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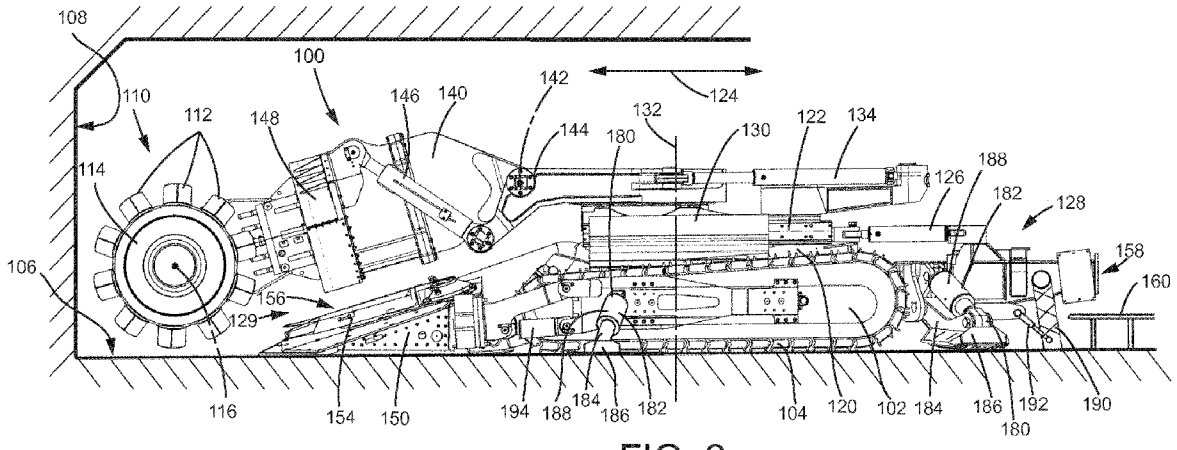

FIG. 2

(57) Abstract: A machine (100) for cutting material includes an undercarriage (102) including propulsion device for propelling the machine (100) and a cutter head (110) disposed on a tool support and positioning assembly (120) movably supported by the undercarriage (102) to remove material from a cutting surface (108). The machine (100) further includes a plurality of ground-engaging devices (180, 190) connected to the undercarriage (102) that can be simultaneously raised and lowered with respect to a ground floor (106). Examples of ground-engaging devices include stabilizers (180) for stabilizing the machine (100) when milling or cutting material and a load shield (190) that prevents material from scattering underneath the machine (100).

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Description

MACHINE AND METHOD OF CUTTING MATERIAL

Technical Field

This patent disclosure relates generally to a machine configured for cutting material and the like and, more particularly, to a system and method for controlling components on the machine used to engage the ground surface.

Background

Mobile machines may be configured for above or underground operation to perform excavation, tunneling, or underground mining. Such machines may have a low profile design and include an undercarriage with continuous tracks or similar propulsion devices to transport the machine about the underground worksite. To perform a cutting or milling operation, a rotary cutter head is disposed on a tool support and positioning assembly supported by the undercarriage. The cutter head can be a circular, drum-like structure that supports a plurality of cutting tools about its circular periphery. The cutting tools themselves may be forcibly rotated with respect to the periphery of the cutter head and include bits made of tungsten carbide, synthetic diamond, or similar hard substances to dislodge and chip material away from the cutting surface or wall. The tool support and positioning assembly can be configured to move the cutter head in multiple directions to make passes or sweeps with respect to the cutting surface removing successive layers of material from the cutting surface.

It can be appreciated that as the cutter head is swept across the cutting surface during the cutting or milling operation, the machine may experience resistive vibrations and reaction forces, especially when milling hard materials such as rock. Therefore, to provide stabilization and support, the machine may be configured with extendable and retractable ground-engaging devices that can be extended to engage the ground floor of the worksite. One

example of such extendable and retractable ground-engaging devices is described in U.S. Patent No. 8,979,209 ("the '209 patent"), which describes an underground machine having a plurality of stabilizers with hydraulically powered leveling and support actuators. When the machine is positioned to perform a cutting or milling operation, the leveling and support actuators are extended to engage both the tunnel floor and tunnel roof to brace and support the machine. The current disclosure is directed to a machine configured with similar extendable and retractable ground engaging devices to stabilize and support the machine and facilitate the operation.

Summary

The disclosure describes, in one aspect, a machine for aboveground or underground cutting or milling of material such as in excavation, mining or tunneling. The machine includes an undercarriage having first and second propulsion devices for propelling the machine about a worksite. To remove material from a cutting surface, the machine includes a cutter head disposed on a tool support and positioning assembly that has a cutter boom slidably disposed over the undercarriage. The machine also includes a plurality of ground-engaging devices that are extendable and retractable from the undercarriage to engage a ground floor. The plurality of ground-engaging device can be configured to be extended and retracted simultaneously through an electronic control system operatively associated with the machine.

The disclosure describes, in another aspect, a method for underground cutting of material by positioning a machine proximate to a cutting surface. To brace the machine when cutting material, a plurality of ground-engaging devices retractably attached to an undercarriage of the machine are simultaneously extended toward the ground floor. A cutter head disposed on a cutter boom disposed on the front of the machine is moved toward a cutting surface to remove material from the cutting surface. After making one or passes with respect to the cutting surface, the cutter head is retracted with respect to the

cutting surface and the plurality of ground-engaging devices are simultaneously retracted with respect to the undercarriage so that the machine can be trammed to a new position.

In yet another aspect, the disclosure describes a machine that includes an undercarriage supported on first and second propulsions devices to propel the machine. The machine also includes a cutter head disposed on a tool support and positioning assembly supported on the undercarriage. A plurality of stabilizers are included that can extend and retract with respect to the undercarriage to contact a ground floor to support the machine when cutting material. In addition, a load shield that is also extendably and retractably attached to the undercarriage can extend to engage to the ground floor. An electronic control system has a switch for simultaneously extending and retracting the plurality of stabilizers and the load shield.

Brief Description of the Drawings

Figure 1 is a front perspective view of an embodiment of a machine configured for cutting material having a rotary cutter head movably supported on an undercarriage with continuous tracks for transporting and tramming the machine with respect to a cutting surface.

Figure 2 is a side elevational view of the machine in an underground worksite or tunnel and having a plurality of extendable and retractable ground-engaging devices extended to engage the ground floor.

Figure 3 is a schematic representation of a remote control for remotely operating the machine including switches and dials for operating the extendable and retractable ground-engaging devices.

