



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
15.11.2023 Bulletin 2023/46

(51) International Patent Classification (IPC):
B21C 47/26 ^(2006.01) **B21F 11/00** ^(2006.01)
B21C 51/00 ^(2006.01)

(21) Application number: **22173287.8**

(52) Cooperative Patent Classification (CPC):
B21C 47/26; B21C 47/267; B21C 51/00;
B21F 11/00

(22) Date of filing: **13.05.2022**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR
 Designated Extension States:
BA ME
 Designated Validation States:
KH MA MD TN

(71) Applicant: **Yeminy Inc.**
Sheridan, WY 82801 (US)

(72) Inventor: **NYLANDER, Jens**
921 31 Lycksele (SE)

(74) Representative: **Swea IP Law AB**
Forskargatan 20G
151 36 Södertälje (SE)

(54) **AN AUTOMATIC TRIMMING APPARATUS FOR WIRE COILS**

(57) The present invention relates to an automatic trimming apparatus for trimming wire coils. The apparatus comprises a rotational member (6) having a space (8) for receiving a wire (5) of the wire coil. The trimming apparatus is arranged to rotate the rotational member in two opposite directions. The rotational member is provided with a first sensor assembly (16) arranged for sensing the wire (5) in the space (8), a second sensor assembly (49) comprising one or more sensor units (50) for measuring one or more physical properties of the wire, and a cutting device (30) arranged to cut the wire upon receiving a cutting command. The apparatus is adapted

to rotate the rotational member (6) in a first direction along the wire until the end of the wire is detected based on output of the first sensor assembly (16), rotate the rotational member (6) in a second direction along the wire opposite the first direction when the end of the wire has been detected, determine when one or more defined quality requirements for the wire are met during rotation in the second direction based on outputs from the second sensor assembly (49), and generate a cutting command to the cutting device (30) based on when said defined quality requirements are met.

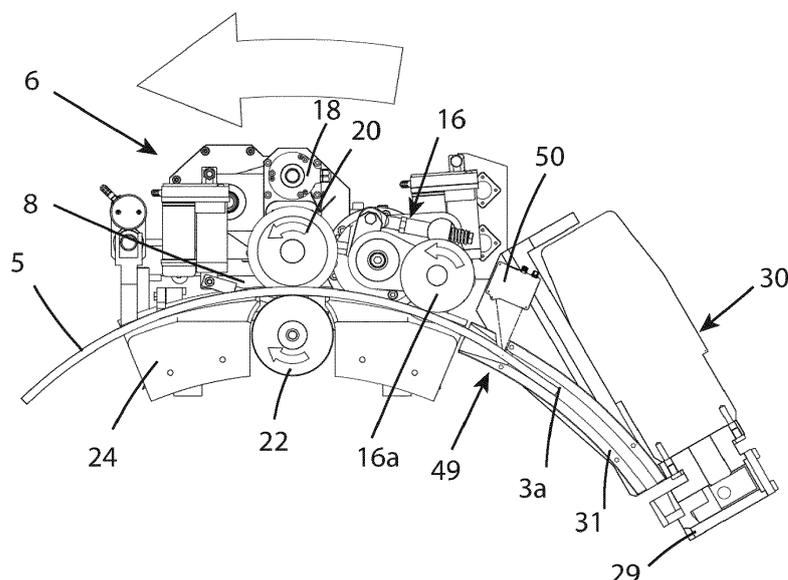


Fig. 13

Description

Technical field

[0001] The present invention relates to an automatic trimming apparatus for trimming wire coils in long rolling mills.

Background

[0002] A wire coil is made up by a continuous multitude of loop-shaped wire which is created by a loop-forming device located after a final shape rolling device in a wire rod rolling mill. The continuous length of the looped wire can be several thousand meters. The loop forming device is followed by a conveyor on which the continuous loops are transported until reaching a vertical collection device into which the loops fall and accumulates into a vertical coil. An important aspect of the product quality in a long rolling mill that produces wire coils is the final material properties of the wire within the coil. Due to activities in the process of manufacturing the wire, such as the rolling process itself, produces wire with differing properties at the head and tail of each coil. The reduced quality of the tail and head of the wire within the coil require their removal before further processing of coils. Coils that have not been trimmed optimally are one factor of poor-quality coils. Thus, the first and last part of the wire in the coil does not meet the quality requirements and must therefore be removed. This process is referred to as coil trimming and can be performed on the coil while supported by a vertical pallet or a horizontal hook.

[0003] The most common conventional method to remove the tail and the head of a wire coil includes largely manual activities whereas an operator identifies and separate the part of the wire rod coil that is to be removed. To determine this, the operator can count individual rings based on a specific minimum length defined by the specific production conditions for the specific product. The operator can also conduct a basic inspection and remove additional wire if required. Once the decision to cut at a specific location has been made by the operator, the wire is cut by using some form of cutting device followed by the operator manually lifting and removing the cut part and dispose of it in a designated receptacle. The working environment in this area is prone to injuries and features a generally poor ergonomic working situation.

[0004] The second most common conventional method is by using a high-speed shear to remove the front and end-section of the rolled billet after the wire has received its final size and shape and before the straight wire is formed into its coiled shape. In this area, the high-speed shear must be able to cut at a very high accuracy and at very high relative speed. Such high-speed shear becomes very complex and expensive to maintain and operate. Due to the complex nature of such high-speed shear, it sometimes fails to perform its intended trimming operation and as a consequence, any removal of head-

and tail wire must be conducted by a manual operator. Even when the high-speed shear operates as intended, some damage to the wire may occur after the high-speed shear which then requires trimming to be conducted by a manual operator. Whilst the high-speed shear can be very useful, it cannot completely eliminate the need for a back-up system or a manual trimming location.

[0005] US2019/0291169, EP0992298A2, GB2047597, and KR101568593B1 discloses prior art trimming apparatus. The prior art trimming apparatus comprises means for determining the number of wire loops to be cut off. A disadvantage such trimming apparatus is that the sheared positions are determined with poor accuracy leading to a waste of wire.

Summary

[0006] It is an aim of the present invention to provide an improved automatic trimming apparatus for wire coils, which determines shear positions with increased accuracy.

[0007] This aim is achieved by an automatic trimming apparatus as defined in claim 1.

[0008] The trimming apparatus comprises:

- a base frame,
- a rotational member rotatably connected to the base frame, and having a space for receiving a wire loop of the wire coil,
- an actuator arranged to rotate the rotational member in two opposite directions,
- a control unit arranged to control the trimming apparatus, and
- a support unit arranged in said space for supporting the wire loop when the rotational member is rotated, wherein the rotational member is provided with
- a first sensor assembly arranged for sensing the wire in the space,
- a second sensor assembly comprising one or more sensor units for measuring one or more physical properties of the wire, and
- a cutting device arranged to cut the wire upon receiving a cutting command from the control unit, and the control unit is adapted to
- control the actuator so that the rotational member is rotated in a first direction along the wire until the end of the wire is detected based on output of the first sensor assembly,
- control the actuator so that the rotational member is rotated in a second direction along the wire opposite the first direction when the end of the wire has been detected,
- determine when one or more defined quality requirements for the wire are met during rotation in the second direction based on outputs from the second sensor assembly, and
- generate a cutting command to the cutting device based on when said defined quality requirements

are met.

[0009] Instead of counting individual rings of the coil as in the prior art, the trimming apparatus according to the invention searches for the end of the wire in the coil while rotating the rotational member along the wire in one direction, and when the end of the wire has been found, the rotational member is rotated in an opposite direction while measuring one or more physical properties of the wire along the wire. The cutting command is generated in dependence on when one or more defined quality requirements are met based the outputs from the second sensor assembly. The cutting device is arranged to cut the wire upon receiving the cutting command from the control unit. Thus, the point of trimming depends on when the quality requirements are met. The second sensor assembly makes it possible to detect defects in the wire that reduces the quality of the wire. The apparatus according to the invention makes it possible to perform quality evaluation of the wire when the rotational member rotates along the wire.

[0010] By having one or more sensor units measuring one or more physical properties of the wire and determining when the defined quality requirements are met makes it possible to find an optimal trimming point on the wire with high accuracy. The accuracy in locating the optimal point of trimming guarantee that no excess wire is removed from the coil. This in turn lead to less scrap having to be remelted which reduces cost and environmental influence. Further, it is ensured that wire of pore quality is removed from the end of the wire.

[0011] The quality requirements are, for example, threshold values for the physical properties measured by the second sensor assembly. The quality requirements can be requirements that must be fulfilled according to a customer specification, an official standard, or an internal production manual. The defined measured physical properties of the wire preferably include at least one of surface roughness, surface imperfections, colour, temperature, brightness, and cross-sectional shape of the wire.

[0012] The trimming apparatus can perform the trimming after a continuous mill production. Unlike trimming equipment located within the actual continuous mill, the trimming apparatus according to the invention performs the trimming immediately after the coil has left the continuous mill, and the wire has achieved its final physical properties. By performing trimming earlier in the process, the quality-feedback can be provided faster, and any quality deviation can be addressed sooner.

[0013] According to an aspect of the invention, the second sensor assembly comprises at least one of the sensor units in the group consisting of a surface sensor, a temperature sensor and a colour sensor, and the at least one sensor being arranged to perform measurement on the wire of the wire loop during rotation of the rotational member.

[0014] According to an aspect of the invention, the sec-

ond sensor assembly comprises a surface sensor arranged to measure surface and cross-sectional shape characteristics of the wire. The surface and cross-sectional shape characteristics are, for example, at least one of ovality of the wire, overfill, underfill, scratches and type of secondary scale on the wire. Overfill or underfill of the wire originates from the rolling mill operation and particular the setup or deviations of the rolls. The secondary scale is, for example, any of wustite (FeO), magnetite (Fe₃O₄) and hematite (Fe₂O₃), and originates from the cooling processing of the wire before reaching the trimming apparatus. The surface sensor may also detect any other surface or shape imperfections than the one mentioned above. The surface sensor makes it possible to find the exact trimming point on the wire with high accuracy. The accuracy in locating the point of trimming guarantee that no excess wire is removed from the coil. The accuracy in locating the point of trimming also guarantee that the entire wire coil has a quality that fulfil set tolerances.

[0015] By having a surface sensor measuring the cross-sectional shape information can be sent back to the rolling mill and the rolls in the rolling mill may be adjusted such that the manufactured wire will have a cross section falling within set tolerances for the process. When the detected surface defects are outside of tolerances or standards a feed-back instruction can be sent to the rolling mill and adjustment made to process parameters, such as rolling temperature, surfaces on the rolls and cooling parameters of the rolled wire such that the quality of the wire is improved.

[0016] According to an aspect of the invention, the surface sensor is a laser scanner. The laser scanner can be a blue laser or a red laser. A red laser scanner can be used when the wire to be measured on is relatively cold. A blue laser scanner is preferred in those instances when the wire to measure on is hot and there may be a risk that a red laser may be sharing its interval for wavelength with infrared heat radiation. By having a laser scanner measuring the surface and/or cross-sectional shape characteristics the cutting command to the cutting device can be executed when the surface and/or cross-sectional shape characteristics are within set tolerances. This makes it possible to find the exact trimming point on the wire with high accuracy. The accuracy in locating the point of trimming guarantee that no excess wire is removed from the coil.

[0017] According to an aspect of the invention, the second sensor assembly comprises a temperature sensor arranged to measure the temperature of the wire. In the production process, the first part of the rolled wire may be uncooled. As such, the physical parameters of the rolled wire may be sub-optimal. Once cooling is turned on, the physical parameters may become as intended. Even several minutes after leaving the cooling equipment, the surface temperature of the wire will differ between the uncooled and the cooled parts of the wire. This temperature difference will be detected by the tempera-

ture sensor and used to identify the optimal trimming position.

[0018] The same temperature sensor will be able to continuously measure the surface temperature on the wire which will make it possible to detect unexpected or unintended local temperature abnormalities, such as a generally colder, or hotter wire than expected, or local hot or cold spot that may indicate equipment errors or process errors. This makes it possible to find the exact trimming point on the wire with high accuracy. The accuracy in locating the point of trimming guarantee that no excess wire is removed from the coil.

