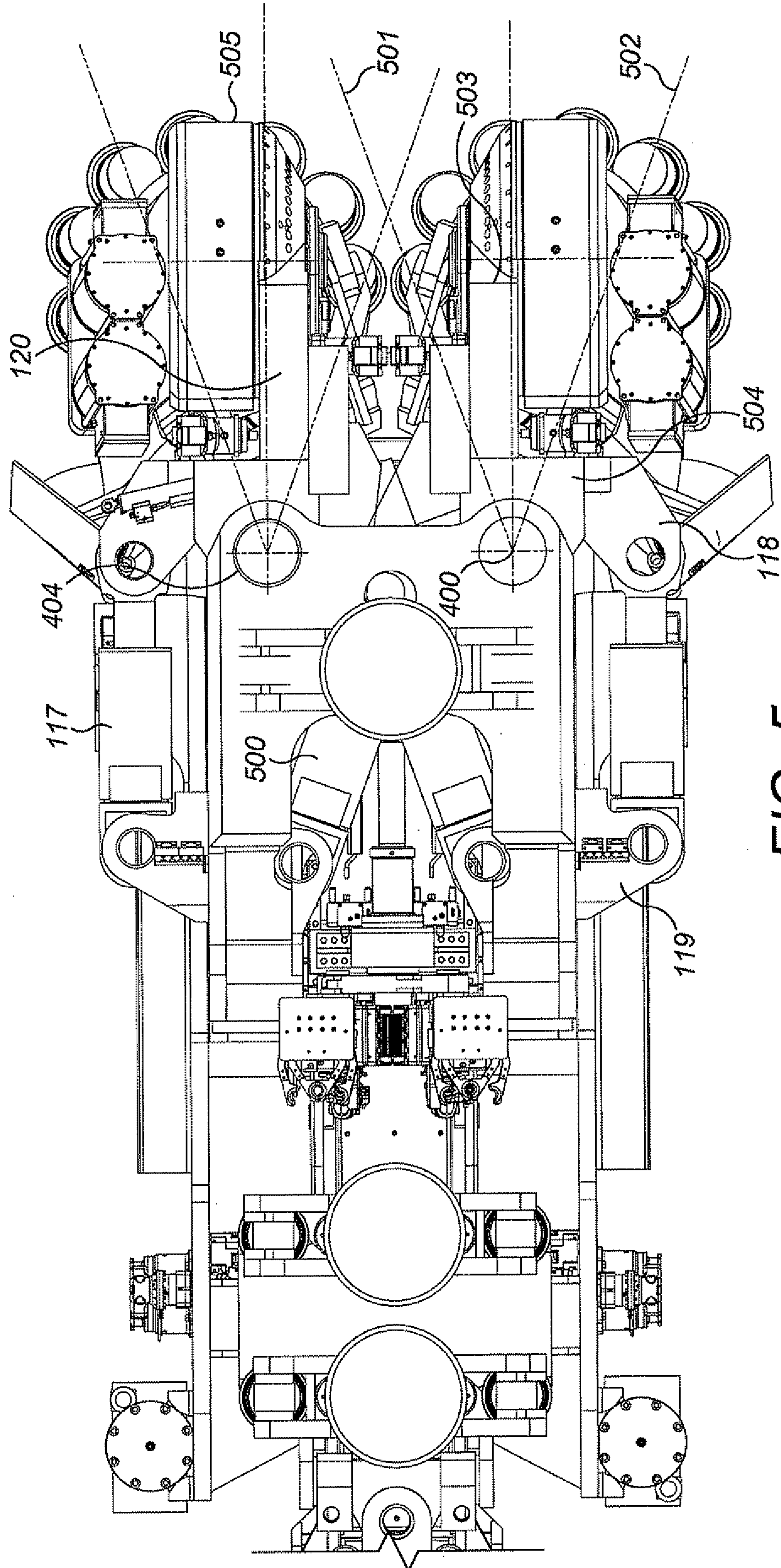


FIG. 5