Figure 4 is a schematic representation of the toggle switch on the remote control for extending and retracting the ground-engaging devices taken through line 4-4 of Figure 5.

Figure 5 is a flowchart or logic diagram illustrating an embodiment of a routine or process for operating the ground-engaging devices during a milling or cutting operation by the machine.

Detailed Description

Now referring to the drawings, wherein like reference numbers refer to like elements, there is illustrated in FIGS. 1 and 2 a mobile or movable machine 100 configured for aboveground or underground operation such as excavation, tunneling, or underground mining. The machine 100 may be relatively large, on the order of several meters in length, and may be intended to remove material in quantities sufficient to create workspaces that are meters high and wide. To propel or transport the machine 100 about the underground worksite, the machine 100 can include an undercarriage 102 configured with a plurality of continuous tracks 104 disposed on opposite sides of the machine 100 that can propel the machine 100 in the forward or reverse directions as well as turn the machine 100 side-to-side. As shown in FIG. 2, the continuous tracks 104 translate as a closed loop or belt with respect to the ground floor 106 to position the machine 100 with respect to a cutting surface or wall 108 from which material such as rock is to be removed. While the illustrated embodiment includes two continuous tracks 104, other embodiments may include any suitable number of continuous tracks 104 or may utilize different propulsive drive mechanisms such as wheels.

To cut or mill material from the cutting surface 108, the machine 100 includes a cutter head 110 having a plurality of cutting tools 112 disposed about its radial periphery. The cutter head 110 can include a drum structure 114 that can be made to forcibly rotate about a cutter head axis 116, thereby revolving the cutting tools 112 with respect to the cutting surface 108. The cutting tools 112 can be supported in corresponding sockets disposed in the drum structure 114 and, in an embodiment, can be made to forcibly rotate or spin within the drum structure 114 for increased cutting action. To impact and dislodge material from

the cutting surface 108, a plurality of bits 118 can be disposed about the exterior surface of the cutting tools 112. The bits 118 can be made of tungsten carbide, polysynthetic diamond, or a similar material having good hardness characteristics. As the bits 118 wear down, the cutting tools 112 may be removed from the cutter head 110 and replaced.

To move the cutter head 110 in passes or sweeps with respect to the cutting surface 108, the cutter head 110 can be supported on a tool support and positioning assembly 120 that is configured to move or pivot in multiple directions or about various axes. For example, to feed the cutter head 110 into the cutting surface 108 or to retract the cutter head 110 from the cutting operations 108, the tool positioning and support assembly 120 includes a cutter boom 122 that is slidably disposed on the undercarriage 102 to laterally translate in the forward and rearward directions along a boom axis 124 indicted by the double-headed arrow. The cutter boom 122 can be generally supported over the continuous tracks 104 on rails or the like to enable translation with respect to the undercarriage 102. To cause the cutter boom 122 to translate along the forward and rearward directions along a boom axis 124, the cutter boom 122 can be operatively associated with one or more hydraulic actuators, specifically a boom actuator 126. The boom actuator 126 can be located on a rear portion 128 of the machine 100 and arranged to slide the cutter boom 122 to feed and retract the cutter head 110 disposed at the front portion 129 of the machine 100. In an embodiment, the travel distance of the cutter boom 122 between a fully extended position toward the front portion 129 of the machine 100 and a fully retracted position toward the rear portion 128 may be about a meter or more.

To cause the cutter head 110 to sweep in a side-to-side motion, the tool support and positioning assembly 120 can include a swing platform 130 such as a pivot table or the like supported on the cutter boom 122 that pivots the cutter head 110 with respect to the undercarriage 102. Actuation of the swing platform 130 moves the cutter head 110 horizontally in an arc about the vertically

orientated swing axis 132. To actuate the swing platform 130, the swing platform 130 can be operatively associated with hydraulic actuators or swing actuators 134 that are connected to either side of the swing platform 130 and to the cutter boom 122. Extension of one swing actuator 134 and retraction of the other will rotate the swing platform 130 though a horizontal plane about the swing axis 132.

To vertically raise and lower the cutter head 110 with respect to the ground floor 106 and cutting surface 108, the tool support and positioning assembly 120 can include a cantilevered lift arm 140 disposed on the swing platform 130. The cantilevered lift arm 140 can pivot the cutter head 110 along the horizontally extending tilt axis 142 that may be parallel with the cutter head axis 116. In particular, the cantilevered lift arm 140 extends over the front portion 129 of the machine 100 and has a hinge or pivot joint 144 that articulates the forward part of the cantilevered lift arm 140 in an up-and-down motion. To actuate the cantilevered lift arm 140, another hydraulic actuator or lift actuator 146 can be operatively arranged on the cantilevered lift arm 140 to articulate the pivot joint 144. In a further possible embodiment, to twist or roll the cutter head 110, the distal end of the cantilevered lift arm 140 can be configured with a roll joint 148 that rolls or rotates the cutter head axis 116 with respect to the rest of the machine 100.

Hence, the tool support and positioning assembly 120 is capable of moving the cutter head 110 in variety of directions and through a range of motions to facilitate making cutting or milling passes with respect to the cutting surface 108. The hydraulic actuators that serve as the boom actuator 126, swing actuator 134, and lift actuator 146 can be configured as double acting hydraulic cylinders with telescoping pistons that extend and retract from the cylinder body. However, in other embodiments of the machine 100, one or more of the hydraulic actuators may be replaced with other hydraulic devices or with electric motors or the like.

Because the cutter head 110 is disposed over the front portion 129 of the machine 100, the material it removes from the cutting surface 108 will gather in front of the machine 100 and can hinder further milling or cutting operations. To remove the gathered material, the front portion 129 of the machine 100 can be equipped with a gathering head or gathering frame 150 that extends across the width of the machine 100 below the cutter head 110 proximate to the ground floor 106. The gathering frame 150 can be configured to scoop the material from the ground floor 106 and may be designed to adjustably span the width of the ground floor 106 between opposing gathering wings 152 that can adjustably extend outwards from the sides of the machine 100.

To remove the material collected by the gathering frame 150, a conveyer 154 in the form of a translating belt is disposed through the machine 100 that passes the material from the front portion 129 through to the rear portion 128 of the machine 100. The conveyer entrance 156 can be an opening centrally disposed in the skirt of the gathering frame 150 with the conveyer 154 extending lengthwise through the machine 100 above the undercarriage 102 to the conveyer exit 158 located at the rear portion 128 of the machine 100. To direct the material to the conveyer 154, the gathering frame 150 can include gathering arms 159 that pivotally sweep across the surface of the gathering frame 150 toward the conveyer entrance 156. Referring to FIG. 2, during the cutting or milling operation, to remove material discharged at the conveyer exit 158, a secondary conveyer system 160, separate from the machine 100 can be positioned proximate to the rear portion 128 of the machine 100 that extends to the entrance of the worksite. Accordingly, the machine 100 and the secondary conveyer system 160 are configured to continuously remove material from the worksite. In an alternative embodiment, instead of a separate conveyer system 160, carts may be used to carry the material away.