[0019] By having a temperature sensor measuring the temperature of the wire, information can be sent back to the rolling mill and any process parameters for the continuous mill may be adjusted such that the manufactured wire will have microstructure falling within set tolerances for the process. When the detected temperature is outside of tolerances or standards a feed-back can be sent to the rolling mill and adjustment made to process parameters, such as the speed of the continuous mill.

[0020] According to an aspect of the invention, the temperature sensor is an infrared sensor.

[0021] According to an aspect of the invention, the second sensor assembly comprises a colour sensor arranged to measure the colour of the wire. The colour sensor makes it possible to detect defects in the wire which reduces the quality of the wire. For example, rust on the actual wire can be detected as well as the colour of the secondary scale, when secondary scale is present. The colour of the wire, or its secondary scale, is also affected by the reflectivity of the surface. Bright or dark spots, with a different rate of reflectivity compared with what is normal or expected can be an indication of process errors or problems with production equipment. By having a colour sensor measuring the visible colour of the wire, information can be sent back to the rolling mill and any process parameters for the continuous mill may be adjusted such that the manufactured wire, or its secondary scale, will have a colour that meets the customer specification, an official standard, or an internal production specification. When the detected colour is outside of specifications or standards a feed-back can be sent to the rolling mill and adjustment made to process parameters.

[0022] According to an aspect of the invention, the colour sensor is an optical sensor.

[0023] According to an aspect of the invention, the support unit comprises a drive roller and a pinch roller arranged movable with respect to the drive roller in a radial direction of the rotational member to allow the wire to be clamped between the drive roller and the pinch roller, and the second sensor assembly is arranged between the pinch roller and the cutting device. This position of the second sensor assembly makes it possible to detect defects in the wire which reduces the quality of the wire before the wire passes the cutter where the wire is cut.

[0024] According to an aspect of the invention, the con-

trol unit is adapted to send feedback about the measured physical properties of the wire to a rolling mill having milled the wire. Continuous feedback to the rolling mill having milled the wire leads to improved quality and a possibility to reduce the cutting length. The quality-feedback to the rolling mill is provided faster than in the prior art, where a physical sample of the wire is cut from the coil and sent back to the rolling mill where it is analyzed. Thus, any quality deviation can be addressed sooner.

[0025] According to an aspect of the invention, the rotational member comprises a distance sensor for sensing a distance travelled along the wire when the rotational member is rotated, and the control unit is adapted to generate a cutting command based on the distance travelled along the wire from the end of the wire. A cutting requirement is, for example, a minimum distance travelled from the wire end. The distance sensor can be used in addition to the sensor units measuring the physical properties of the wire to avoid that the wire is cut too close to the end.

The quality of the wire can vary along the wire and the quality requirements can be fulfilled at parts close to the end of the wire while they are not fulfilled further away from the end. Measuring the distance travelled along the wire from the end of the wire simultaneously with the quality measurements, makes it possible to provide information on where on the wire there are defects that affects the quality of the wire. This also provides valuable feedback to the rolling mill.

[0026] According to an aspect of the invention, the control unit is adapted to generate said cutting command based on the present distance travelled along the wire from the end of the wire and a predetermined minimum distance travelled from the end of the wire. Thus, it is avoided that the wire is cut too close to the end. The minimum distance travelled from the end of the wire can be defined beforehand based on calculating an optimal trimming position on the wire. The minimum distance travelled from the end of the wire is a variable parameter and is preferably determined by the user of the trimming apparatus and is normally a function of final rolling velocity of the wire and a specific rolling time which is calculated into a specific distance, or it could be a specific distance based on the physical dimensions of a rolling mill production apparatus.

[0027] According to an aspect of the invention, the distance sensor is arranged to detect the distance travelled by the support unit along the wire.

[0028] According to an aspect of the invention, the support unit comprises a drive roller and a pinch roller arranged movable with respect to the drive roller in a radial direction of the rotational member to allow the wire to be clamped between the drive roller and the pinch roller, and wherein the distance sensor is a pulse encoder arranged to detect the rotational motions of any of the drive roller or the pinch roller. By allowing the wire to be clamped between the drive roller and the pinch roller, the position of the wire in a radial direction of the rotational member is fixed while the rotational member is rotating

with respect to the wire. The distance moved can, for example, be calculated based on the number of revolutions of the drive roller. This will provide high accuracy of the distance measurement.

Brief description of the drawings

[0029] The invention will now be explained more closely by the description of different embodiments of the invention and with reference to the appended figures.

Fig. 1 shows an example of an automatic trimming apparatus in a perspective view.

Fig. 2 shows an example of a rotational member of the trimming apparatus in a perspective view with a part removed to show the interior of the rotational member.

Fig. 3 shows an enlarged part of the interior of the rotational member.

Fig. 4 shows the trimming apparatus and a wire coil with wire loops in the head or tail separated.

Fig. 5 illustrates a gripping device of the trimming apparatus placing a wire loop in a receiving guide.

Fig. 6 shows the wire loop positioned in the receiving guide.

Figs. 7a-b illustrate a pinch roller arranged movable with respect to a drive roller so that the wire can be clamped between them.

Fig. 8 shows in a perspective view of a part of the rotational member rotating along the wire loop in a clockwise direction while searching for the end of the wire.

Fig. 9 illustrates in a front view the motions of the rotational member when the trimming apparatus rotates clockwise while unscrambling the wire loops and searching for the end of the wire.

Fig. 10 shows the rotational member upon detecting the end of the wire.

Fig. 11 shows a cross-section through the rotational member and a cutting device when the rotational member is rotating in a counter-clockwise direction after the end of the wire has been detected.

Fig. 12a shows the cutting device moving to a forward position for receiving the wire when the end of the wire has been detected.

Fig. 12b shows the cutting device returning to a retracted position after the wire has been cut.

Fig. 13 shows a cross-section through the rotational member, the cutting device and a first example of a second sensor assembly when the rotational member is rotating in a counter-clockwise direction after the end of the wire has been detected.

Fig. 14 shows a cross-section through the rotational member, the cutting device and a second example of the second sensor assembly when the rotational member is rotating in a counter-clockwise direction after the end of the wire has been detected.

Fig. 15 shows a cross-section through the rotational

member, the cutting device and a third example of the second sensor assembly when the rotational member is rotating in a counter-clockwise direction after the end of the wire has been detected.

5

Detailed description

[0030] Aspects of the present disclosure will be described more fully hereinafter with reference to the accompanying drawings. The trimming apparatus can, however, be realized in many different forms and should not be construed as being limited to the aspects set forth herein. Like numbers in the drawings refer to like elements throughout.

10

15

[0031] The terminology used herein is for the purpose of describing particular aspects of the disclosure only, and is not intended to limit the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

20

[0032] Unless otherwise defined, all terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure belongs.

25

[0033] Figure 1 shows an example of an automatic trimming apparatus 1. The trimming apparatus 1 is designed to cut and remove a specific amount of wire 5 from an end of a wire 3a including a plurality of wire loops 3. The specific amount of wire to be cut and removed is contingent on physical and geometrical conditions of the wire as well as specific production parameters at the manufacturing location. The specific amount of wire to be cut and removed can be determined based on when one or more defined cutting requirements for the wire are met. The defined cutting requirements can be based on one or more quality requirements for the wire, or on the one or more quality requirements for the wire in combination with a cutting length requirement. The cutting length requirement can be based on a predetermined minimum distance travelled from the wire end 3a or a desired cutting length value. The cutting length can vary due to the type and size of the wire coil 2 and depends on the type of production machines in the wire rod rolling mill. The cutting length typically varies between 200 mm up to 20 m. The cutting length of the wire can be determined based on when one or more quality requirements for the wire are met in combination with a previously established optimal trimming position on the wire. The one or more quality requirements for the wire can be one or more physical properties measured during the trimming operation.

30

35

40

45

50

55

[0034] The trimming apparatus 1 comprises a base frame 4, a rotational member 6 rotatably connected to the base frame 4, a first actuator 10 arranged to rotate the rotational member 6 in two opposite directions, and a control unit 12 arranged to control the first actuator 10 and accordingly to control the rotational motions of the rotational member 6. The rotational member 6 is substantially ring shaped. The rotational member 6 is ar-

ranged so that it is able to rotate around its center-axis A1. The direction of the rotation can be either clockwise or counter-clockwise. The interior of the rotational member 6 is described later with reference to figures 2 and 3.

[0035] In this example, the trimming apparatus 1 is arranged on a floor mounted rail 40 onto which the trimming apparatus 1 is running supported on roller wheels. The trimming apparatus 1 is propelled in both directions along the extension of the rail by means of an electric motor (not shown). The rotational member 6 comprises a wire separation unit adapted to separate the wire loops in the coil from each other, and by that make it possible to pick one of the wire loops from the coil. Several types of wire separation units are known in the art. In this example, the wire separation unit comprises two separating rollers 42. The separating rollers 42 are mounted at a shallow angle in relation to the horizontal plane and is powered by an electrical motor. Each separating roller 42 is equipped with a helical shaped groove with a gradually increasing pitch. Each separating roller groove is mirrored to the other separating roller groove and is intended to rotate in opposite directions to each-other. The combined effect of these mirrored gradually increasing grooves rotating in opposite directions is intended to transport the individual wire loops along the angled separating roller 42 while gradually increasing the space between the individual loops, as shown in figure 4. It is also possible to use other types wire separation units. After the separating rollers 42 there is a horizontal landing surface 44 onto which the separated wire loops 3 will be accumulated as the process proceeds.

[0036] The base frame 4 supports the rotational member 6, which is able to rotate around its center-axis A1 by means of the first actuator 10. The first actuator 10 is, for example, an electrical motor equipped with a toothed sprocket wheel. The first actuator 10 is attached to the base frame 4. The torque from the electrical actuator 10 is, for example, applied to a large sprocket connected to rotational member 6 by means of a toothed belt or a sprocket, thus making the rotational member 6 to rotate. Optionally, the rotational member 6 is equipped with a vision sensor 46 arranged to identify a single wire loop resting on the landing surface 44 within the plurality of wire loops.

[0037] The rotational member 6 is provided with a wire receiving guide 24 for receiving a wire loop. The wire receiving guide 24 is arranged movable between an extended position on the outside of the rotational member 6 and a retracted position inside the rotational member 6 by means of an actuator 25, shown in figure 7a. The wire receiving guide 24 is arranged linearly movable in an axial direction of the rotational member 6. The wire receiving guide moves the wire from the outside of the rotational member to the space 8 inside the rotational member.

[0038] The trimming apparatus 1 may further comprise a gripping device 48 adapted to grab the identified single wire loop on the landing surface 44 and to place the single

wire loop selected from the plurality of wire loops into the wire receiving guide 24 when the wire receiving guide is in the extended position on the outside of the rotational member 6. In this example, the gripping device 48 is a multi-axis robotic arm equipped with a gripper used to grab and move the identified single wire loop. However, other known types of devices for gripping and moving items can be used.

[0039] Figure 2 shows an example of the rotational member 6 in a perspective view with a part removed to show the interior of the rotational member. Figure 3 shows an enlarged part of the interior of the rotational member 6. The interior of the rotational member 6 defines a space 8 for receiving a wire loop of the coil. The rotational member 6 comprises a support unit 14 arranged in the space 8 for supporting the wire loop 3 in the space 8 when the rotational member 6 is rotated. The support unit 14 is arranged to move along the wire of the coil while the rotational member 6 is rotating. The rotational member 6 and the support unit 14 are moved relative the wire while the rotational member 6 is rotating. The wire loop 3 supported by the support unit stays still during the rotation of the rotational member.

[0040] The rotational member 6 comprises a first sensor assembly 16 arranged in the space 8 for sensing the presence of a wire in a defined area 17 of the space 8. The first sensor assembly 16 is disposed at a distance from the support unit 14 so that the end of the wire is detected before it reaches the support unit 14. The first sensor assembly 16 comprises at least one sensor but may comprise two or more sensors to allow optimization of the process speed and to achieve redundancy. The distance between the support unit 14 and the defined area 17 is known. The rotational member 6 further comprises at least one distance sensor 18 for sensing a distance travelled along the wire during the rotation of the rotational member 6. The rotational member 6 further comprises a second sensor assembly 49 comprising one or more sensors for sensing one or more physical properties of the wire 5.