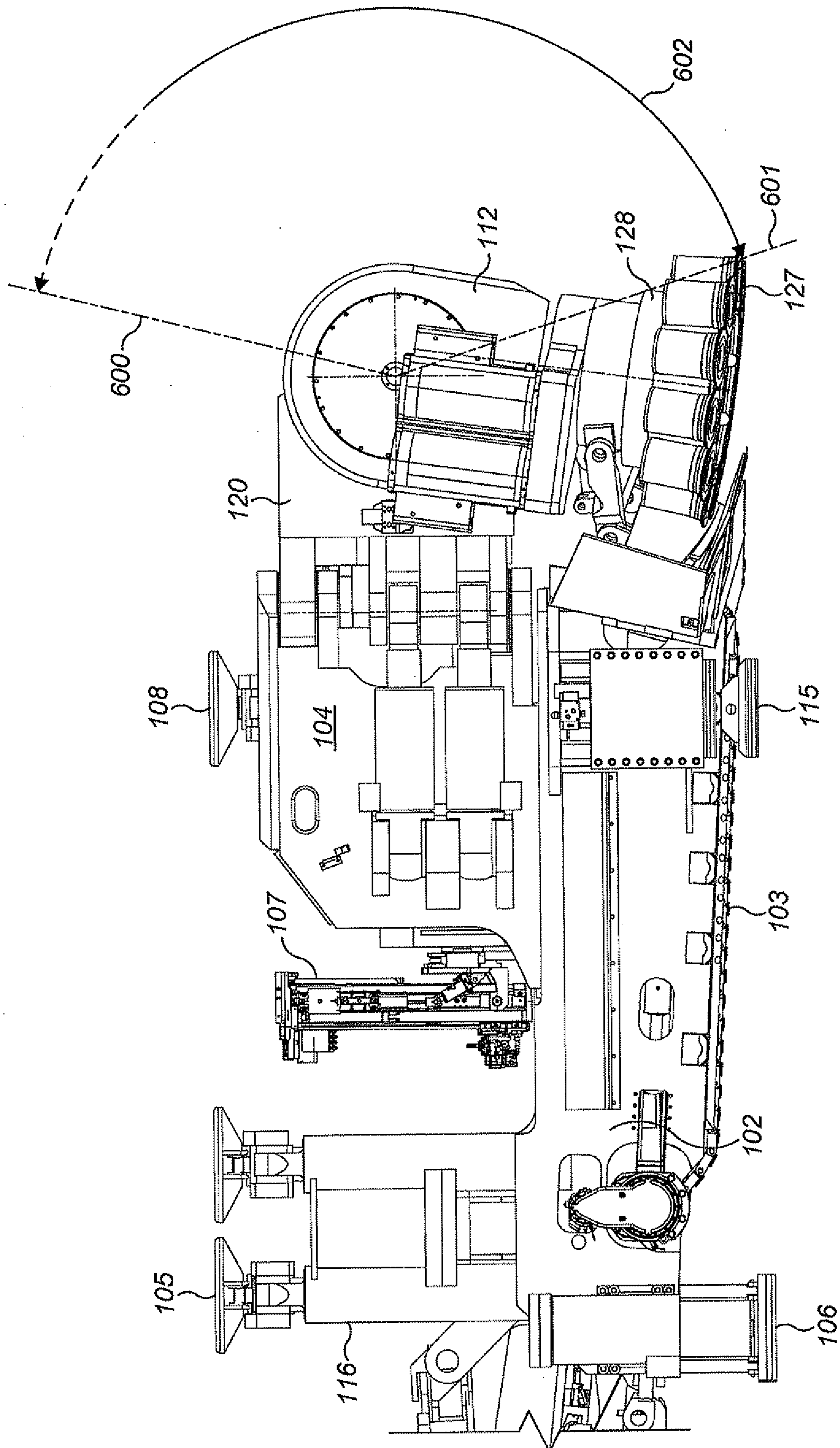
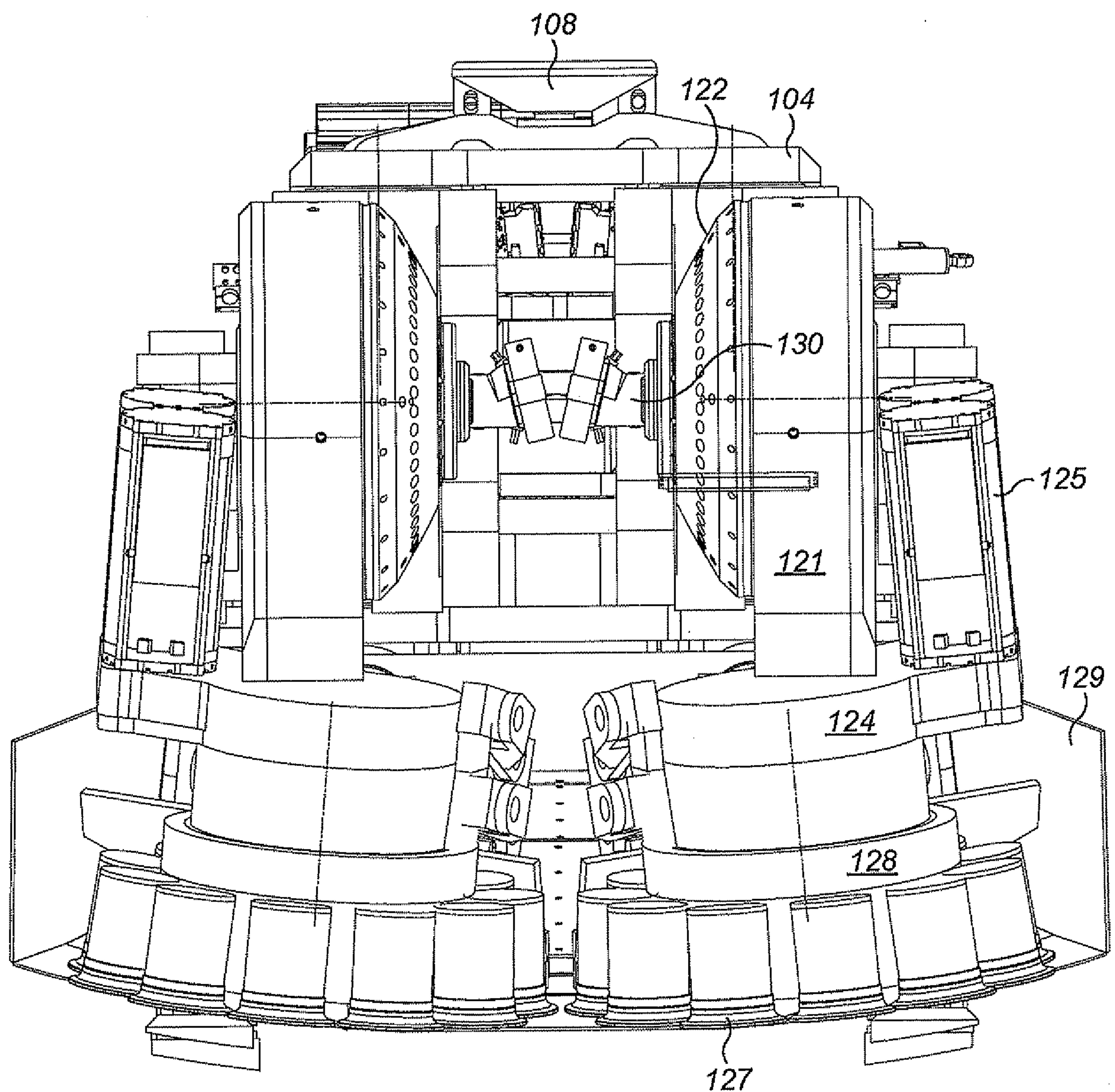