Because the machine 100 may be intended for underground work where exhaust from internal combustion engines would be unacceptable,

referring to FIG. 1, the machine 100 can be equipped with one or more electric motors 170 that provide power. A remote power source, such as a generator, can provide three-phase electrical power to the electric motors 170 via cables. In the embodiments in which the continuous tracks 104 and hydraulic actuators of the tool support and positioning assembly 120 are hydraulically operated, a hydraulic system 172 including a hydraulic pump and a hydraulic fluid reservoir can be operatively associated with the electrical motors 170 to generate fluid pressure for operation. To further facilitate the milling or cutting operation, the machine 100 can be equipped with one or more hydraulically extendable and retractable devices that are operatively associated with the hydraulic system 172. For example, the machine 100 can include ground-engaging devices retractably attached to the undercarriage 102 that can be hydraulically extended to contact the ground floor 106.

Referring to FIG. 2, as a more specific example, to stabilize and support the machine 100 during a cutting or milling operation as the cutter head 110 is fed into the cutting surface 108, the machine 100 can include one or more stabilizers 180. In the illustrated embodiment, four stabilizers 180 can be retractably attached to the undercarriage 102 proximate to the corners of the machine 100. The stabilizers 180 can include a hydraulic actuator designated as a stabilizer actuator 182 that extends and retracts a stabilizer leg 184 attached at its distal end to a ground pad 186. During the milling or cutting operation, the stabilizer leg 184 is extended so that the ground pad 186 contacts the ground floor 106 and braces the machine 100. However, if the cutter head 110 must be repositioned with respect to the cutting surface 108, the stabilizers 180 can be retracted lifting the ground pads 186 so the continuous tracks 104 can move the machine 100 with respect to the ground floor 106. For example, the feed distance the cutter boom 122 can move with respect to the boom axis 124 is fixed and after the cutter boom 122 has been fully extended, the machine 100 needs to be repositioned with respect to the cutting surface 108 to perform the next milling or

cutting operation. The process of repositioning the machine 100 with respect to the cutting surface 108 between successive milling or cutting operations may be referred to as tramming the machine 100.

In an embodiment, the stabilizers 180 can operate individually and autonomously from each other. Specifically, each stabilizer 180 can include a pressure sensor 188 monitoring hydraulic pressure in the stabilizer actuator 182 and that is operatively configured to cease extension of the stabilizer leg 184 if the monitored pressure exceeds a pressure threshold, indicating that the stabilizer has firmly engaged the ground floor 106. Accordingly, even if the ground floor 106 is uneven, each stabilizer 180 extends to a coordinated distance to assist in leveling the machine 100 with respect to the ground floor 106.

As another example of a ground-engaging device may be a load shield 190 disposed on the rear portion 128 of the machine 100 proximately below the conveyer exit 158. The load shield 190 can prevent the material discharged from the conveyer exit 158 from scattering underneath the undercarriage 102 and can assist directing the discharged material to the secondary conveyer system 160. In an embodiment, the load shield 190 can be a flat plate connected perpendicularly to the undercarriage 102 and that extends proximately the width of the machine 100. To lower the load shield 190 to contact the ground floor 106 during a milling or cutting operation, and to raise the load shield 190 during tramming, a hydraulically actuated shield actuator 192 can be operatively connected to pivotally swing the load shield 190 underneath the undercarriage 102. In other embodiments, however, the load shield 190 may be raised and lowered by other methods. As a further example of a ground-engaging device, in an embodiment the gathering frame 150 may be connected to the undercarriage 102 by one or more frame actuators 194. The frame actuators 194 can lower the gathering frame 150 to the ground floor 106 during a milling or cutting operation and can raise the gathering frame 150 when tramming.

The stabilizer actuators 182 associated with the stabilizers 180 and the shield actuator 192 associated with the load shield can also be configured as double acting hydraulic cylinders with telescoping pistons that extend and retract from the cylinder body. It should be appreciated that operation of the hydraulic actuators is not instantaneous and that extension and retraction may require time to occur.

To control operation of the machine 100, an electronic control system 200 can be included as shown in FIG. 1. The electronic control system 200 can have any suitable computer architecture and can be in electronic communication with the various components and systems on the machine 100 to send and receive electronic signals in digital or analog form that enable the electronic control system 200 to monitor and regulate the operations and functions of the machine 100. The electronic control system 160 may execute and process functions, steps, routines, control maps, data tables, charts, and the like saved in and executable from computer readable and writable memory or another electronically accessible storage medium to control the machine 100. To perform these functions and operations, the electronic control system 200 can be configured as a microprocessor, an application specific integrated circuit (ASIC), or other appropriate circuitry and may have memory or other data storage capabilities. The memory can include any suitable type of electronic memory devices such as random access memory ("RAM"), read only memory ("ROM"), dynamic random access memory ("DRAM"), flash memory and the like. Although in the schematic representation of FIG. 1, the electronic control system 200 is represented single, discrete unit, in other embodiments, the electronic control system 200 and its functions may be distributed among a plurality of distinct and separate components.

In an embodiment, the machine 100 may be remotely operated through the electronic control system 200. As illustrated in FIG. 1, a remote control 202 can be in communication with the electronic control system 200 to

send and receive operation signals that direct operation of the machine 100. Accordingly, an operator can stand away from the machine 100 while controlling its operations via the remote control 202. Communication between the electronic control system 200 and the remote control 202 may be wireless, i.e., via radio signals or other electromagnetic technology, or may be conducted through control cables. As described more fully below, in an embodiment, the electronic control system 200 and the remote control 202 may be configured for either or both automated or automatic control and operator or manual control of the machine 100.

Referring to FIG. 3 in addition to FIGS. 1 and 2, the remote control 202 can be configured with various dials, switches, and controls to interface with the electronic control system 200. For example, the remote control 202 can include a first multi-directional joystick 204 that selectively operates the continuous tracks 104 on the undercarriage 102 to position the machine 100. A second multi-directional joystick 206 can be used to selectively control the tool support and positioning system 120 to orientate and operate the cutter head 110 during a milling or cutting operation. In addition to the foregoing, the remote control 202 can include a display screen 208 such as a liquid crystal display to provide operational information regarding the machine 100.

