



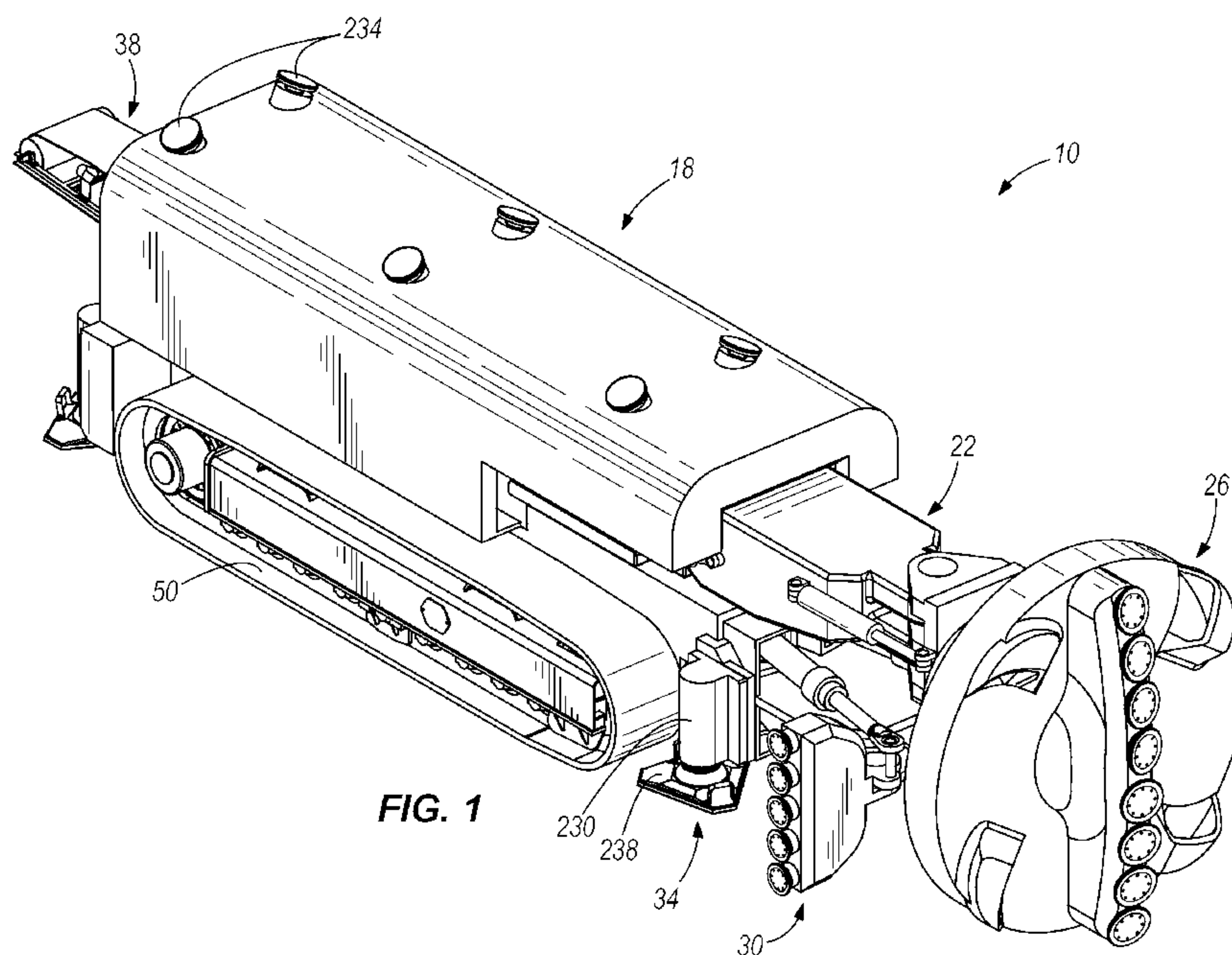
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(54) Titre : MACHINE DE FORAGE SOUTERRAIN
(54) Title: UNDERGROUND BORING MACHINE