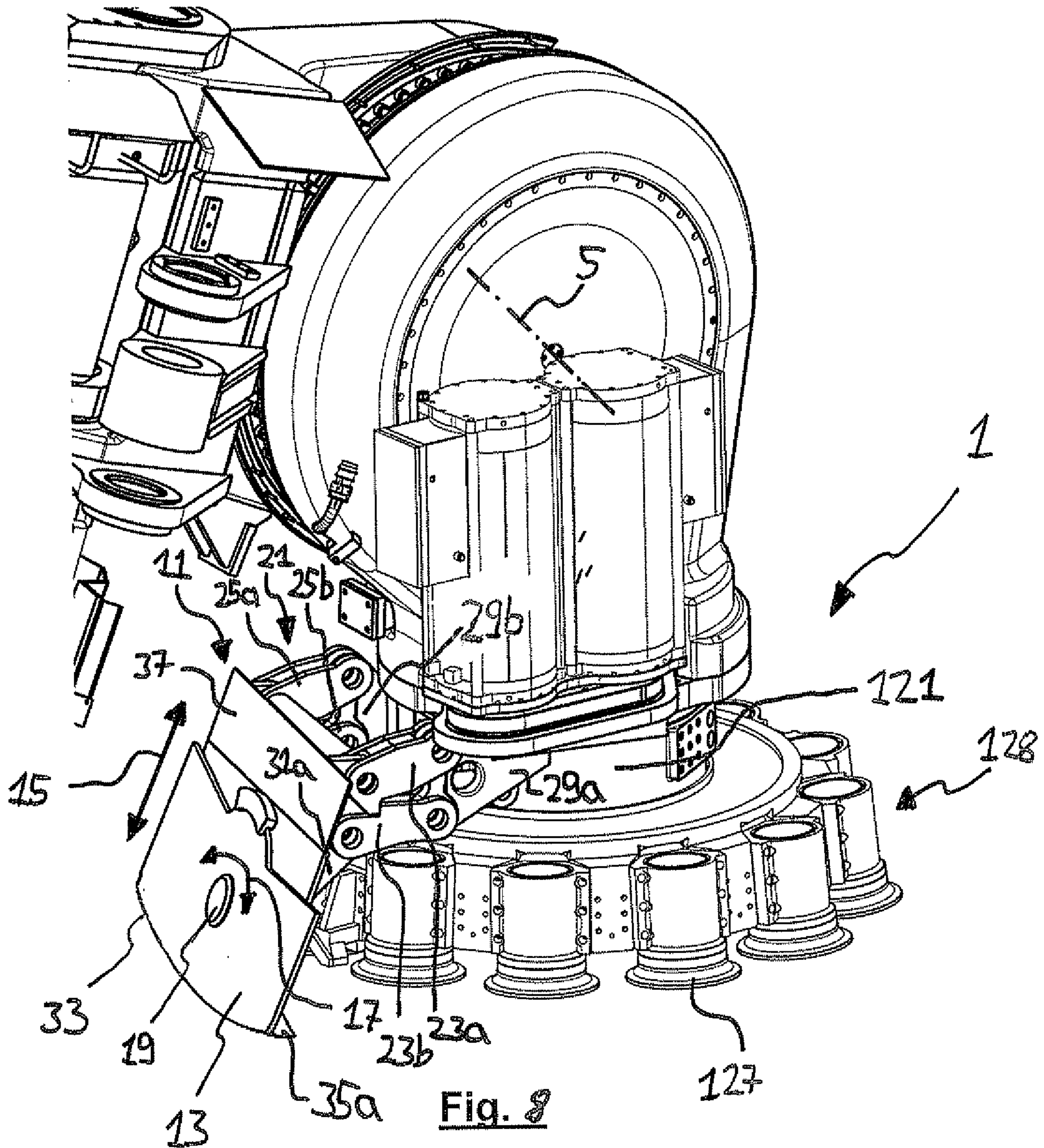
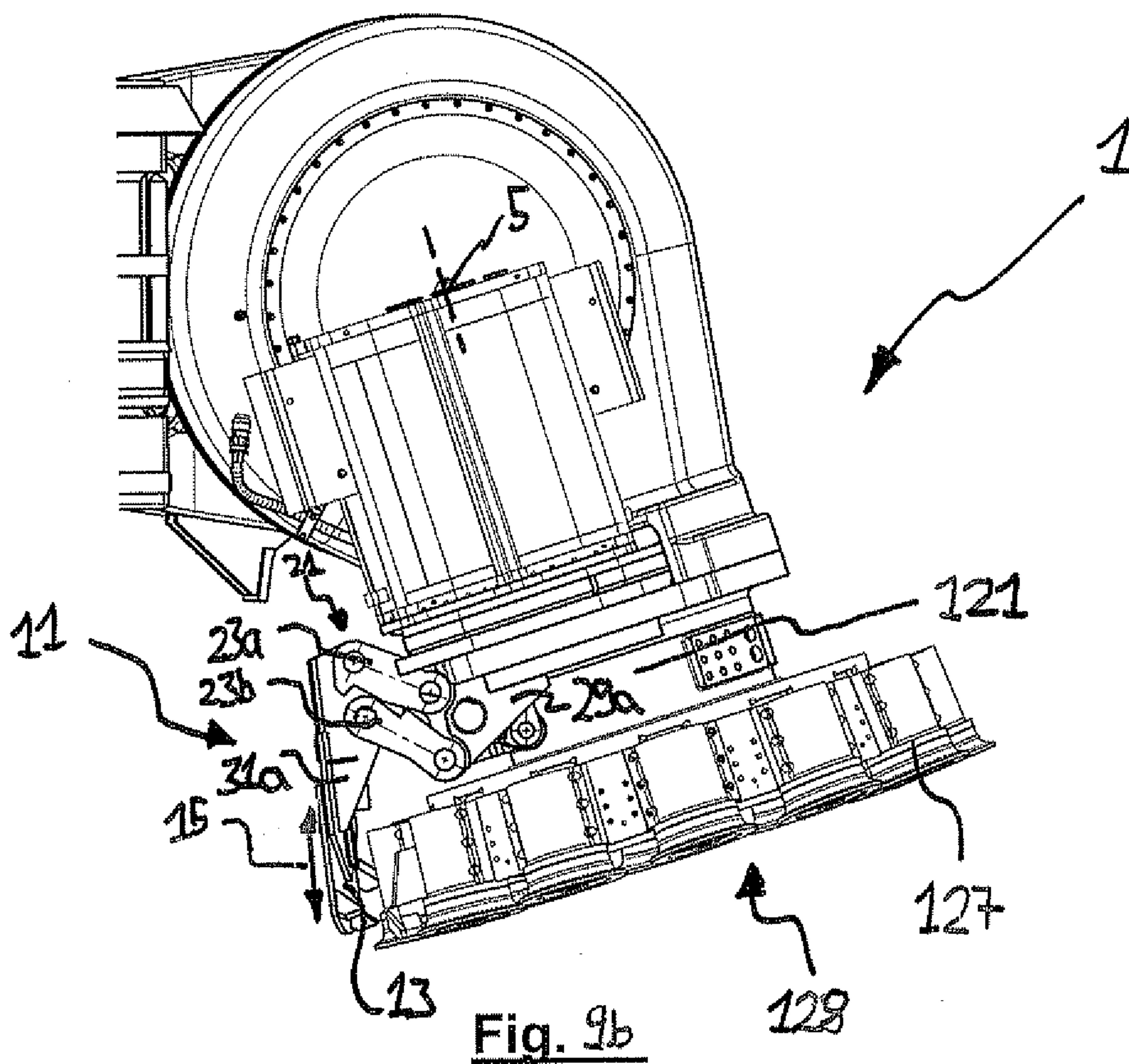