To extend the stabilizers 180 prior to initiating a milling or cutting operation, the remote control can include a toggle switch 210 that includes a mechanical lever that can be moved to various positions to selectively actuate the stabilizer actuators 182. In an embodiment, the toggle switch 210 can have a multi-throw configuration with the mechanical lever 211 movable between an extend position 212 to extend the stabilizers 180 to the ground floor 106, a retract position 214 to retract the stabilizers 180 with respect to the undercarriage 102, and a neutral position 216 in which the stabilizers 180 remain locked in their extended or retracted position. In a further embodiment, the toggle switch 210 can be configured as a normally opened circuit that requires the mechanical lever

211 of the trigger switch 210 be held in the selected position to continue actuation of the stabilizers 180, and will bias the mechanical lever back to the neutral position 216 and cease actuation upon release. In other embodiments, the toggle switch 210 can be configured as a single-throw or single action switch in which the selected actuation of the stabilizers will continue upon release of the mechanical lever 211.

In a further embodiment, illustrated in FIG. 4, the toggle switch 210 may be configured with a counter or detents that switches between ceasing activity upon release and acting as a single-throw switch. For example, the mechanical lever 211 may be normally biased to a central, upright orientation corresponding to the neutral position 216. If the mechanical lever 211 is partially toggled or pivoted in one direction or the other, it may enter the extended position 212 or retracted position 214 where it functions as a normally opened circuit such that release of the mechanical lever 211 biases it back into the neutral position breaking the circuit and ceasing movement of the ground-engaging devices. However, if the mechanical lever 211 is pushed or toggled further into the extend or retract positions 212, 214, it may physically slide past the detents 220 formed in the slot of the toggle switch 210 into an auto-extend position 222 or an auto-retract position 224. In the auto-extend and auto-retract positions 222, 224, extension or retraction of the ground-engaging devices continues automatically even upon release of the mechanical lever 211, similar to a single-throw configuration. The electrical contacts within the body of the toggle switch 210 can be arranged to recognize the separate positions. The detents 220 may provide a tactile indication that the mechanical lever 211 has been toggled into the auto-extend and auto-retract positions 222, 224. To selectively cease extension or retraction of the ground-engaging devices, the mechanical lever 211 may be toggled past the detents 220 in the opposite direction. In another embodiment, cessation of the extension or retraction of the ground-engaging devices can be directed by moving the mechanical lever 211 of the toggle switch 210 in the

opposite direction through the neutral position 216 and into the respective extend or retract positions 212, 214 but before sliding past the detents 220 and into the auto-extend or auto-retract positions 222, 224.

In an embodiment, the machine 100 can be configured with different operating modes selectable via a mode switch or mode dial 220 illustrated in FIG. 3. For example, to move and position the machine 100 at the underground worksite, the mode dial 230 can be turned to a positioning mode 232 that enables operation of the continuous tracks 104 but prevents actuation of the cutter head 110 and tool support and positioning assembly 120. The positioning mode 232 may also be selected to tram the machine 100 and move the cutter head 110 proximate to the cutting surface 108 between successive milling or cutting operations. To conduct a milling or cutting operation, the mode dial 230 can be turned to a cutting mode 234 that enables operation of the cutter head 110 and tool support and positioning assembly 120 but prevents engagement of the continuous tracks 104 to avoid unintentional reorientation of the machine 100. When the cutting mode 234 is selected, the remote control 202 in cooperation with the electronic control system 200 can confirm that the stabilizers 180 have been extended to stabilize the machine 100 prior to initiating the operation or cutting operation.

It should be appreciated that in an alternative embodiment, the machine 100 may not be configured for remote operation. In such an embodiment, the machine 100 may include an operator station that can accommodate a operator and where a number of the foregoing controls can be accessed for operating the machine, including the toggle switch 210 for raising and lowering the ground-engaging devices and the mode dial 220 for selecting the operating mode of the machine 100.

Industrial Applicability

Referring to FIG 4, there is illustrated a process 300 for operating the machine 100 that can be conducted through a plurality of steps executed by

the electronic control system 200 in conjunction with the remote control 202. The process 300 can be embodied as software including instructions and commands written in computer-executable programming code. The process 300 illustrated in FIG. 5 may be specifically intended to regulate and control operation of the extendable and retractable ground-engaging devices. Referring to FIGS. 1-4, in an initialization step 302, the process 300 can initialize the remote control 202 to communicate operation signals to and from the electronic control system 200 on the machine 100. Once initialized, operation of the machine 100 can occur through use of the remote control 202.

For example, the process 300 may execute a monitoring step 304 that monitors or senses the position of the toggle switch 210 on the remote control 202. If, in a subsequent toggle position determination step 306, the process 300 determines the toggle switch 210 has been moved to the extend position 212 indicating that an operator intends to extend the stabilizers 180 to perform a milling or cutting operation, the remote control 202 communicates an extend command 310 to the electronic control system 200. The extend command 310 directs the stabilizer actuators 182 to extend the stabilizers 180 with respect to the undercarriage 102 (extend stabilizers 312). Because the operation will likely be conducted with the conveyer 154 operating, the extend command 310 can also act to extend the load shield 190 concurrently by appropriately directing operation of the shield actuator 192 (extend shield 314). The extend command 310 thereby ties, couples, or latches two operations of the ground-engaging devices together.

If the position determination step 306 instead determines that the toggle switch 210 has been moved to the retract position 214, for example to tram the machine 100, the remote control 202 can communicate a retract command 320 to the electronic control system 200. The retract command 320 directs the stabilizer actuators 182 to retract the stabilizers 180 with respect to the ground floor 106 (retract stabilizers 322). Similarly, the retract command 320 can also

function to concurrently retract the loading shield 190 (retract shield 324). Hence, the extend command 310 and the retract command 320 simultaneously operate both the stabilizer actuators 182 and the shield actuator 192, thereby reducing the actions taken with respect to the remote control 202. In the embodiments where the gathering frame 150 can be selectively positioned, the extend command 310 and the retract command 320 can simultaneously activate the appropriate action of the frame actuator 194. In a further embodiment, the process 300 can return to a neutral state 328 to maintain the current position of the ground-engaging devices then repeat itself to determine if the position of the ground-engaging device should be changed.