An underground boring machine includes a vehicle frame, a boom, and a boring cutter head. The boom includes a first end coupled to the vehicle frame and a second end. The boring cutter head includes a rotary joint, a first arm, and a second arm angularly spaced apart from the first arm. The rotary joint defines an axis of rotation and supports the boring cutter head for rotation with respect to the second end of the boom. The first arm includes a first end coupled to the rotary joint, a second end, and at least one disc cutter coupled to the first arm and oriented to engage the wall. The first arm extends from the first end toward the second end in a plane that is perpendicular to the axis of rotation. The second arm includes a first end coupled to the rotary joint, a second end, and at least one disc cutter coupled to the second arm and oriented to engage the wall. The second arm extends from the first end toward the second end in a plane that is perpendicular to the axis of rotation.

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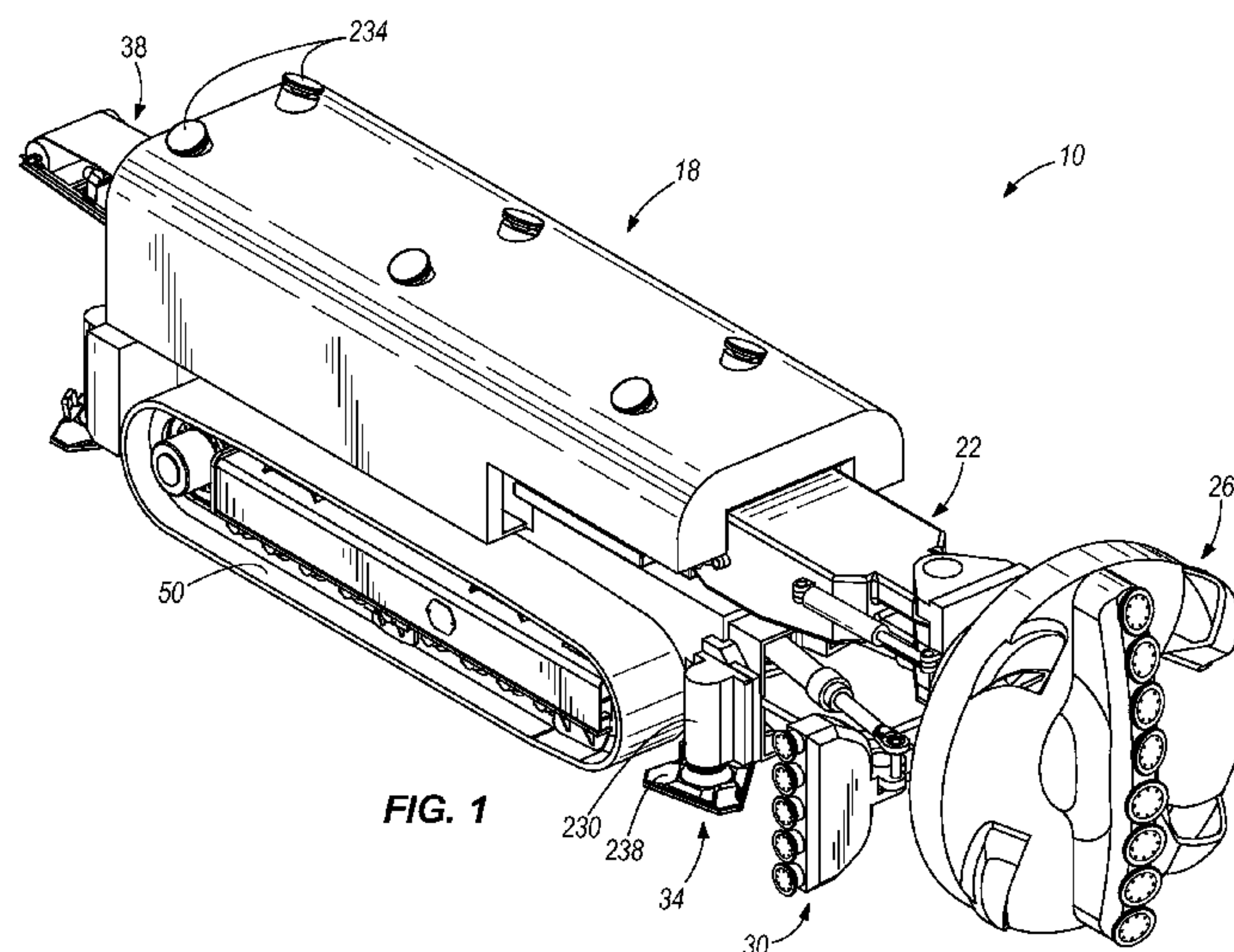
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(54) Title: UNDERGROUND BORING MACHINE