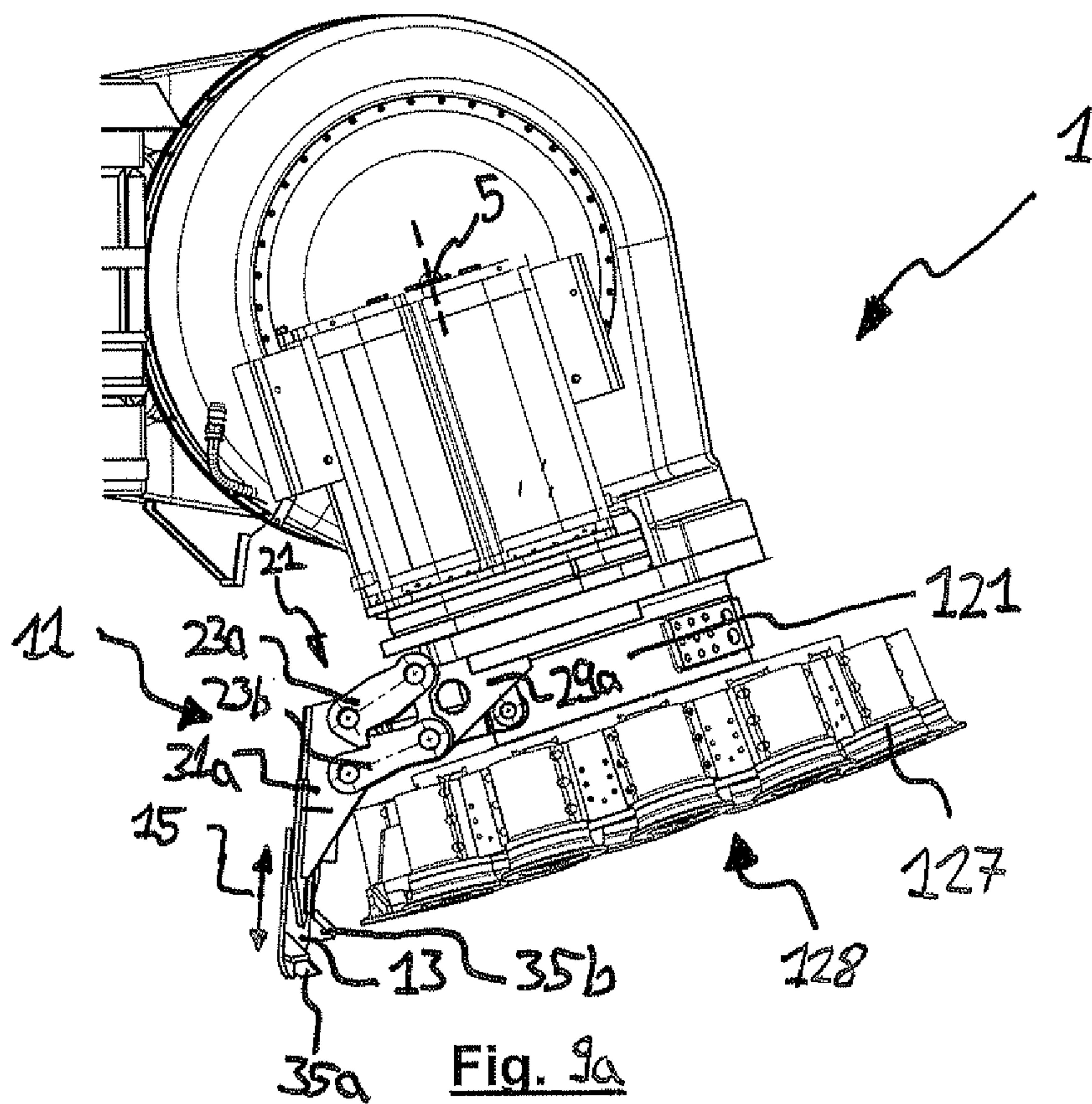


FIG. 6