In another embodiment, the process 300 can execute a monitoring step 329 to monitor selection of the mode dial 230 to determine which operating mode has been selected. The process further executes a mode determination step 330 that can couple operation of the extendable and retractable ground-engaging devices to the selected operating mode of the machine 100. For example, if the mode dial 230 is turned to the positioning mode 232, possibly indicating that the machine 100 is about to tram to reposition the cutter head 110, the remote control 202 can communicate a tram command 332 to the electronic control system 200. To prepare for tramming, the tram command 332 can activate the stabilizer actuators 182 to retract the stabilizers 180 with respect to the ground floor 106 (retract stabilizers 334) so the stabilizers 180 do not obstruct tramming of the machine 100. The tram command 332 can simultaneously activate the shield actuator 192 to retract the load shield 190 (retract shield 336) and disengage from the ground floor 106. Hence, the tram command 332 ties operation of the stabilizers 180 and load shield 190 together.

Likewise, if the mode determination step 330 determines the mode dial 230 is turned to the cutting mode 234, the remote control 202 can communicate a cutting command 342 to the electronic control system 200 concurrently and simultaneously extending the stabilizers 180 (extend stabilizers

344) and the load shield 190 (extend load shield 346) to contact the ground floor 106. Hence, the stabilizers 180 brace the machine 100 and the load shield 190 is appropriately set at the start of the milling or cutting operation. Again, in the embodiments where the gathering frame 150 is movable, the retract and extend commands can direct appropriate actuation of the frame actuator 194. The process 300 can proceed to a neutral state 348 similar to that described above. A possible advantage of the mode determination step 330 is that it ensures the extendable and retractable ground-engaging devices are properly situated before the respective operation of the machine may be commenced.

It will be appreciated that the foregoing description provides examples of the disclosed system and technique. However, it is contemplated that other implementations of the disclosure may differ in detail from the foregoing examples. All references to the disclosure or examples thereof are intended to reference the particular example being discussed at that point and are not intended to imply any limitation as to the scope of the disclosure more generally. All language of distinction and disparagement with respect to certain features is intended to indicate a lack of preference for those features, but not to exclude such from the scope of the disclosure entirely unless otherwise indicated.

Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context.

The use of the terms “a” and “an” and “the” and “at least one” and similar referents in the context of describing the invention (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The use of the term “at least one” followed by a list of one or more items

(for example, "at least one of A and B") is to be construed to mean one item selected from the listed items (A or B) or any combination of two or more of the listed items (A and B), unless otherwise indicated herein or clearly contradicted by context.

Accordingly, this disclosure includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the disclosure unless otherwise indicated herein or otherwise clearly contradicted by context.

Claims

1. A machine (100) for removing material comprising:

an undercarriage (102) including a first propulsion device and a second propulsion device for propelling the machine (100) about an worksite;

a cutter head (110) disposed on tool support and positioning assembly (120) including a cutter boom (122) that is slidably disposed on the undercarriage (102); and

a plurality of ground-engaging devices (180, 190) that are extendable and retractable with respect to the undercarriage (102) to engage a ground floor (106), the plurality of ground-engaging device (180, 190) are configured to be extended and retracted simultaneously through an electronic control system (200) operatively associated with the machine (100).

2. The machine (100) of claim 1, wherein the plurality of ground-engaging devices (180, 190) includes a stabilizer (180) and a load shield (190).

3. The machine (100) of claim 2, wherein the stabilizer (180) includes a stabilizer actuator (182) that hydraulically extends and retracts a stabilizer leg (184) attached to a ground pad (186).

4. The machine (100) of claim 3, wherein the load shield (190) is pivotally connected to the undercarriage (102) and can be pivoted with respect to the undercarriage (102) by a shield actuator (192).

5. The machine (100) of claim 4, further comprising a conveyer (150) disposed through the machine (100) from a conveyer entrance

(156) to a conveyer exit (158) to move material from a front portion (129) of the machine (100) to a rear portion (128) of the machine (100).

6. The machine (100) of claim 5, wherein the load shield (190) is disposed proximate to the conveyer exit (158).

7. The machine (100) of any one of claims 1-6, further comprising a remote control (202) for communicating with the electronic control system (200) on the machine (100).

8. The machine (100) of claim 7, wherein the remote control (202) includes a switch (210) for simultaneously extending and retracting the plurality of ground-engaging devices (180, 190).

9. The machine (100) of any one of claims 1-8, wherein the propulsion devices are continuous tracks (104).

10. A method for removing material comprising:

positioning a machine (100) proximate to a cutting surface (108);

simultaneously extending a plurality of ground-engaging devices (180, 190) retractably attached to an undercarriage (102) toward a ground floor (106);

feeding a cutter head (110) disposed on a cutter boom (122) of the machine (100) toward the cutting surface (108) to remove material from the cutting surface (108);

retracting the cutter head (110) from the cutting surface (108) prior to tramming the machine (100) to a new position with respect to the cutting surface (108);

simultaneously retracting the plurality of ground-engaging devices (180, 190) with respect to the ground floor (106) prior to tramming the machine (100) to the new position.