[0041] The rotational member 6 further comprises a cutting device 30 arranged to cut the wire upon receiving a cutting command from the control unit 12. For example, the cutting device 30 comprises an electro-hydraulic cutter. The cutting device 30 is attached to the rotational member 6. The cutting device 30 is disposed a distance from the support unit 14. The cutting device 30 is also disposed a distance from defined area 17. The second sensor assembly 49 is arranged between the pinch roller 22 and the cutting device 30.

[0042] The control unit 12 comprises processing circuitry for processing sensor data received from the sensor assembly 16, the distance sensor 18 and the second sensor assembly 49, and for sending instructions to the components it is controlling, such as actuators 10, 23 and the cutting device 30. Communication between the control unit 12 and the sensors 16, 18, 47 and the components it is controlling, may comprise wired or wireless

communication. The control unit 12 may comprise software code portions, such as a computer program, comprising instructions for carrying out steps of the invention, and hardware, such as a processor, memory and input/output devices, for carrying out the instructions of the software code portions.

[0043] The control unit 12 is adapted to generate a cutting command to the cutting device 30 based on based on when one or more defined cutting requirements for the wire are met. The defined cutting requirements can be based on one or more quality requirements for the wire, or on the one or more quality requirements for the wire in combination with a cutting length requirement. The control unit 12 can be adapted to receive information about the one or more physical properties of the wire 5 sensed by the second sensor assembly 49. The control unit can calculate and adapt the desired cutting length from the one or more physical properties. The desired cutting length may be adapted when one or more threshold values for the one and more physical properties have been reached. The control unit may also store the information about the one or more physical properties of the wire in the data storage. The control unit may send feedback about the physical properties of the wire 5 to the rolling mill having milled the wire. Therewith the process parameters of the rolling mill may be continuously adapted in dependence of the sensed one or more physical properties to continuously improve the quality of the wire.

[0044] The control unit 12 is adapted to receive outputs from the first sensor assembly 16, the second sensor assembly 49 and optionally output from the distance sensor 18. The control unit 12 is adapted to detect the end of the wire 3a based on the output from the first sensor assembly 16, to control the first actuator 10 so that the rotational member 6 is rotated in a first direction until the end of the wire is detected, to control the first actuator 10 so that the rotational member 6 is rotated in a second direction opposite the first direction when the end of the wire has been detected, to determine the distance travelled along the wire when the rotational member is rotated in the second direction based on the output from second sensor assembly 49. The second sensor assembly 49 comprises a at least one of the sensors in the group consisting of a surface sensor 50, a temperature sensor 51 and a colour sensor 52, and the at least one sensor being arranged to perform measurement on the wire 5 of the wire loop 3 during rotation of the rotational member 6.

[0045] The control unit 12 is adapted to generate said cutting command based on the distance travelled along the wire from the end of the wire and a predetermined minimum distance travelled from the end of the wire. Thus, it is avoided that the wire is cut to close to the end. The minimum distance travelled from the end of the wire can be defined beforehand based on calculating an optimal trimming position on the wire. The minimum distance travelled from the end of the wire is a variable parameter and is preferably determined by the user of the trimming apparatus and is normally a function of final

rolling velocity of the wire and a specific rolling time which is calculated into a specific distance, or it could be a specific distance based on the physical dimensions of a rolling mill production apparatus.

5 **[0046]** The support unit 14 is arranged to move along the wire while the rotational member 6 is rotating. The rotational member 6 and the support unit 14 are moving relative the wire. The support unit 14 comprises a drive roller 20 and a pinch roller 22 rotatably connected to the rotational member 6. The trimming apparatus comprises a second actuator 21 arranged to rotate the drive roller 20 in two opposite directions, shown in figure 8. The second actuator 21 is, for example, an electric motor. The pinch roller 22 is arranged linearly movable with respect to the drive roller 20 in a radial direction of the rotational member, as shown in figure 7a-b, to allow the wire loop to be clamped between the drive roller 20 and the pinch roller 22, as shown in figure 9. Thus, the position of the wire in a radial direction of the rotational member is fixed while the rotational member 6 is rotating with respect to the wire. The rotational member 6 comprises an actuator 23 arranged to move the pinch roller 22 towards and away from the drive roller 20.

20 **[0047]** The wire receiving guide 24 has a recess 26 for receiving the pinch roller 22 in the retracted position. The wire receiving guide 24 is arranged linearly movable with respect to the pinch roller 22 in an axial direction of the rotational member 6. The pinch roller 22 is arranged linearly movable with respect to the recess 26 in the radial direction of the rotational member 6. Due to the recess 26, the pinch roller is allowed to move towards and away from the drive roller 20 when the wire receiving guide 24 is in the retracted position. The receiving guide 24 has an exit 24a for the wire arranged in one end.

25 **[0048]** The drive roller 20 and the pinch roller 22 are arranged so that they rotate in opposite directions with respect to each other when the wire is clamped between them, and the rotational member 6 is rotated in any of the first and the second directions as shown in figures 10 and 11. Thus, the drive roller 20 and the pinch roller 22 are rolled along the wire 3 while the rotational member 6 is rotated. Thus, unintentional damage of the wire is avoided when the support unit 14 clamps the wire during rotation of the rotational member 6. The friction between the wire and the drive roller 20 and the pinch roller 22 is reduced due to the fact that the drive roller 20 and the pinch roller 22 rotate along the wire instead of sliding along the wire.

30 **[0049]** The control unit 12 is adapted to control the first and second actuators 10, 21 so that the drive roller 20 and the rotational member 6 are rotated in the same direction in a synchronized manner to allow the drive roller 20 and the pinch roller 22 to roll on the wire while the rotating member 6 is rotated relative the wire. In this example, the pinch roller 22 has no actuator. The pinch roller 22 is rotated due to the friction against the wire and the movements of the rotating member 6.

35 **[0050]** The rotational member 6 is arranged rotatable

with respect to the base frame 4 about a first rotational axis coinciding with the central axis A1. The drive roller 20 is arranged rotatable with respect to a second rotational axis in parallel with the central axis A1, and the pinch roller 22 is arranged rotatable with respect to a third rotational axis in parallel with the central axis A1, and the first, second, and third rotational axes are in parallel.

[0051] The control unit 12 is adapted to control the first and second actuators 10, 21 so that the rotational member 6 and the drive roller 20 are rotated in the first direction in a synchronized manner until the end of the wire 3a has been detected, as shown in figure 9 and 10, and to control the first and second actuators 10, 21 so that the rotational member 6 and the drive roller 20 are rotated in the second direction after the end of the wire 3a has been detected, as shown in figure 11. The control unit 12 is adapted to control the first and second actuators 10, 21 so that the rotational member 6 and the drive roller 20 are rotated in the second direction until the distance travelled along the wire corresponds to the predetermined cutting distance. The control unit 12 is adapted to stop the rotational movements of the rotational member 6 and the drive roller 20 and to generate the cutting command when the support unit 14 has travelled the predetermined cutting distance along the wire in the second direction. The control unit 12 is adapted to send feedback about the measured physical properties of the wire to a rolling mill having milled the wire.

[0052] The first sensor assembly 16 is arranged to detect when the end of the wire 3a is present in the defined area 17. The first sensor assembly 16 can be arranged for sensing the presence of the wire 3 in the defined area 17 of the space 8, as shown in figure 9, and also to detect when the wire 3 is no longer present in the defined area 17, as shown in figure 10. The first sensor assembly 16 is used to detect the end of the wire 3a. For example, the output from the first sensor assembly 16 stays 1 as long as the wire 3 is sensed in the defined area 17, and the output from the first sensor assembly 16 is switched to 0 when the wire is no longer present in the defined area. Thus, it is possible for the control unit 12 to detect when the end of the wire 3a has passed through the defined area 17. Different types of sensor can be used to detect the end of the wire. For example, the first sensor assembly 16 may comprise an optical sensor adapted to detect when the end of the wire is present in the defined area 17. In this example, the first sensor assembly comprises a sensor roller 16a and an inductive sensor 16b arranged to detect when the sensor roller 16 is moved downwards, as shown in figure 10. The sensor roller 16a is spring tensioned so that the sensor roller is biased towards the wire. The sensor roller 16a is arranged so that it rolls on the wire 3 as long as the wire is present in the area 17, as shown in figure 9. When the end of the wire 3a is present in the area 17, the sensor roller 16a rolls off the wire and is moved a short distance towards the centre of the rotating member due to the spring force acting on the sensor roller 16, as shown in figure 10. The inductive

sensor 16b is arranged to detect the movement of the sensor roller 16a. This type of sensor assembly is known in the art.

[0053] The distance sensor 18 can be arranged in different ways. For example, the distance sensor 18 can be arranged to detect the distance travelled by the support unit 14 along the wire. In one example, the distance sensor 18 can be an electrical pulse-encoder connected to the driven roller 20 and arranged to detect the rotational motions of the drive roller 20. Thus, the actual length of wire passing through the support unit 14 can be measured. The distance sensor 18 can, for example, be arranged to detect the number of revolutions of a drive axis of the motor 21 actuating the drive roller 20. The control unit 12 receives outputs from the distance sensor 18 and determines the distance travelled along the wire in the second direction based on the received output from the sensor 18. In this example, the distance sensor 18 senses the distance travelled by the drive roller 20 along the wire. Other examples could be to connect a distance sensor of electrical pulse-encoder type, to the sensor roller 16a or to the pinch roller 22. In these examples, the actual length of wire passing through the first sensor assembly 16 can be measured on non-powered rotating members.

[0054] Figure 4 shows the trimming apparatus 1 and a coil 2 comprising a plurality of circular wire loops 3. A wire loop 3 consists of a wire 5. Figure 4 shows the coil with the wire loops 3 separated at an end facing the trimming apparatus 1. One of the wire loops 3 is disposed on the horizontal landing surface 44.

[0055] Figure 5 illustrates when the trimming apparatus receives a single wire loop 3 of the wire coil. The receiving guide 24 is in the extended position on the outside of the rotational member 6.

[0056] Figure 6 shows the wire receiving guide 24 in a side view. The wire receiving guide 24 is provided with an elongated groove 28 for receiving the wire loop 3. The gripping device 48 positions the wire loop 3 in the groove 28 of the wire receiving guide 24, as shown in figure 5. Upon receiving the single wire loop 3 in the groove 28, the control unit 12 activates the actuator 25 to retract the wire receiving guide 24 to its retracted position.

[0057] Figures 7a-b shows the interior of the rotational member 6 in a front view. The pinch roller 22 is arranged movable with respect to the drive roller 20 so that the wire loop 3 can be clamped between them. The control unit 12 activated the actuator 23 to press the pinch roller 22 against a part of the looped wire 3 within the wire receiving guide 24 and against the drive roller 20. A different actuator (not shown) is activated to press the sensor roller 16a against another part of the wire within the wire receiving guide 24, as shown in figure 9.

[0058] Figure 8 shows a part of the rotational member 6 rotating along the wire loop 3 to find the end of the wire 3a. The rotational member 6 begins to rotate around its centre axis A1 by means of the electrical motor 10 attached to the base frame 4. The direction of the rotation can be either clockwise or counter-clockwise, depending

on the specific production parameters when producing the coiled loops. While the rotational member 6 is rotating in one direction, the driven roller 20, powered by the actuator 21, is arranged to rotate along the looped wire in the same rotational direction in a synchronized manner between the two rotating motions, resulting in axially unscrambling of the different wire loops while not changing the actual geometry of each individual loop in the radial direction while simultaneously organizing the wire loops in a successive order, one after another starting with the last wire loop in the plurality of wire loops closest to the rotational part 6 of the trimming apparatus. These rotating motions continues until the sensor roller 16a detects the end 3a of the last wire loop in the coil and activates the inductive sensor 16b.

[0059] Figure 9 illustrates the motions of the rotational member 6, the drive roller 20, the pinch roller 22, and the sensor roller 16a when the trimming apparatus is searching for the end of the wire. The rotational member 6 is rotated in a first direction. As seen from the figure, the drive roller 20 and the pinch roller 22 rotate in opposite directions, and the rotational member 6, the drive roller 20, and the sensor roller 16a rotate in the same directions. The drive roller 20, the pinch roller 22, and the sensor roller 16a are in physical contact with the wire 3. The drive roller 20 and the pinch roller 22 are moving along the wire in the first direction and towards the end of the wire 3a.