**FIG. 7**





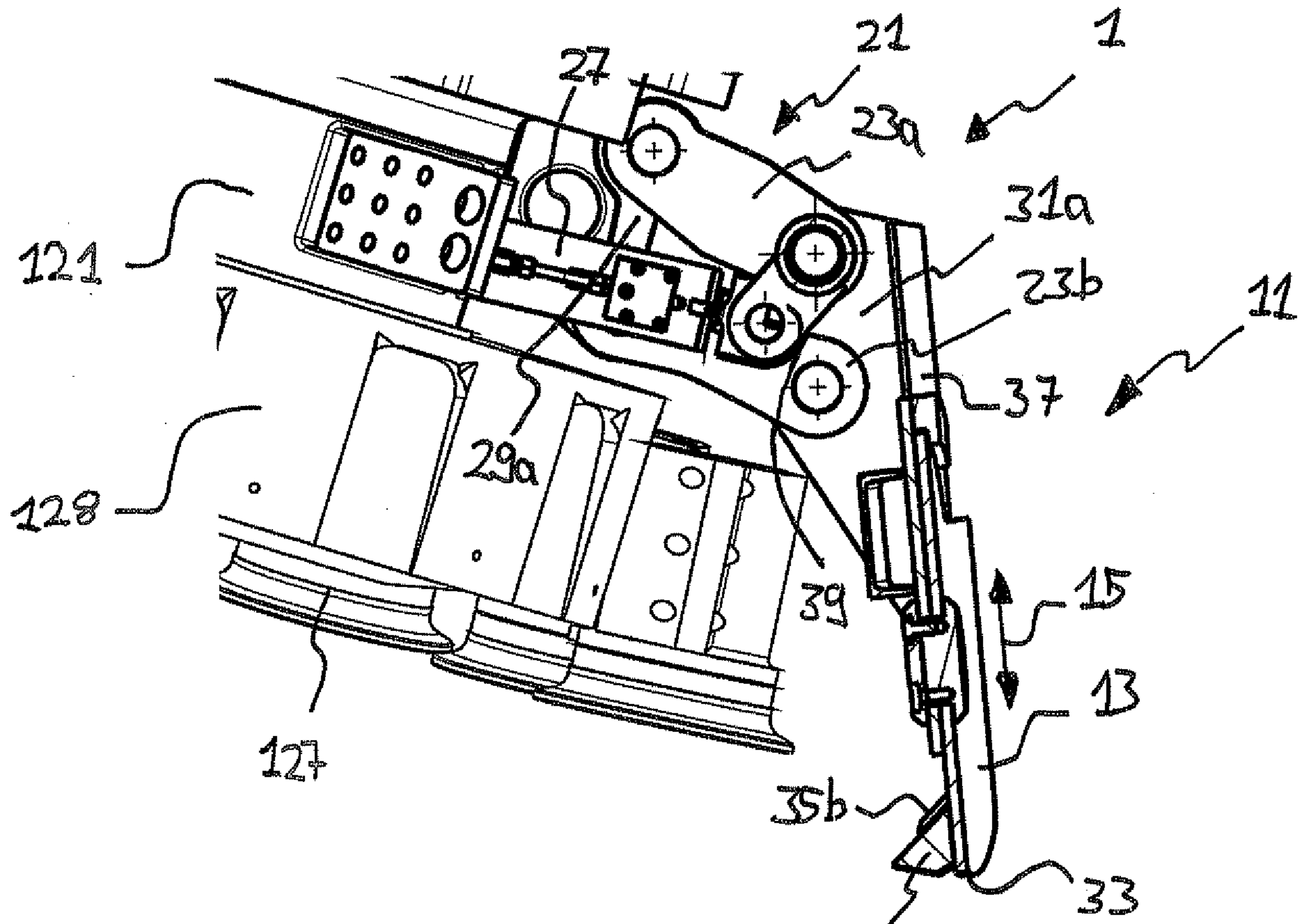


Fig. 10a