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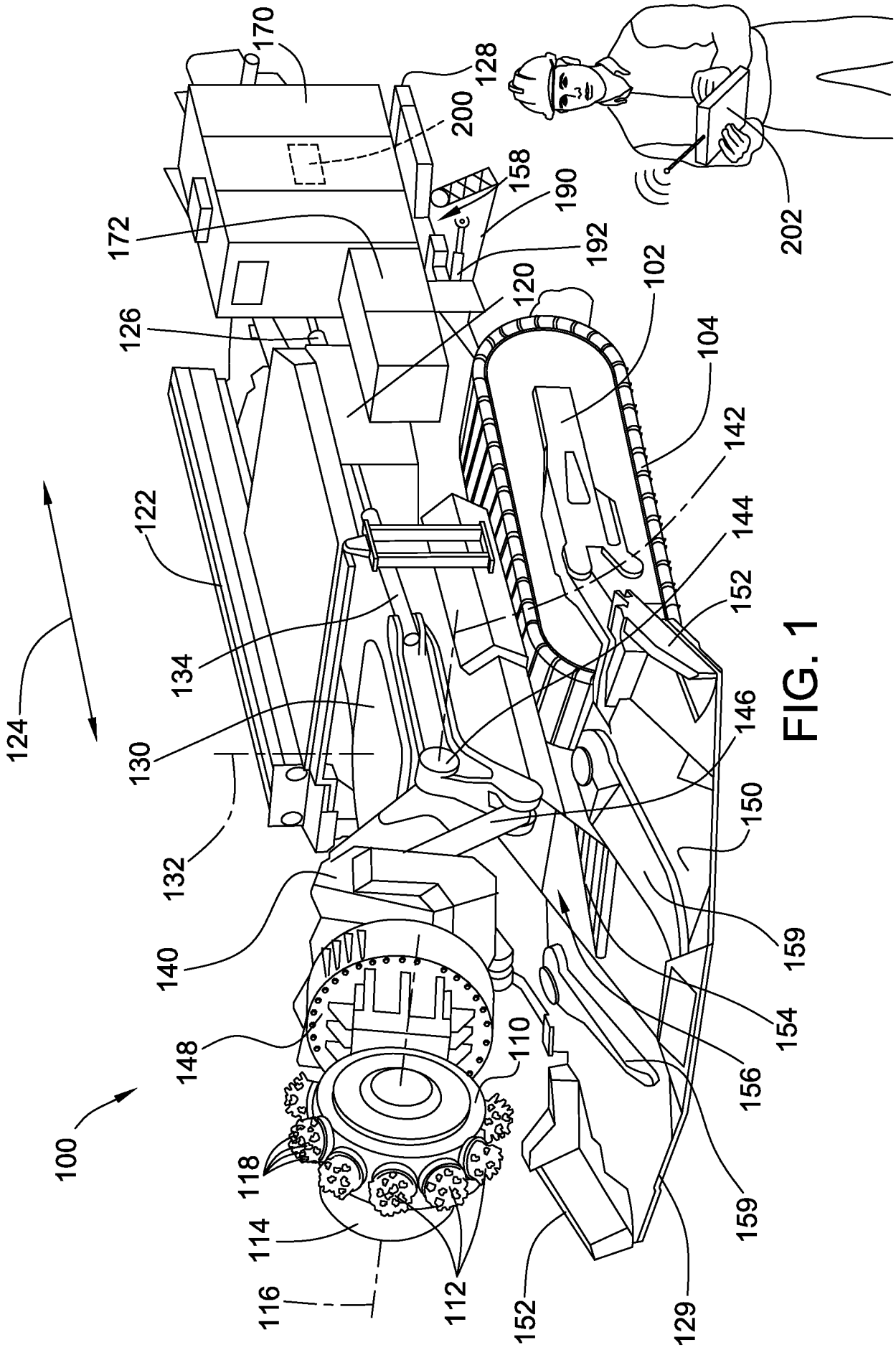
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FIG. 1

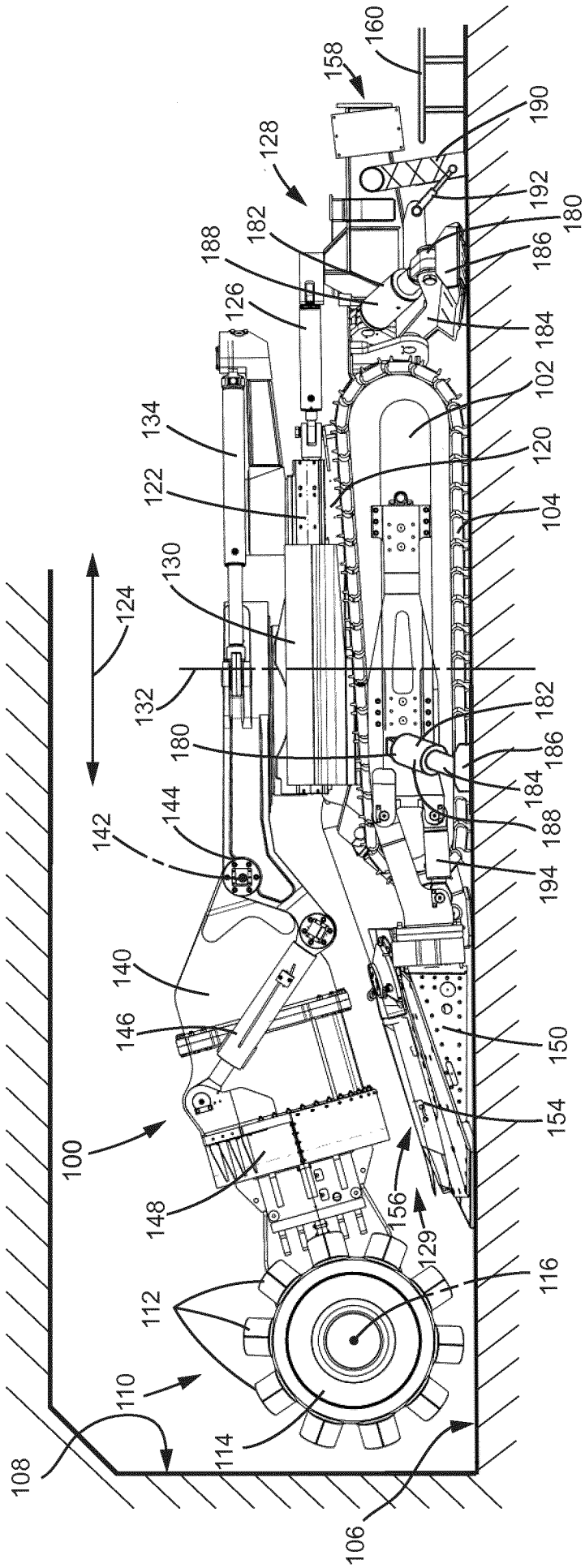
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FIG. 2