[0060] Figure 10 shows interior of the rotational member 6 upon detecting the end of the wire 3a. The sensor roller 16a is moved downwards due to the spring tension when the sensor roller 16a has passed the end of the wire, and the inductive sensor 16b detects the change of position of the sensor roller 16a. The control unit 12 receives information on that the end of the wire has been detected from the inductive sensor 16b. The control unit 12 send orders to the first and second actuators 10, 21 to change the direction of the rotation of the rotational member 6 and the drive roller 20 upon receiving the information that the end of the wire has been detected.

[0061] Figure 11 illustrates the motions of the rotational member 6, the drive roller 20, the pinch roller 22, and the sensor roller 16a after the end of the wire 3a has been detected. The rotational member 6 and the drive roller 20 are now rotated in the second direction, opposite the first direction. The drive roller 20 and the pinch roller 22 are moving along the wire in the second direction and away from the end of the wire 3a. During the rotation of the rotational member 6 in the second direction, the distance sensor 18 measures the distance travelled along the wire. The rotation of the rotational member 6 continues until the distance travelled along the wire in the second direction is equal to the predetermined cutting distance. The rotational member 6 can be rotated several turns until the distance travelled along the wire is equal to the predetermined cutting distance.

[0062] Figure 11 shows a cross-section through the rotational member 6 including an example of a cutting

device 30. The cutting device 30 comprises a cutter 29 provided with a movable steel cutter 36. In this example, the cutter 29 is an electro-hydraulic cutter 29. However, other types of cutters can be used. The cutting device 30 may comprise a guide member 31 for guiding the wire towards the steel cutter 36. In the illustrated example, the guide member 31 is attached to the cutter 29. In an alternative embodiment, the guide member 31 can be a separated part movable with respect to the cutting device 30. The guide member 31 has an accommodation 32 with an inlet 34 arranged to receive the end of the wire 3a when the rotational member 6 is rotated in the second direction. In the illustrated example, the cutting device 30 is linearly movable between a retracted position and a forward position, as shown in figures 12a-b. In this example, the cutting device 30 is movable in an axial direction of the rotational member 6. The steel cutter 36 is cutting the wire while in the forward position and is retracted after completed cutting process. In its retracted location it is positioned and ready for the next trimming operation. The rotational member 6 comprises an actuator 37 for moving the cutting device 30. The control unit 12 is controlling the actuator 37 and accordingly the motions of the cutting device 30. In an alternative embodiment, the cutting device 30 can be fixedly attached to the rotational member 6 and accordingly not movable with respect the rotational member, and the guide member 31 is movable with respect to the cutting device 30. This is advantageous if the cutting device is heavy.

[0063] The cutting device 30 is arranged to move the steel cutter 36 upon receiving the cutting command so that the wire guided by the accommodation 32 is cut. The cutting device 30 may comprises an actuator (not shown) for moving the steel cutter so that it cuts the wire. For example, the actuator is an electrical motor driving a small hydraulic pump. The hydraulic fluid in the pump is pressing against the steel cutter 36, forcing it forward to cut the wire. The actuator for moving the steel cutter 36 is controlled by the control unit 12, and the actuator is activated upon receiving the cutting command.

[0064] Figure 13 shows a cross-section through the rotational member 6, a cutting device 30, and a first example of a second sensor assembly 49 comprising at least one sensor unit 50. The cutting device 30 may be the same type of cutting device 30 as described in connection to the illustrated example in figure 11, but it can also be an alternative cutting device being suitable in a trimming apparatus. The rotational member 6 comprises a drive roller 20 and a pinch roller 22 arranged movable with respect to the drive roller 20 in a radial direction of the rotational member to allow the wire 5 to be clamped between the drive roller 20 and the pinch roller 22. The second sensor assembly 49 is arranged between the pinch roller and the cutting device 30 such that defects in the wire can be detected before the wire passes the cutter 29 where the wire is cut.

[0065] The first example of the second sensor assembly 49 comprises a surface sensor 50 arranged to meas-

ure surface and cross-sectional shape characteristics along the wire 5. The surface sensor 50 is, for example, a laser scanner. Examples of surface and cross-sectional shape characteristics of the wire are at least one of the following: ovality, overfill, underfill, scratches, type of secondary scale and any other surface or shape imperfections. The surface sensor 50 can be used to find the exact trimming point on the wire.

[0066] The arrow above the rotational member 6 illustrates the motions of the rotational member 6, the drive roller 20, the pinch roller 22, and the sensor roller 16a after the end of the wire 3a has been detected. The rotational member 6 and the drive roller 20 are now rotated in the second direction, opposite the first direction. The drive roller 20 and the pinch roller 22 are moving along the wire in the second direction and away from the end of the wire 3a. During the rotation of the rotational member 6 in the second direction, the surface sensor 50 measures the surface and cross-sectional shape characteristics along the wire 5. The rotation of the rotational member 6 continues until one or more quality requirements for the wire are met during rotation in the second direction based on outputs from the second sensor assembly 49. The rotational member 6 can be rotated several turns until the distance travelled along the wire is equal to the predetermined cutting distance.

[0067] Figure 14 shows a cross-section through the rotational member 6, a cutting device 30, and a second example of a second sensor assembly 49 and is an alternative to the previous embodiment in figure 13. The difference to the embodiment in figure 14 is that the second sensor assembly 49 comprises a surface sensor 50 arranged to measure surface and cross-sectional shape characteristics of the wire, and a temperature sensor 51 arranged to measure the temperature of the wire 5. The temperature sensor 51 is, for example, an IR-sensor. The second sensor assembly 49, comprising the surface sensor 50 and the temperature sensor 51, is arranged between the pinch roller 22 and the cutting device 30 such that defects in the wire can be detected before the wire passes the cutter 29 where the wire is cut. The surface sensor 50 and the temperature sensor 51 may be arranged in any order along the wire 5. The surface sensor 50 in combination with the temperature sensor 51 can be used to find the exact trimming point on the wire.

[0068] Figure 15 shows a cross-section through the rotational member 6, a cutting device 30, and a third example of a third sensor assembly 49 and is an alternative embodiment to the two previous embodiments in figure 13 and 14. The difference is that the second sensor assembly 49 in addition to the surface sensor 50 the temperature sensor 51 also comprises a colour sensor 52 arranged to measure the colour of the wire 5. The temperature sensor 51 is, for example, an IR-sensor. The second sensor assembly 49, comprising the surface sensor 50, the temperature sensor 51, and the colour sensor 52, is arranged between the pinch roller 22 and the cutting device 30 such that defects in the wire can be detected

before the wire passes the cutter 29 where the wire is cut. The colour sensor is for example an optical sensor. The surface sensor 50, temperature sensor 51 and colour may be arranged in any order along the wire.

[0069] Although the first example of the second sensor assembly 49 as illustrated in figure 13 comprises a surface sensor 50, according to an alternative embodiment the surface sensor 50 in figure 13 could instead be the temperature sensor 51. The surface sensor 50 and the temperature sensor 51 can each individually, or in combination, be used to find the exact trimming point on the wire.

[0070] According to an embodiment at least one of the surface sensor 50 and the temperature sensor 51 is used in combination with the colour sensor 52 to find the exact trimming point on the wire.

[0071] According to an embodiment the embodiments described in connection to any of figures 13-14 may also comprise a distance sensor for sensing a distance travelled along the wire when the rotational member 6 is rotated, and the control unit is adapted to generate a cutting command based on the distance travelled along the wire from the end of the wire and a predetermined minimum distance travelled from the end of the wire. Thus, it is avoided that the wire is cut too close to the end. The minimum distance travelled from the end of the wire can be defined beforehand based on calculating an optimal trimming position on the wire. The minimum distance travelled from the end of the wire is a variable parameter and is preferably determined by the user of the trimming apparatus and is normally a function of final rolling velocity of the wire and a specific rolling time which is calculated into a specific distance, or it could be a specific distance based on the physical dimensions of a rolling mill production apparatus. The distance sensor may be arranged to detect the distance travelled by the support unit along the wire. According to an example the distance moved can, for example, be calculated based on the number of revolutions of the drive roller. This will provide high accuracy of the distance measurement.

[0072] Figure 12a shows the cutting device 30 moving to the forward position when the end of the wire has been detected. Figure 12b shows the cutting device 30 returning to the retracted position after the wire has been cut.

[0073] When the end of the wire has been detected, the control unit 12 sends an order to the actuator 37 to move the cutting device 30 from its retracted position to its forward position, as shown in figure 12a, so that the inlet 34 of the guide member 31 is aligned with the exit 24a of the receiving guide 24. While moving in a synchronized manner, the rotational member 6 and the drive roller 20 now start to rotate in the second direction, moving the end of the wire 3a into the accommodation 32 of the guide member 31, through the accommodation 32, through the cutter 29 and further into a segmented discard wire guide (not shown).

[0074] The present invention is not limited to the embodiments disclosed but may be varied and modified

within the scope of the following claims.

Reference list

[0075]

1. Automatic trimming apparatus
2. wire coil
3. wire loops
- 3a end of the wire
4. base frame
5. wire
6. rotational member
8. space
10. first actuator
12. control unit
14. support unit
16. first sensor assembly
- 16a sensor roller
- 16b inductive sensor
17. defined area of the space
18. distance sensor
20. drive roller
21. Second actuator
22. pinch roller
23. actuator
24. receiving guide
- 24a. exit of the receiving guide
25. actuator
26. recess of wire receiving guide
28. groove of the wire receiving guide
29. cutter
30. cutting device
31. guide member
32. accommodation of guide device
- 34 inlet of the guide member
36. steel cutter
- 37 actuator for moving the cutting device
- 40 rail
- 42 separating roller
- 44 landing surface
- 46 vision sensor
- 48 gripping device
- 49 second sensor assembly
- 50 surface sensor
- 51 temperature sensor
- 52 colour sensor

Claims

1. An automatic trimming apparatus (1) for trimming wire coils (2) including a plurality of wire loops (3) of a wire (5), characterized in that the apparatus (1) comprises:
 - a base frame (4),
 - a rotational member (6) rotatably connected to

the base frame (4), and having a space (8) for receiving a wire loop (3) of the coil (2),

- an actuator (10) arranged to rotate the rotational member (6) in two opposite directions,
- a control unit (12) arranged to control the trimming apparatus (1),
- a support unit arranged in said space for supporting the wire loop when the rotational member is rotated,

wherein the rotational member (6) is provided with

- a first sensor assembly (16) arranged for sensing the wire (5) in the space (8),
- a second sensor assembly (49) comprising one or more sensor units (50, 51, 52) for measuring one or more physical properties of the wire (5), and
- a cutting device (30) arranged to cut the wire upon receiving a cutting command from the control unit (12), and

the control unit (12) is adapted to

- control the actuator (10) so that the rotational member (6) is rotated in a first direction along the wire until the end of the wire is detected based on output of the first sensor assembly (16),
- control the actuator (10) so that the rotational member (6) is rotated in a second direction along the wire opposite the first direction when the end of the wire has been detected,
- determine when one or more defined quality requirements for the wire are met during rotation in the second direction based on outputs from the second sensor assembly (49), and
- generate a cutting command to the cutting device (30) based on when said defined quality requirements are met.

2. The trimming apparatus according to claim 1, wherein said measured physical properties of the wire include at least one of surface roughness, surface imperfections, colour, temperature, brightness, and cross-sectional shape of the wire.
3. The trimming apparatus according to any of the previous claims, wherein said second sensor assembly (49) comprises at least one of the sensors in the group consisting of a surface sensor (50), a temperature sensor (51) and a colour sensor (52), and the at least one sensor being arranged to perform measurement on the wire (5) of the wire loop (3) during rotation of the rotational member (6).
4. The trimming apparatus according to any of the previous claims, wherein the second sensor assembly (49) comprises a surface sensor (50) arranged to measure surface and cross-sectional shape characteristics of the wire (5).