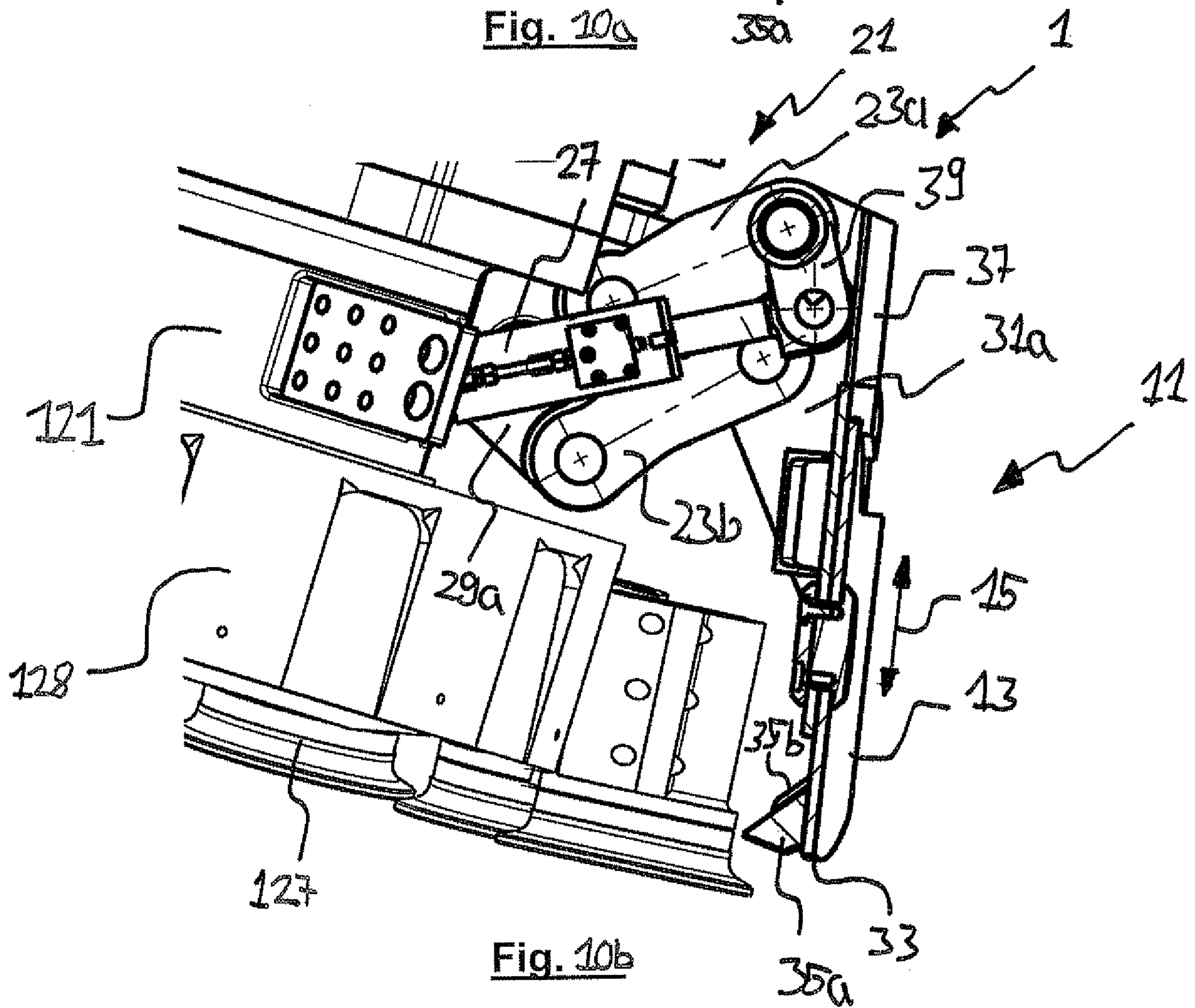
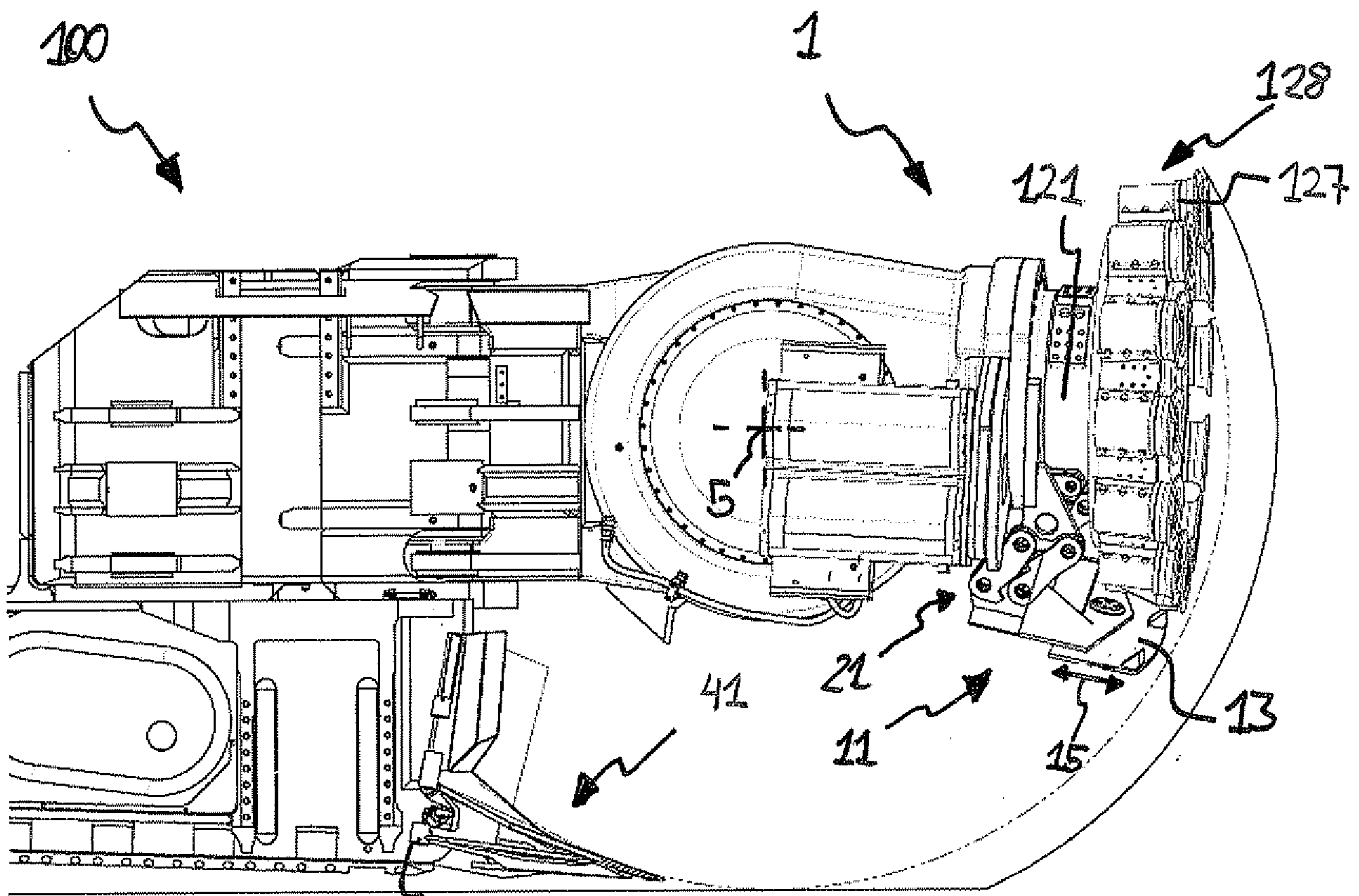