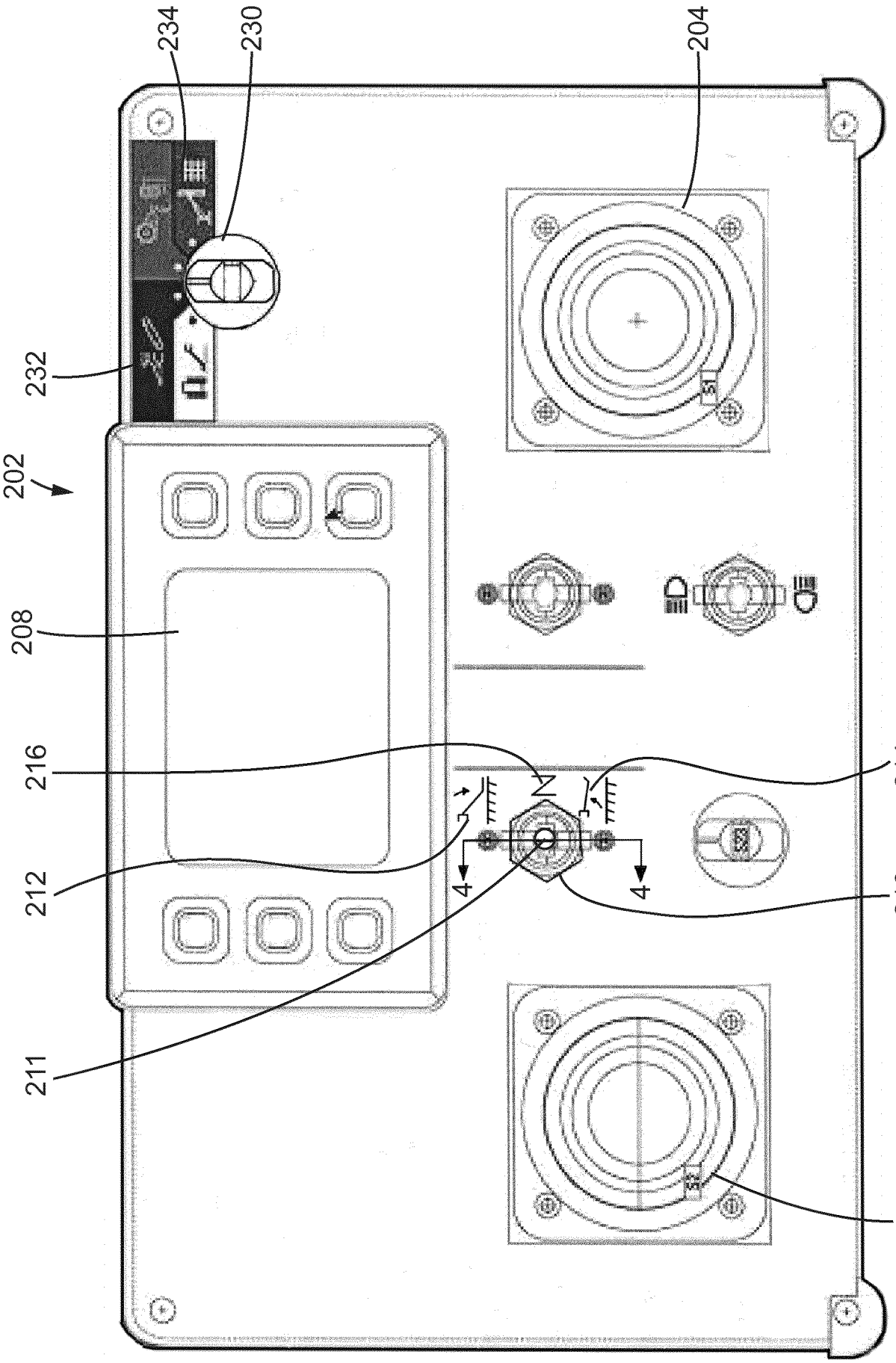


FIG. 3

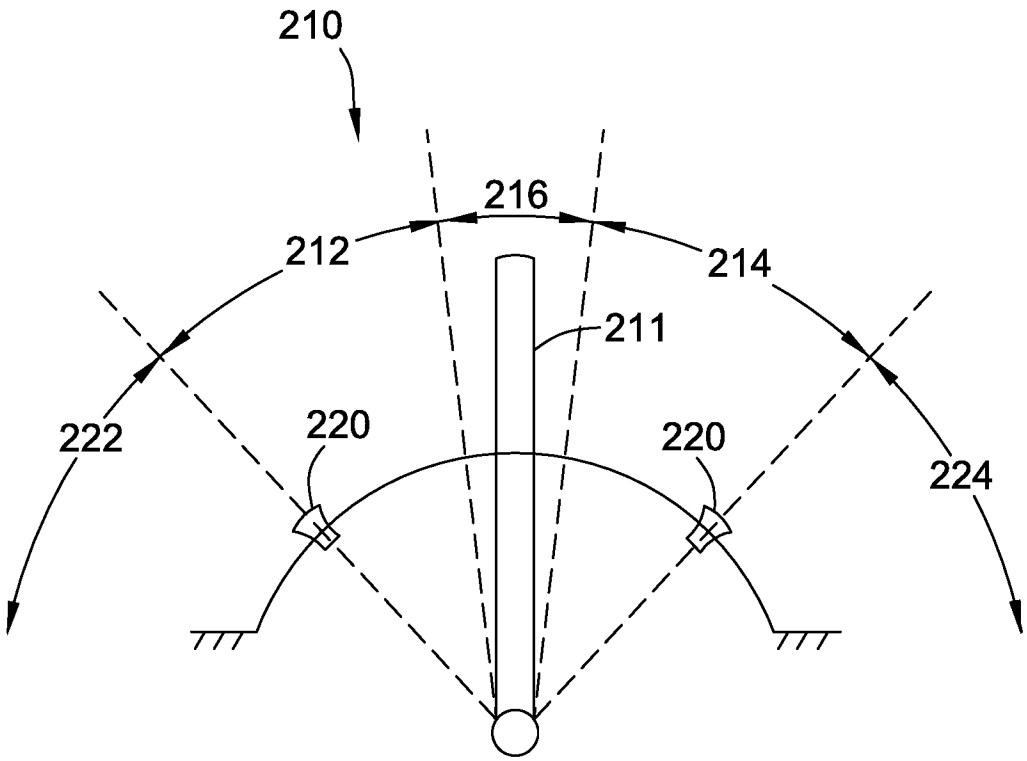
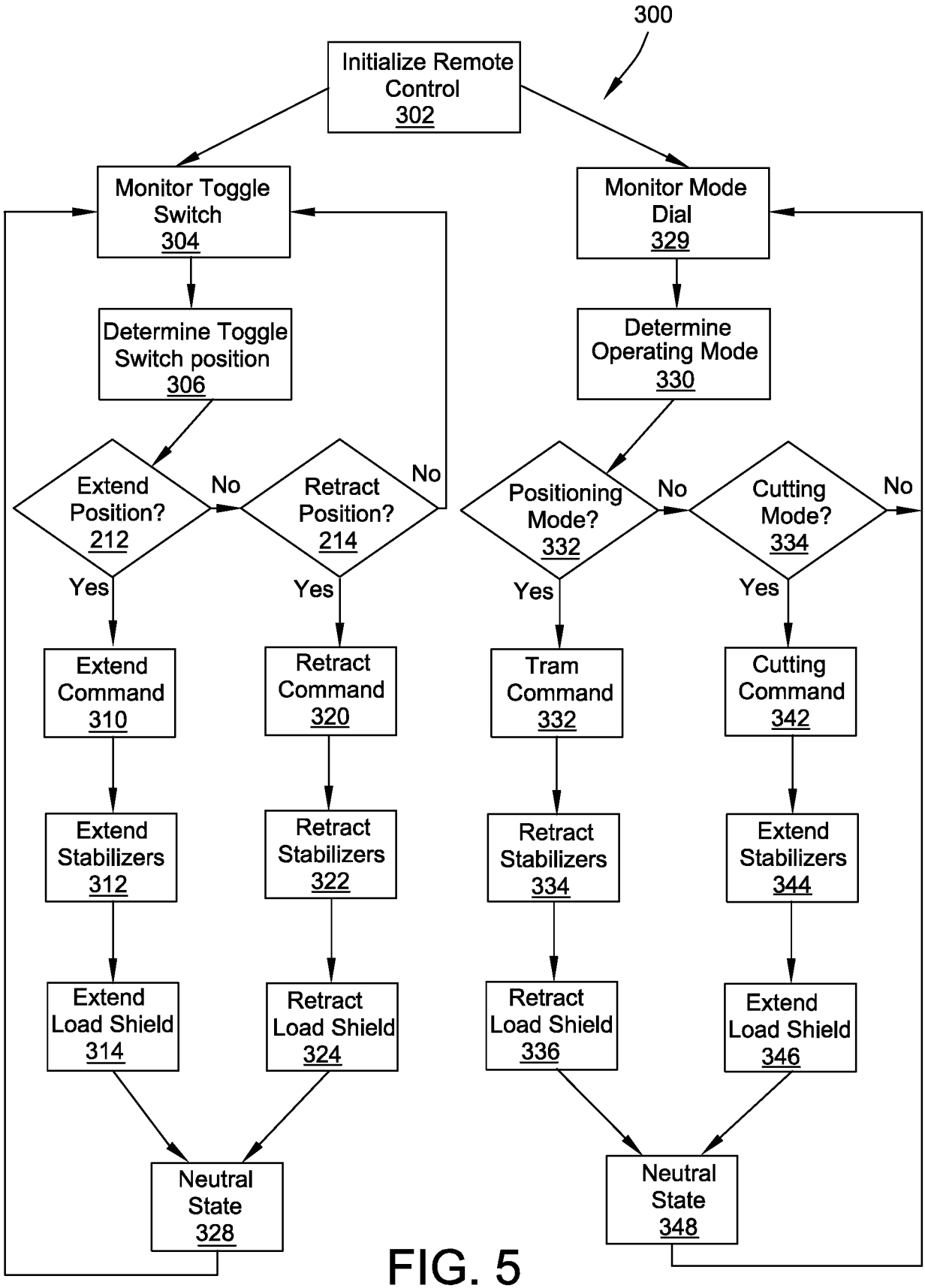