5. The trimming apparatus according to claim 4, wherein the surface sensor (50) is a laser scanner.
6. The trimming apparatus according to any of the previous claims, wherein the second sensor assembly (49) comprises temperature sensor (51) is arranged to measure the temperature of the wire (5).
7. The trimming apparatus according to claim 6, wherein the temperature sensor (51) is an IR-sensor.
8. The trimming apparatus according to any of the previous claims, wherein the second sensor assembly (49) comprises a colour sensor (52) arranged to measure the colour of the wire (5).
9. The trimming apparatus according to claim 8, wherein the colour sensor (52) is an optical sensor.
10. The trimming apparatus according to any of the previous claims, wherein the support unit comprises a drive roller (20) and a pinch roller (22) arranged movable with respect to the drive roller (20) in a radial direction of the rotational member to allow the wire to be clamped between the drive roller (20) and the pinch roller (20), and the second sensor assembly (49) is arranged between the pinch roller (22) and the cutting device (30).
11. The trimming apparatus according to any of the previous claims, wherein said rotational member (6) comprises a distance sensor (18) for sensing a distance travelled along the wire when the rotational member (6) is rotated in the second direction, and the control unit (12) is adapted to generate said cutting command based on the distance travelled along the wire (5) from the end of the wire (3a).
12. The trimming apparatus according to claim 11, wherein the control unit (12) is adapted to generate said cutting command based on the distance travelled along the wire (5) from the end of the wire (3a) and a predetermined minimum distance travelled from the end of the wire.
13. The trimming apparatus according to any of claims 11-12, wherein the distance sensor (18) is arranged to detect the distance travelled by the support unit (14) along the wire.
14. The trimming apparatus according to any of claims 11-13, wherein the support unit comprises a drive roller (20) and a pinch roller (22) arranged movable with respect to the drive roller (20) in a radial direction of the rotational member to allow the wire to be clamped between the drive roller (20) and the pinch roller (20), and wherein the distance sensor (18) is a pulse encoder arranged to detect the rotational mo-
- tions of any of the drive roller (20) or the pinch roller (22).
15. The trimming apparatus according to any of the previous claims, wherein the control unit (12) is adapted to send feedback about the measured physical properties of the wire to a rolling mill having milled the wire (5).

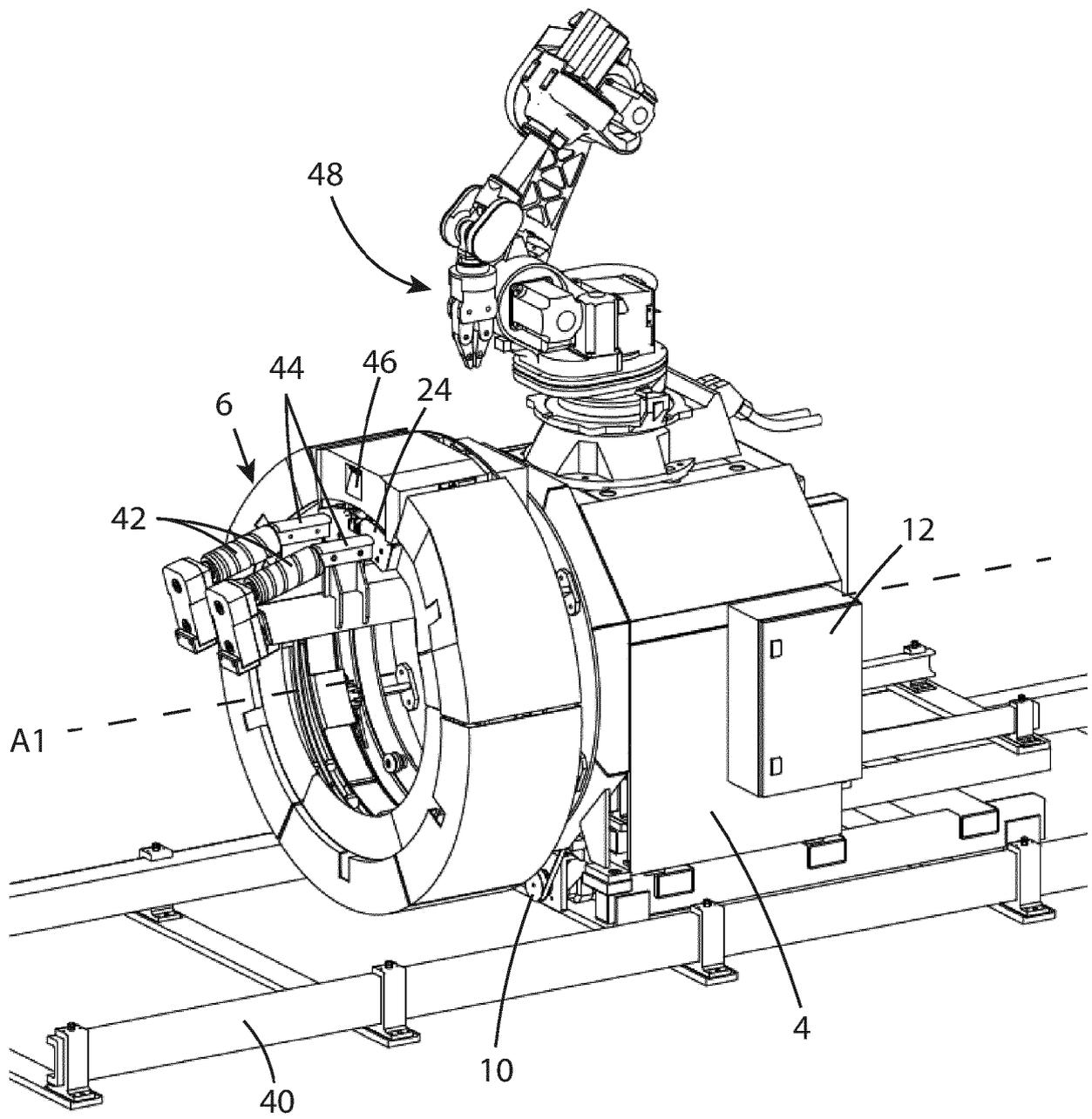


Fig. 1

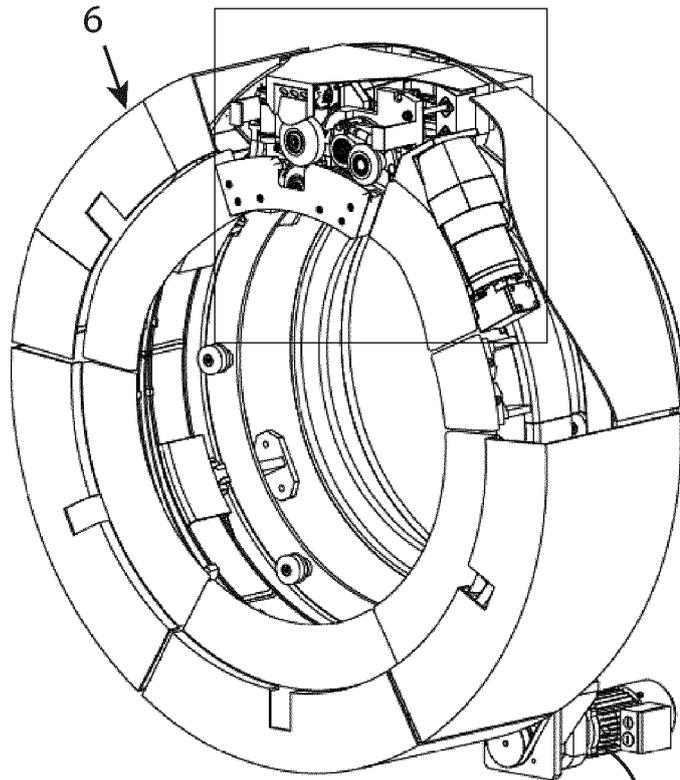


Fig. 2

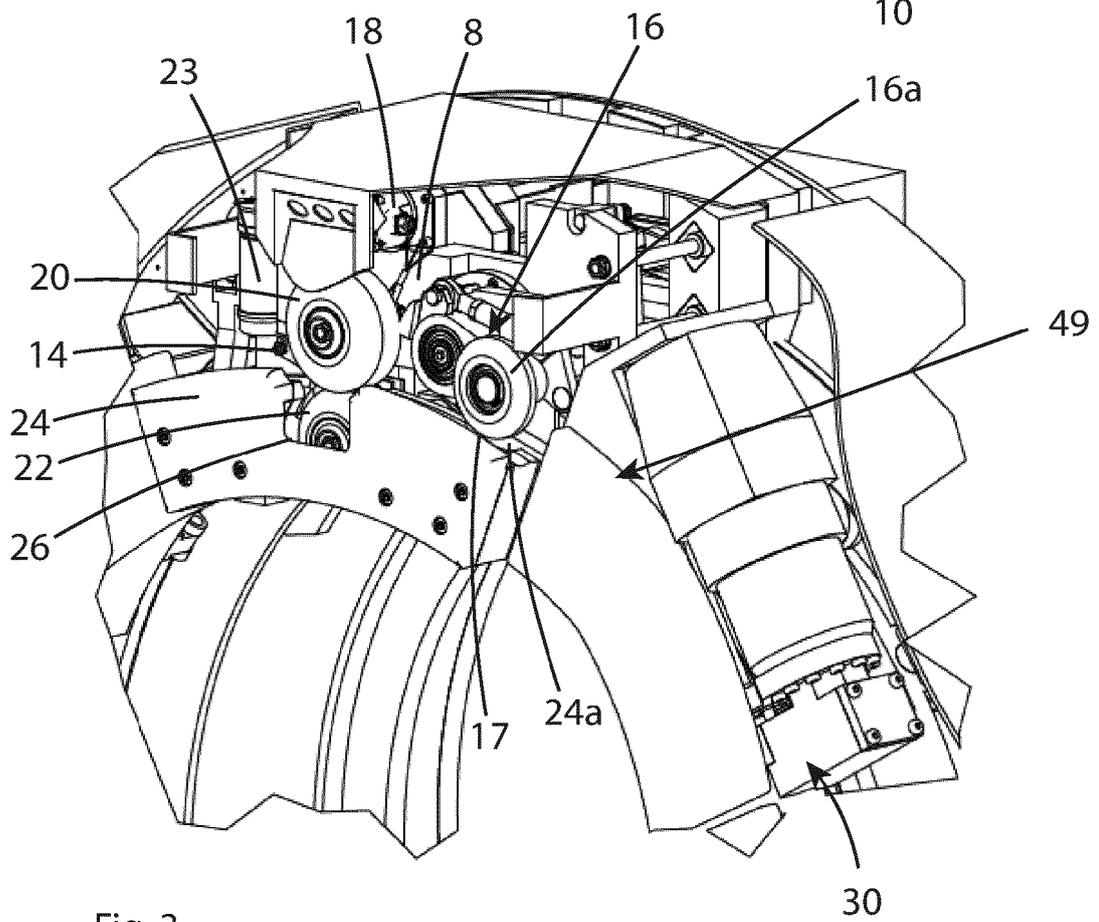
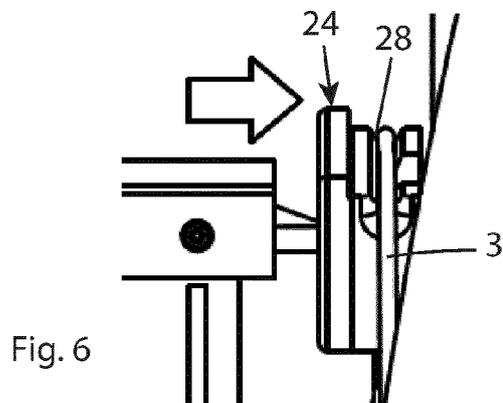
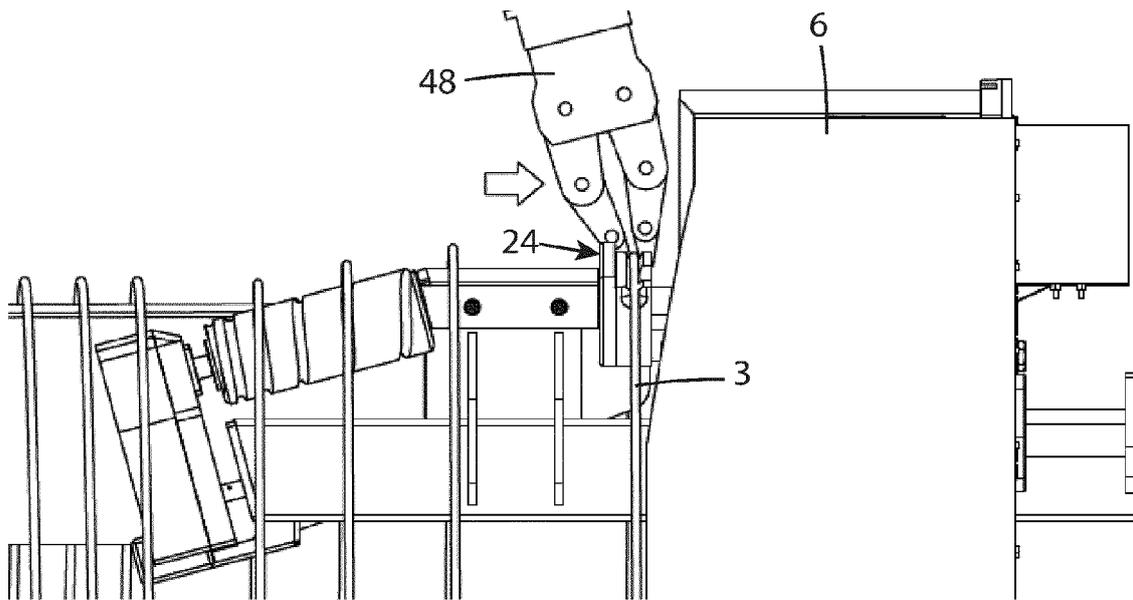
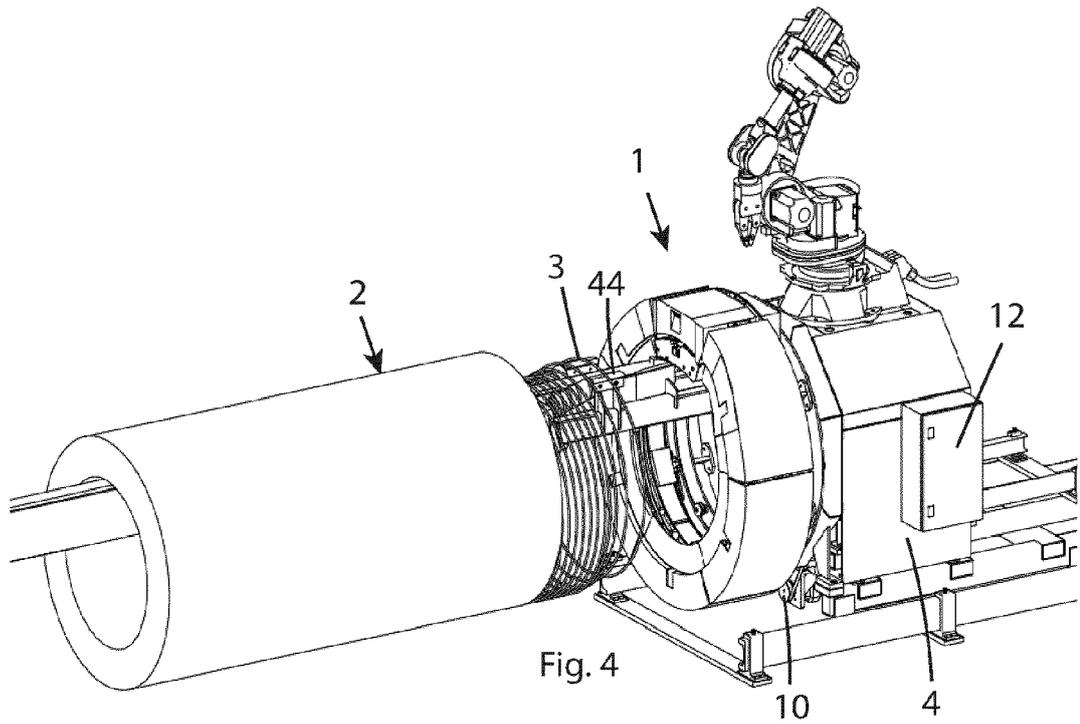