(57) **Abstract:** An underground boring machine includes a vehicle frame, a boom, and a boring cutter head. The boom includes a first end coupled to the vehicle frame and a second end. The boring cutter head includes a rotary joint, a first arm, and a second arm angularly spaced apart from the first arm. The rotary joint defines an axis of rotation and supports the boring cutter head for rotation with respect to the second end of the boom. The first arm includes a first end coupled to the rotary joint, a second end, and at least one disc cutter coupled to the first arm and oriented to engage the wall. The first arm extends from the first end toward the second end in a plane that is perpendicular to the axis of rotation. The second arm includes a first end coupled to the rotary joint, a second end, and at least one disc cutter coupled to the second arm and oriented to engage the wall. The second arm extends from the first end toward the second end in a plane that is perpendicular to the axis of rotation.

UNDERGROUND BORING MACHINE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application 61/370,342, filed August 3, 2010, the entire contents of which are incorporated herein by reference.

BACKGROUND

[0002] The present invention relates to mining equipment, and in particular to an underground boring machine.

[0003] Conventional underground excavation machines provide a rotating cutter head for creating an entry or tunnel in a wall of material. The cutter head includes a cutting mechanism for breaking material from the wall. These excavation machines have difficulty changing the direction of the tunnel, as this often requires changing the orientation of the entire boring machine. This can be a complicated task, since it requires maneuvering the boring machine within the confines of the excavated tunnel. In addition, the cutting mechanism of conventional boring machines can create high stresses, decreasing the working life of the machine and requiring frequent maintenance.

SUMMARY OF THE INVENTION

[0004] In one embodiment, the invention provides an underground boring machine for creating a tunnel in a wall, the machine comprising a vehicle frame, a boom, and a boring cutter head. The boom includes a first end coupled to the vehicle frame and a second end. The boring cutter head includes a rotary joint, a first arm, and a second arm angularly spaced apart from the first arm. The rotary joint defines an axis of rotation and supports the boring cutter head for rotation with respect to the second end of the boom. The first arm includes a first end coupled to the rotary joint, a second end, and at least one disc cutter coupled to the first arm and oriented to engage the wall. The first arm extends from the first end toward the second end in a plane that is perpendicular to the axis of rotation. The second arm includes a first end coupled to the rotary joint, a second end, and at least one disc cutter coupled to the second arm and oriented to engage

the wall. The second arm extends from the first end toward the second end in a plane that is perpendicular to the axis of rotation.

[0005] In another embodiment, the invention provides an underground boring machine for creating a tunnel in a wall. The underground boring machine is supported on a floor defining a floor plane, and the underground boring machine includes a vehicle frame, a boom, and a boring cutter head. The vehicle frame supports the underground boring machine on the floor and defines a frame axis that is parallel to the floor plane. The boom includes a first end slidably coupled to the vehicle frame, a second end, a first portion proximate the first end, a second portion pivotably coupled to the first portion, and a third portion proximate the second end and pivotably coupled to the second portion. The boring cutter head includes a rotary joint, a first arm, and a second arm angularly spaced apart from the first arm. The rotary joint defines a rotary axis and is rotatably coupled to the second end of the boom. The first arm includes a first end coupled to the rotary joint, a second end, and at least one disc cutter coupled to the first arm and oriented to engage the wall. The second arm includes a first end coupled to the rotary joint, a second end, and at least one disc cutter coupled to the second arm and oriented to engage the wall. The second boom portion pivots with respect to the first boom portion about a first axis that is substantially perpendicular to the frame axis. The third boom portion pivots with respect to the second boom portion about a second axis that is substantially perpendicular to the first axis, and the boring cutter head rotates with respect to the second end of the boom about the rotary axis.