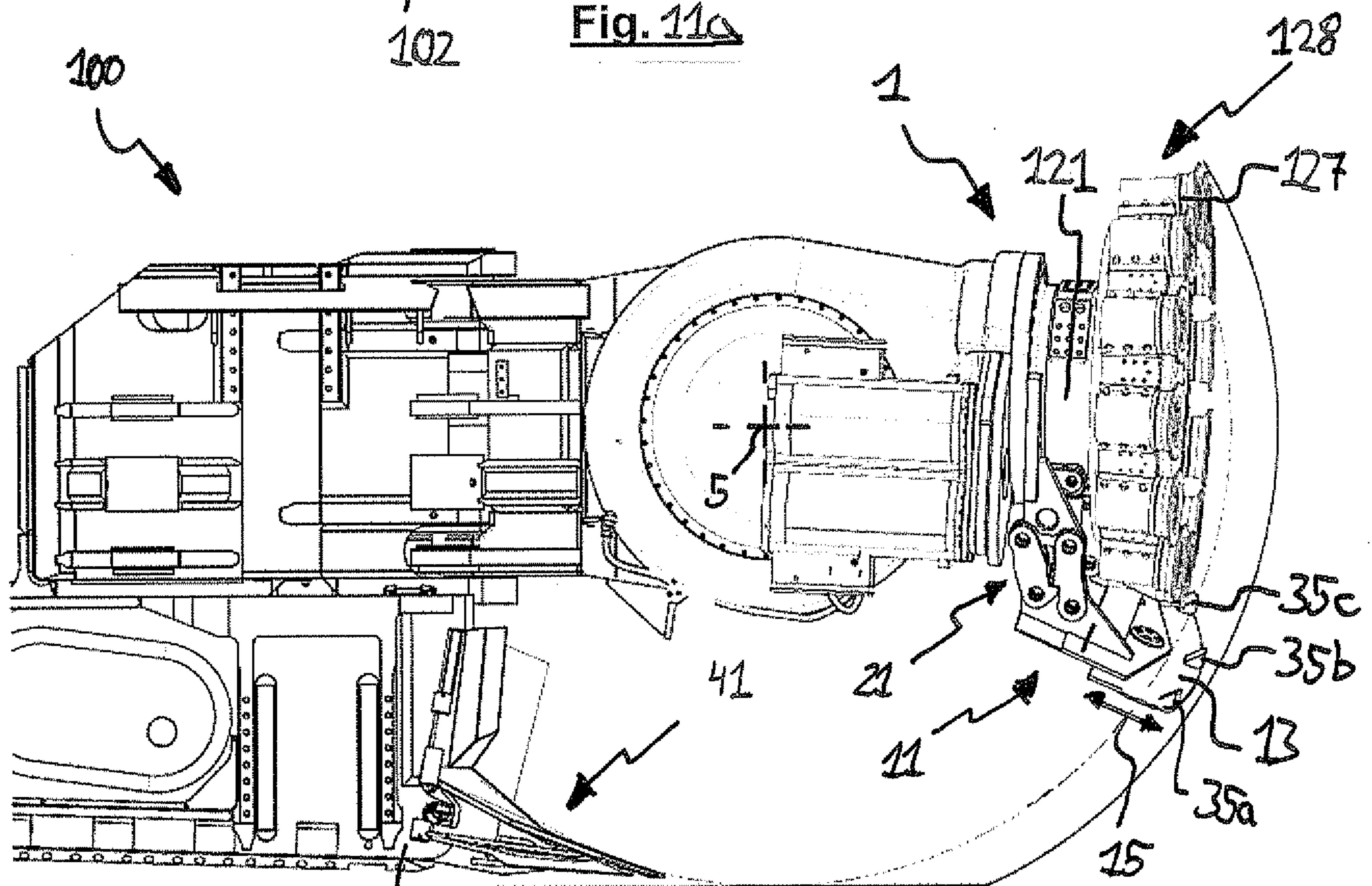


Fig. 10b