Fig. 3



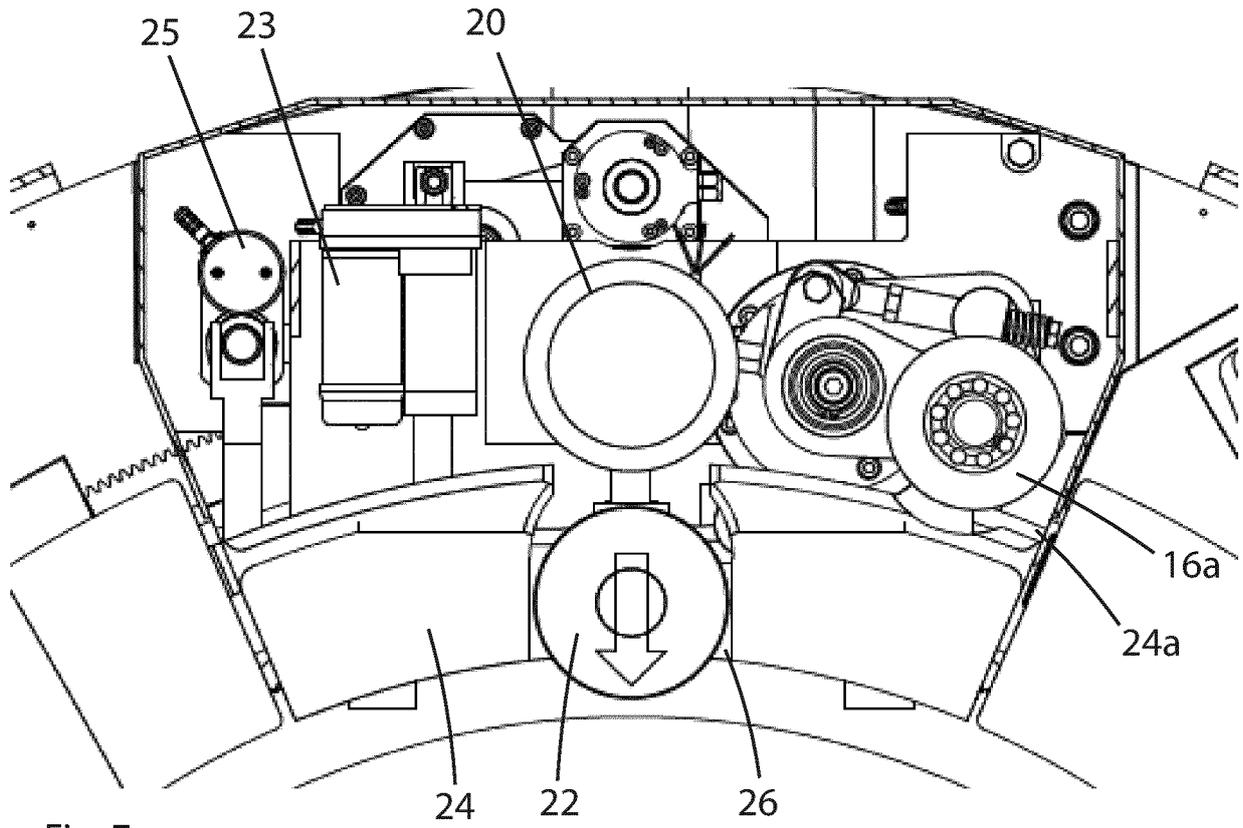


Fig. 7a

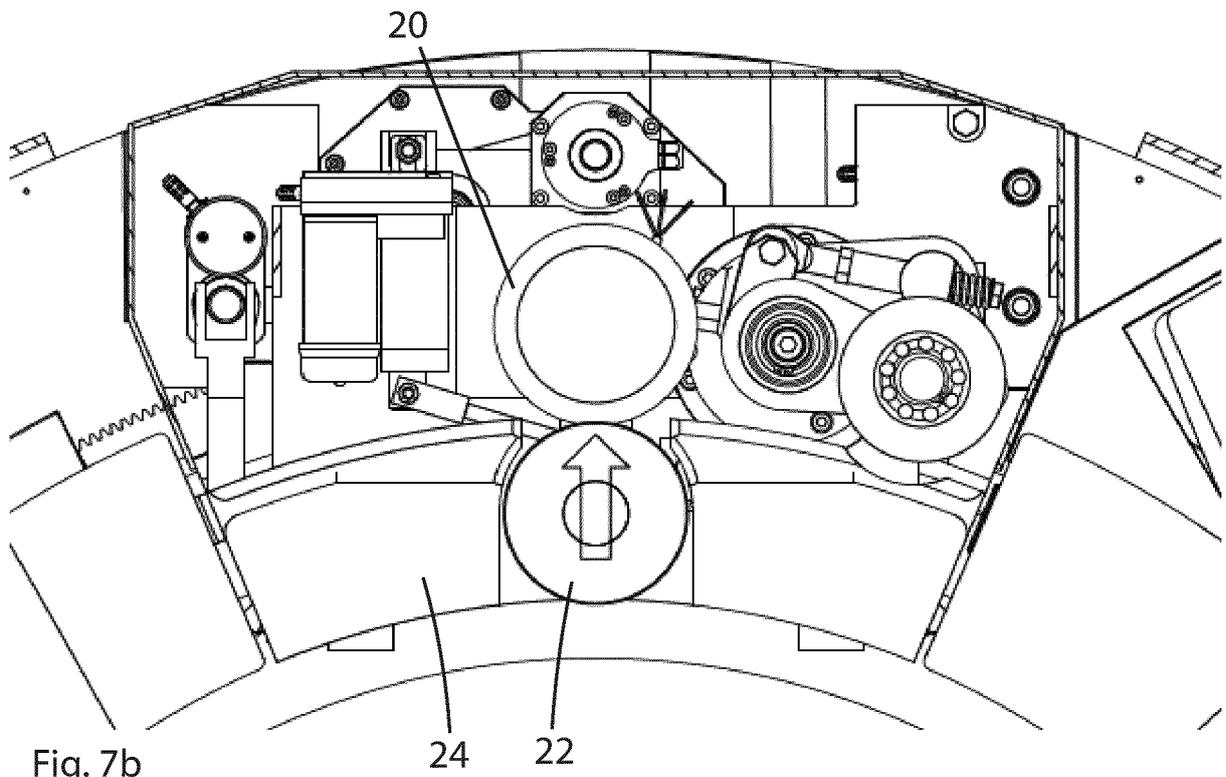


Fig. 7b

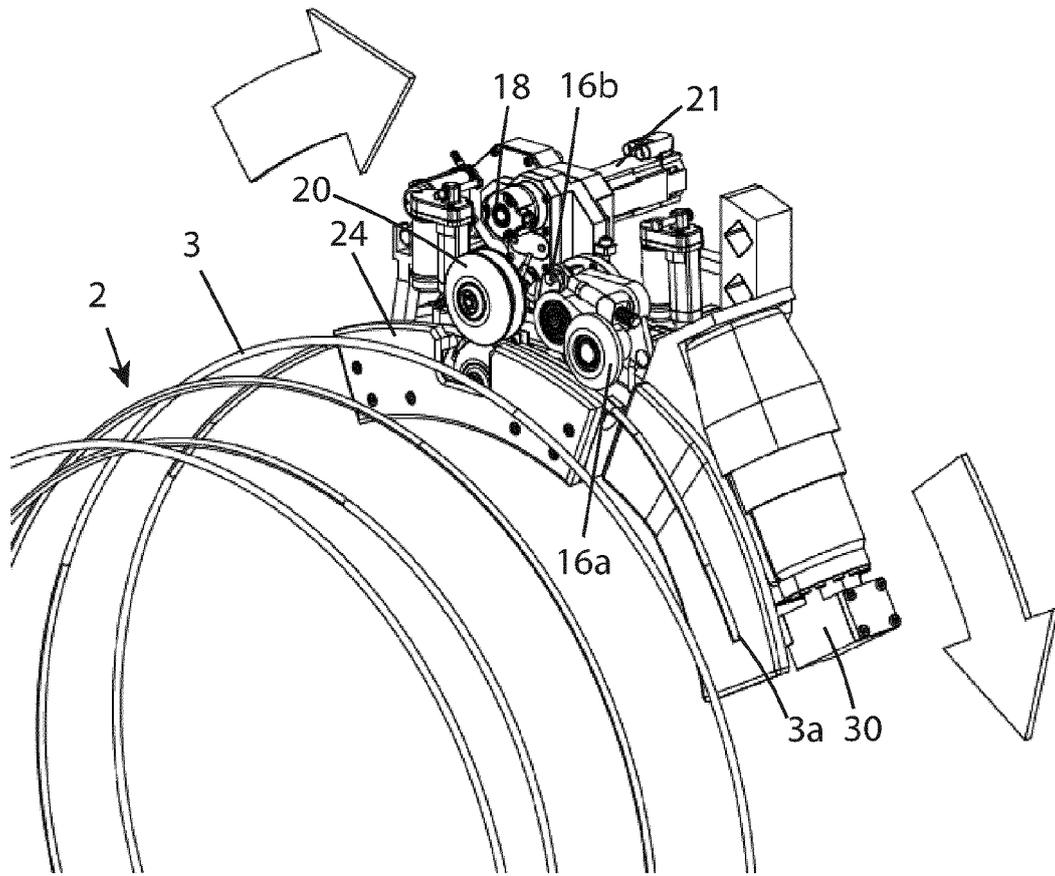


Fig. 8

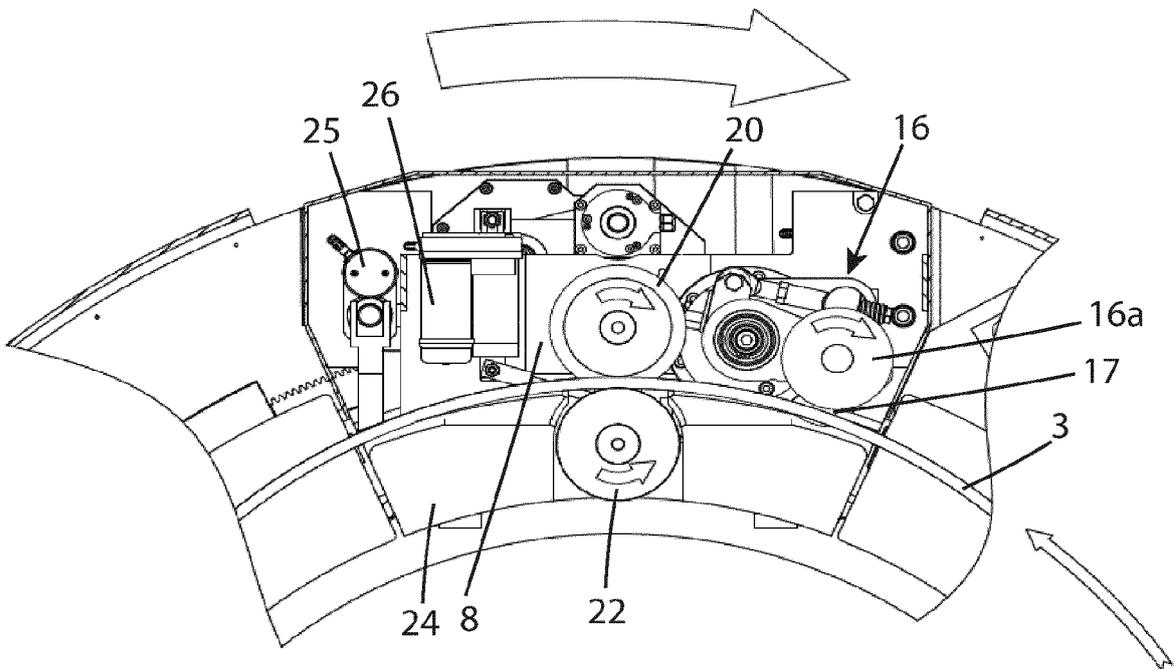


Fig. 9

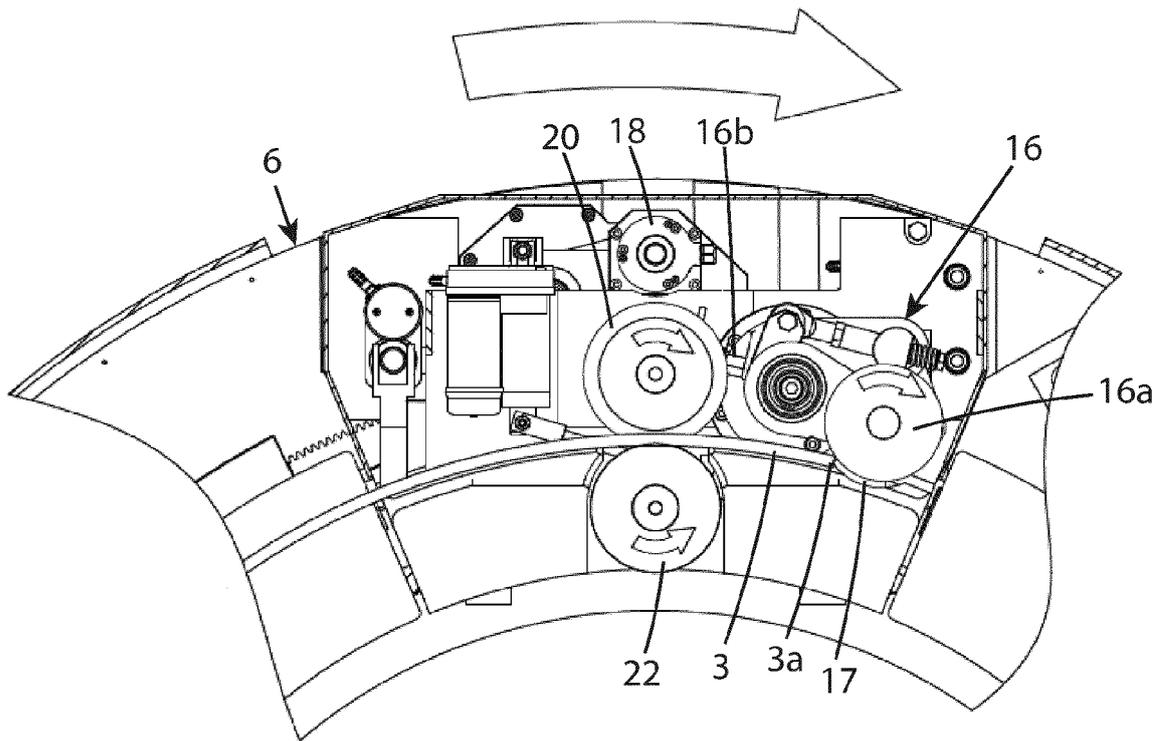


Fig. 10

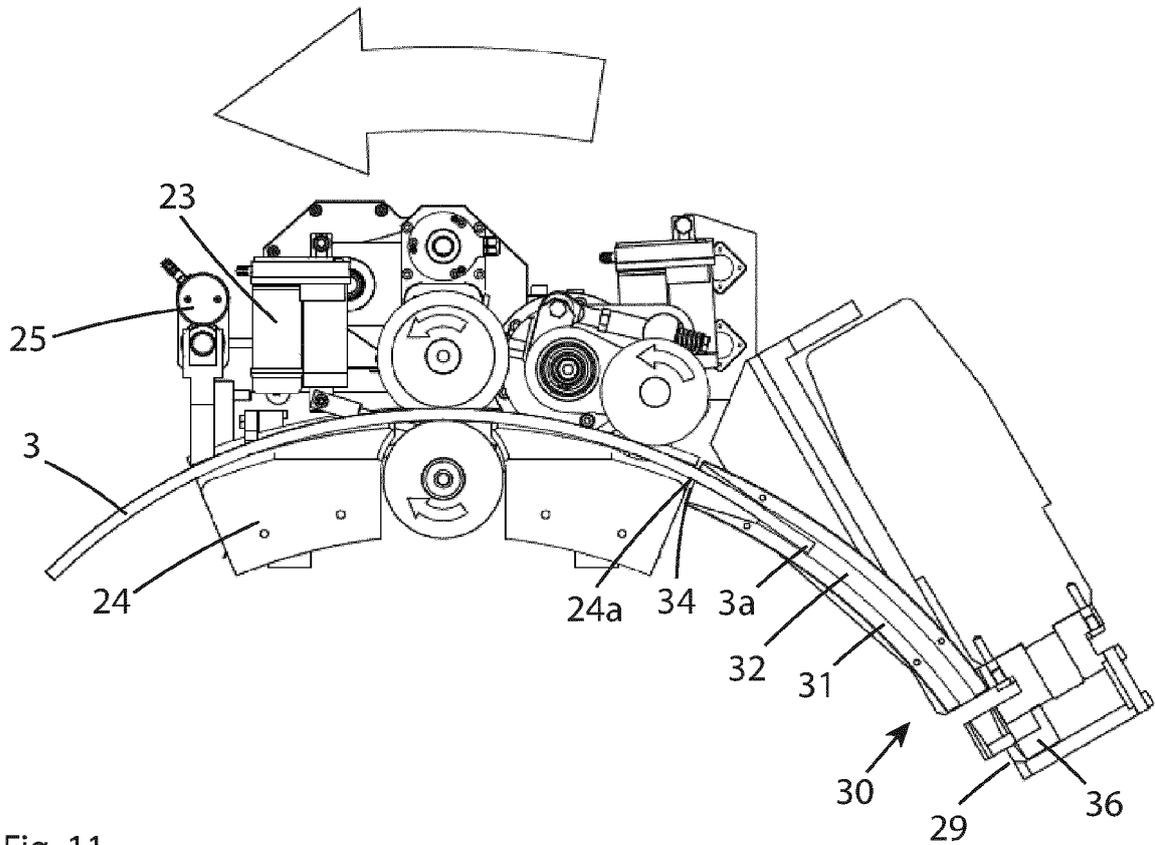


Fig. 11

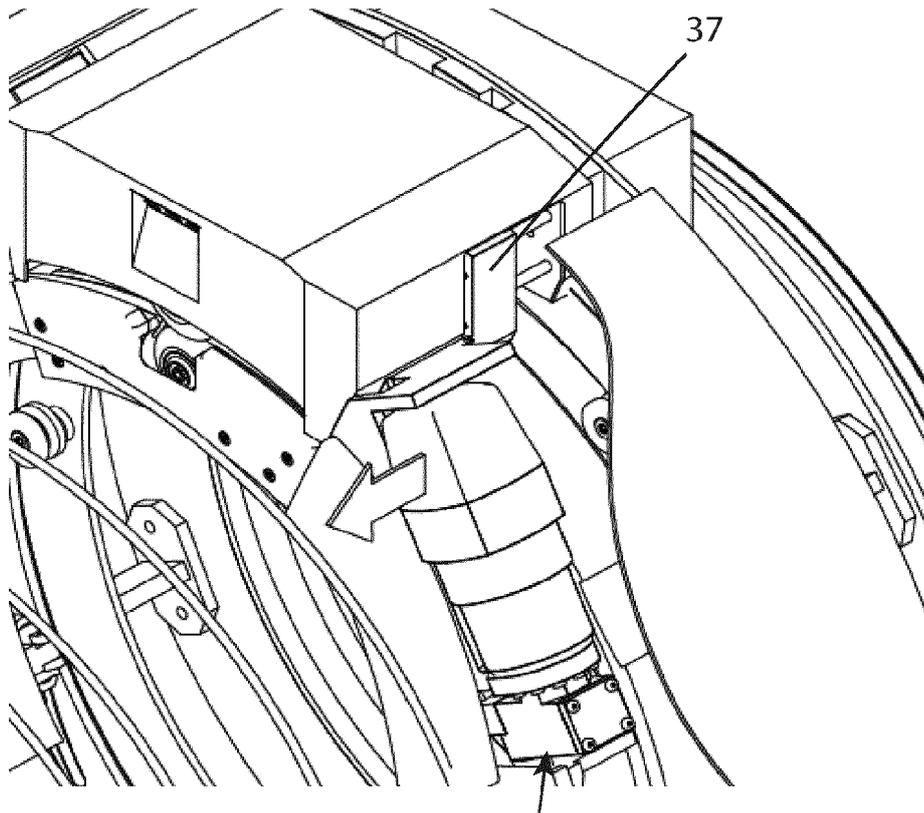


Fig. 12a

30

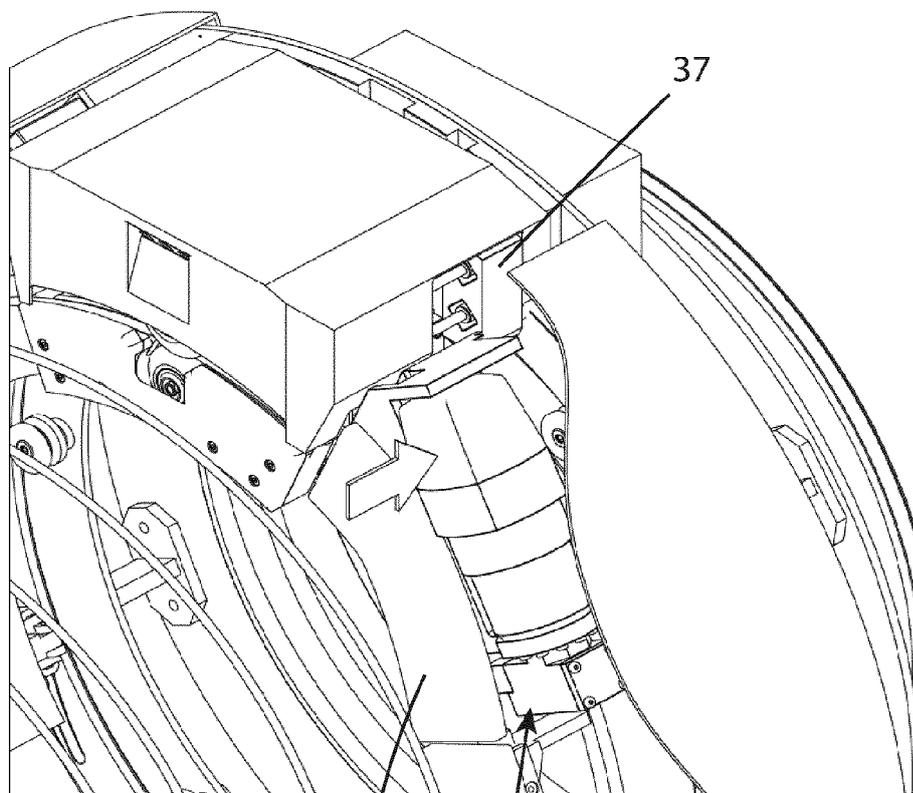


Fig. 12b

31

30

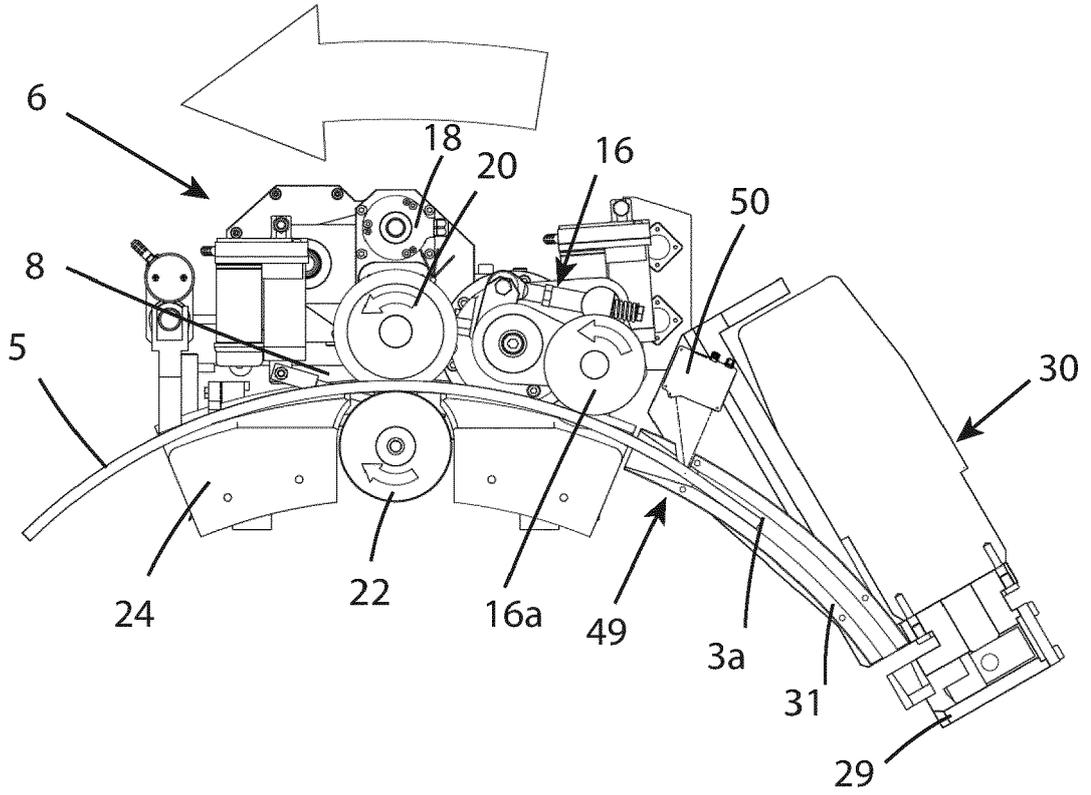


Fig. 13

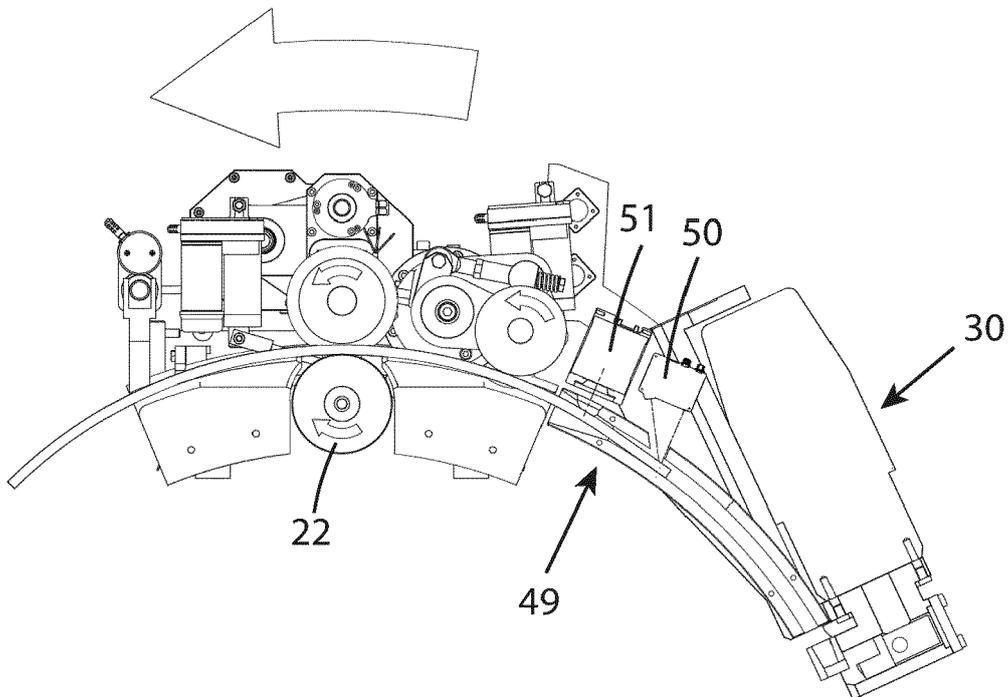


Fig. 14

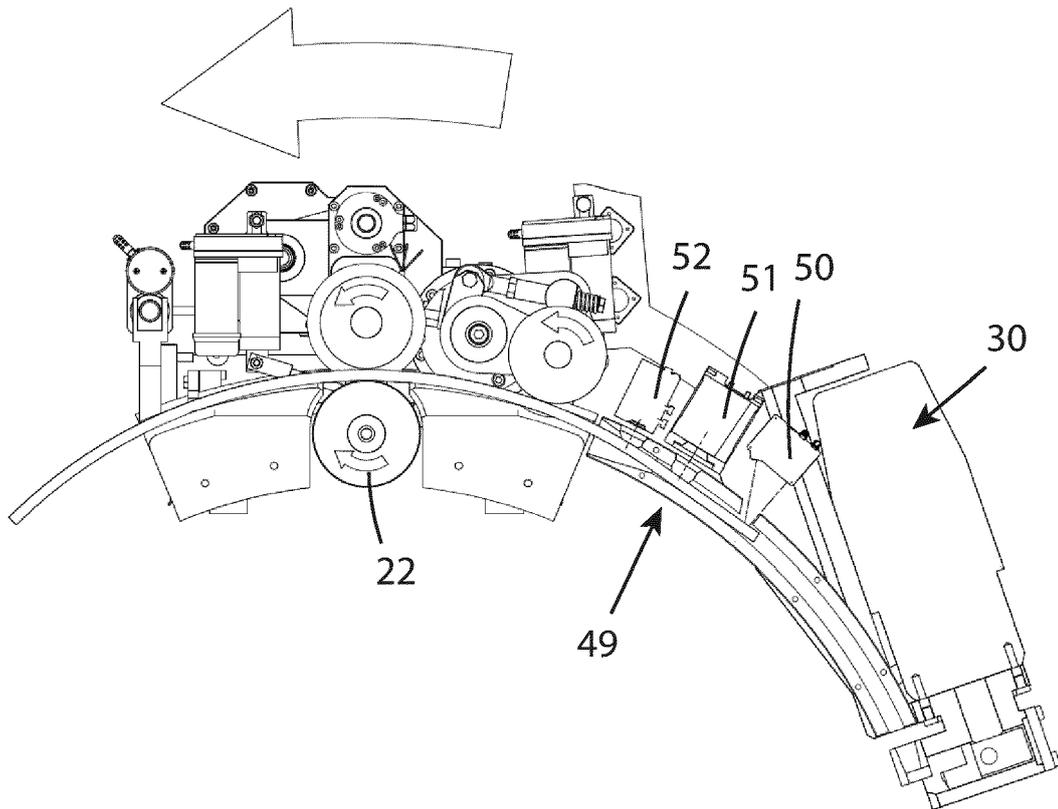


Fig. 15



EUROPEAN SEARCH REPORT

Application Number

EP 22 17 3287

5

10

15

20

25

30

35

40

45

50

55

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A, D	US 2019/291169 A1 (TEEGAVAPU SUDHAKAR [US] ET AL) 26 September 2019 (2019-09-26) * figures *	1-15	INV. B21C47/26 B21F11/00 B21C51/00