[0006] In yet another embodiment, the invention provides a cutter head for boring through a wall, the cutter head comprising a rotary union, a first arm, and a second arm. The rotary union defines a rotary axis and supports the cutter head for rotation about the rotary axis. The first arm includes a first end, a second end, and at least one disc cutter. The first end is coupled to the rotary union. The first arm extends from the first end toward the second end in a direction that is substantially perpendicular to the rotary axis. The at least one disc cutter is coupled to the first arm and oriented to engage the wall. The second arm is angularly spaced apart from the first arm. The second arm includes a first end, a second end, and at least one disc cutter. The first end is coupled to the rotary union. The second arm extends from the first end toward the second

end in a manner that is substantially perpendicular to the rotary axis. The at least one disc cutter is coupled to the second arm and oriented to engage the wall.

[0007] Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a perspective view of a boring machine according to one embodiment of the invention.

[0009] FIG. 2 is a side view of the boring machine of FIG. 1.

[0010] FIG. 3 is a top view of the boring machine of FIG. 1.

[0011] FIG. 4 is an enlarged section view taken from the side of the boring machine of FIG. 3.

[0012] FIG. 5 is a top view of the boring machine of FIG. 1, with a boring cutter head articulated to the left.

[0013] FIG. 6 is a front view of the boring machine of FIG. 1.

[0014] FIG. 7 is a perspective section view of the boring cutter head.

[0015] FIG. 8 is a side view of the boring cutter head.

[0016] FIG. 9 is a perspective view of a profiling cutter head.

[0017] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways.

DETAILED DESCRIPTION

[0018] FIGS. 1 and 2 illustrate an underground boring machine 10 for engaging a wall (not shown) to create a tunnel or entry into the wall. The boring machine 10 includes a vehicle frame 18, a boom 22, a boring cutter head 26, a pair of profiling cutter heads 30, a stabilization system 34, and a material handling system 38. The frame 18 defines a frame axis 46 (FIG. 3) and includes a pair of tracks 50 for supporting the vehicle frame 18 on a floor or support surface. In other embodiments, the frame 18 may include a hydraulic walking or hydraulic pushover mechanism, and may include fewer or more profiling cutter heads 30. The frame 18 may also include additional pump stations and power packs (not shown) for providing primary drive energy to the boring cutter head 26 and the profiling cutter heads 30.

[0019] As shown in FIGS. 3 and 4, the boom 22 includes a first end 58 (FIG. 4), a second end 62, a first portion 66 (FIG. 4) proximate the first end 58, a second portion 70 pivotably coupled to the first portion 66, a third portion 74 proximate the second end 62 and pivotably coupled to the second portion 70, advance cylinders 78 (FIGS. 2 and 4), a vertical actuator 82 (FIG. 2), and a horizontal actuator 86. As used in this application, the term “horizontal” and variants thereof refer to a direction in a plane that is parallel to the floor. As used in this application, the term “vertical” and variants thereof refer to a direction in a plane that is perpendicular to the floor. The first end 58 of the boom 22 is coupled to the vehicle frame 18 by, for example, a rail (not shown), permitting the boom 22 to slidably extend and retract in a direction parallel to the frame axis 46. Advance cylinders 78 drive the first end 58 of the boom 22 to move the boom 22 with respect to the vehicle frame 18.