FIG. 4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Initialize Remote Control 302
Monitor Toggle Switch 304
Monitor Mode Dial 329
Determine Toggle Switch position 306
Determine Operating Mode 330
Extend Position? 212
No
Retract Position? 214
No
Positioning Mode? 332
No
Cutting Mode? 334
No
Yes
Yes
Yes
Yes
Extend Command 310
Retract Command 320
Tram Command 332
Cutting Command 342
Extend Stabilizers 312
Retract Stabilizers 322
Retract Stabilizers 334
Extend Stabilizers 344
Extend Load Shield 314
Retract Load Shield 324
Retract Load Shield 336
Extend Load Shield 346
Neutral State 328
Neutral State 348

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/083315

A. CLASSIFICATION OF SUBJECT MATTER
INV. E02F9/08 B60S9/12 E21C35/06 E21C25/16 E21D9/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B60S B66C E21C E21D E02F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 1 359 204 A (SALZGITTER MASCHINEN AG) 10 July 1974 (1974-07-10) page 2, lines 80-96 page 3, line 29 - line 105 figures 1,5,6	1-10
X	US 8 979 209 B2 (WADE ET AL. [ZA]) 17 March 2015 (2015-03-17) cited in the application the whole document	1-10
X	US 5 382 114 A (TREVISANI DAVIDE [IT]) 17 January 1995 (1995-01-17) the whole document	1-10

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 February 2018	27/02/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Dekker, Derk

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/083315

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2016/122972 A1 (PRICE DAVID [GB]) 5 May 2016 (2016-05-05) the whole document in particular: paragraphs [0025], [0026], [0057], [0058]; figures -----	1-10

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/083315

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 1359204 A	10-07-1974	AT 309358 B	10-08-1973
		DE 2037317 A1	10-02-1972
		GB 1359204 A	10-07-1974
US 8979209 B2	17-03-2015	AU 2012289908 A1	20-02-2014
		AU 2012289920 A1	20-02-2014
		AU 2012289923 A1	20-02-2014
		AU 2017203063 A1	01-06-2017
		CN 103827398 A	28-05-2014
		CN 103827443 A	28-05-2014
		CN 103827444 A	28-05-2014
		CN 106368713 A	01-02-2017
		CN 107255031 A	17-10-2017
		EP 2739792 A1	11-06-2014
		EP 2739824 A1	11-06-2014
		EP 2739825 A1	11-06-2014
		EP 3199750 A2	02-08-2017
		EP 3199751 A2	02-08-2017
		EP 3199752 A2	02-08-2017
		RU 2014107845 A	10-09-2015
		RU 2014107846 A	10-09-2015
		RU 2014107893 A	10-09-2015
		US 2013033085 A1	07-02-2013
		US 2013033086 A1	07-02-2013
		US 2013033087 A1	07-02-2013
		US 2013033088 A1	07-02-2013
		US 2013033089 A1	07-02-2013
		US 2013033090 A1	07-02-2013
		US 2015167462 A1	18-06-2015
		US 2017241264 A1	24-08-2017
		WO 2013020056 A1	07-02-2013
		WO 2013020068 A1	07-02-2013
		WO 2013020071 A1	07-02-2013
		ZA 201400861 B	25-03-2015
		ZA 201400864 B	25-03-2015
		ZA 201400865 B	25-03-2015
US 5382114 A	17-01-1995	AT 152808 T	15-05-1997
		DE 69310411 D1	12-06-1997
		DE 69310411 T2	09-10-1997
		EP 0557805 A1	01-09-1993
		ES 2102539 T3	01-08-1997
		IT 1256533 B	07-12-1995
		JP 2519380 B2	31-07-1996
		JP H06235296 A	23-08-1994
		US 5382114 A	17-01-1995
US 2016122972 A1	05-05-2016	CN 105564236 A	11-05-2016
		EP 3015604 A1	04-05-2016
		GB 2531765 A	04-05-2016
		JP 2016089617 A	23-05-2016
		KR 20160052391 A	12-05-2016
		US 2016122972 A1	05-05-2016