A, D	EP 0 992 298 A2 (SCHLOEMANN SIEMAG AG [DE]) 12 April 2000 (2000-04-12) * figures *	1-15	
A, D	GB 2 047 597 A (KRUPP GMBH) 3 December 1980 (1980-12-03) * figures *	1-15	
A	DE 29 28 497 A1 (KRUPP GMBH) 29 January 1981 (1981-01-29) * figures *	1-15	
A	KR 2014 0050384 A (POSCO [KR]) 29 April 2014 (2014-04-29) * figures *	1-15	
E	EP 4 008 447 A1 (ROMITEK LLC [US]) 8 June 2022 (2022-06-08) * figures *	1-15	TECHNICAL FIELDS SEARCHED (IPC) B21C B21F
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 26 October 2022	Examiner Charvet, Pierre
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

1
EPO FORM 1503 03:82 (F04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.

EP 22 17 3287

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

26-10-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2019291169 A1	26-09-2019	NONE	

EP 0992298 A2	12-04-2000	AT 258474 T	15-02-2004
		DE 19846101 C1	31-08-2000
		EP 0992298 A2	12-04-2000
		US 6227091 B1	08-05-2001

GB 2047597 A	03-12-1980	CA 1130699 A	31-08-1982
		DE 2915716 A1	23-10-1980
		ES 487739 A1	16-06-1980
		FR 2454343 A1	14-11-1980
		GB 2047597 A	03-12-1980
		IT 1141459 B	01-10-1986
		JP S55141326 A	05-11-1980
		US 4302994 A	01-12-1981

DE 2928497 A1	29-01-1981	NONE	

KR 20140050384 A	29-04-2014	NONE	

EP 4008447 A1	08-06-2022	EP 4008447 A1	08-06-2022
		WO 2022117584 A1	09-06-2022

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- US 20190291169 A [0005]
- EP 0992298 A2 [0005]
- GB 2047597 A [0005]
- KR 101568593 B1 [0005]