Fig. 11aFig. 11b

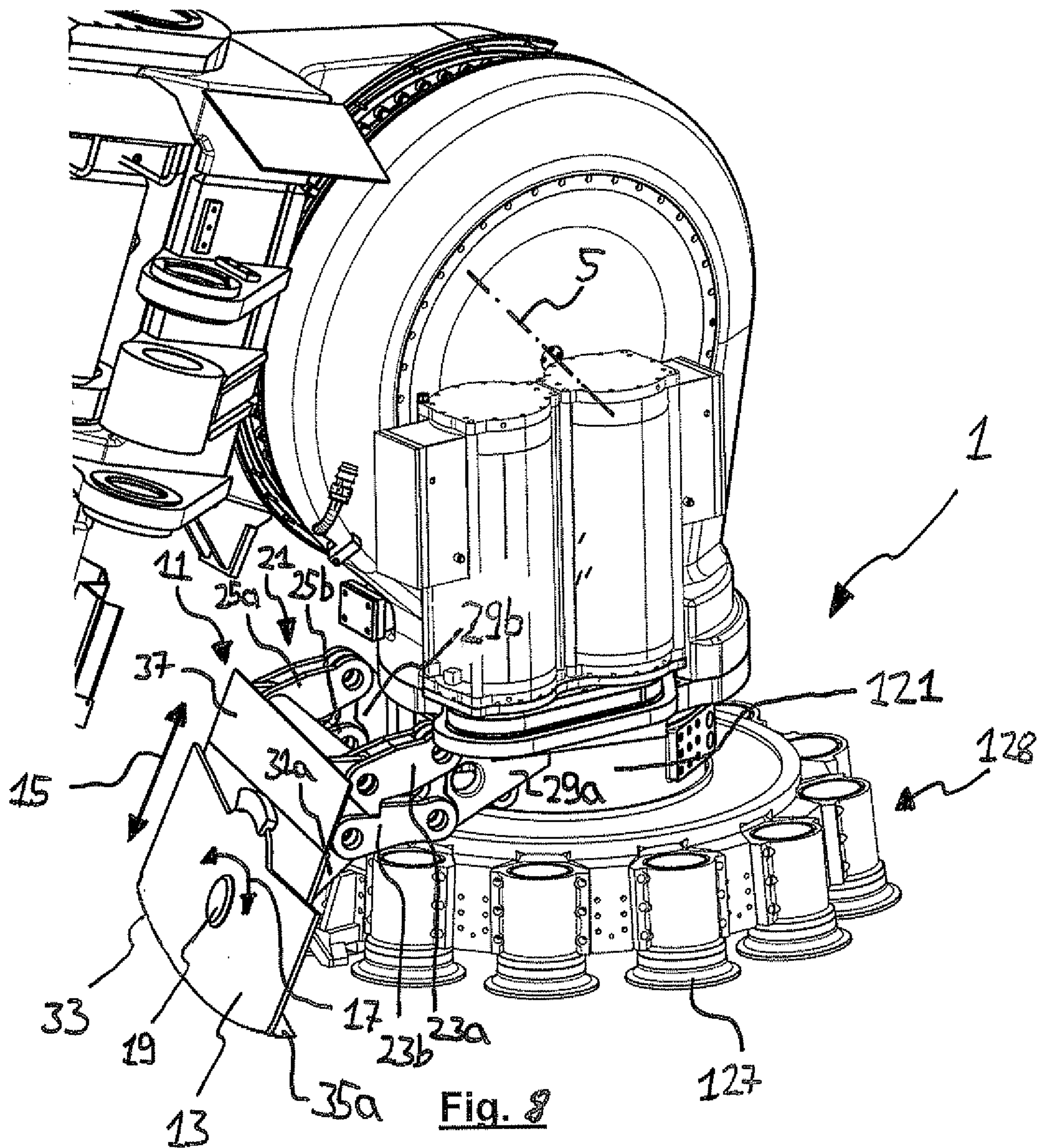


Fig. 8