[0020] The second portion 70 of the boom 22 is pivotably coupled to the first portion 66 of the boom 22 by a first pivot joint 90 (FIG. 4) defining a first axis 94. The second portion 70 pivots with respect to the first portion 66 about the first axis 94. In the illustrated embodiment, the vertical actuators 82 drive the second portion 70 to rotate about the first axis 94. The first axis 94 is substantially perpendicular to the frame axis 46 and is substantially parallel to the floor. Thus, rotation of the second portion 70 about the first axis 94 changes the pitch or vertical height of the second end 62 of the boom 22.

[0021] The third portion 74 of the boom 22 is pivotably coupled to the second portion 70 of the boom 22 by a second pivot joint 98 defining a second axis 102. The third portion 74 pivots with respect to the second portion 70 about the second axis 102 (FIG. 4). As shown in FIG. 5, the horizontal actuators 86 drive the third portion 74 to rotate about the second axis 102. The second axis 102 is substantially perpendicular to the first axis 94 and substantially perpendicular to the frame axis 46. Thus, rotation of the third portion 74 about the second axis 102 changes the horizontal orientation of the second end 62 of the boom 22. In the illustrated embodiment, the vertical actuators 82 and horizontal actuators 86 are hydraulic cylinders.

[0022] In other embodiments, a rotary actuator, including a gearcase, may be coupled to the pivot joints 90, 98 to articulate the second portion 70 and the third portion 74. Also, the first pivot joint 90 may be positioned vertically in order to control the horizontal orientation of the second end 62 of the boom 22, and the second pivot joint 98 may be positioned horizontally to control the vertical position of the second end 62 of the boom 22.

[0023] Referring to FIG. 3, the boring cutter head 26 includes a rotary base joint 110 (FIG. 4), a motor (not shown), a body 118, a first arm 126, and a second arm 130 (FIG. 6). The rotary base joint 110 defines a rotary axis 134, and includes a support member 142 and a rotary coupler 146. The support member 142 is coupled to the second end 62 of the boom 22 and is rotatably coupled to the rotary coupler 146. The rotary coupler 146 is attached to the body 118 of the boring cutter head 26. The rotary coupler 146 can rotate continuously with respect to the support member 142, permitting continuous rotation of the boring cutter head 26 with respect to the second end 62 of the boom 22. The motor is positioned within the support member 142 and drives the rotary coupler 146 for rotation about the rotary axis 134. As illustrated in FIG. 6, the boring cutter head 26 rotates counterclockwise. The rotary base joint 110 supports hydraulic, electrical, and vacuum conduit to connect to the motor and other components within the boring cutter head 26, while the boring cutter head 26 rotates. Rotary base joints are commonly known in the art, and no further description of them is provided here.

[0024] As shown in FIGS. 6 and 7, the body 118 is positioned behind the first arm 126 and the second arm 130 and defines an interior cavity 158 (FIG. 7). In the illustrated embodiment, the body 118 generally is shaped as a flat disc having a diameter that is substantially equal to the

combined length of the first arm 126 and the second arm 130, and includes four intake ducts 162. The body 118 rotates with the support member 142 about the rotary axis 134. The ducts 162 are positioned to follow the first arm 126 and the second arm 130 as the arms 126, 130 rotate, and the ducts 162 collect the material that is liberated from the wall and guides the material into the interior cavity 158. In other embodiments, the body 118 may include fewer or more ducts 162 and may have a different size or shape. For instance, the body 118 may be a simple a frame for supporting the first arm 126 and the second arm 130

[0025] Referring again to FIGS. 3 and 6, the first arm 126 includes a first end 170, a second end 174, and multiple disc cutters 178 coupled to the first arm 126. The first arm 126 is coupled to the body 118 and is substantially perpendicular to the rotary axis 134. The second arm 130 also includes a first end 186, a second end 190, and multiple disc cutters 178 coupled to the second arm 130. The second arm 130 is coupled to the body 118 and is substantially perpendicular to the rotary axis 134. The first arm 126 and the second arm 130 rotate with the body 118 about the rotary axis 134.

[0026] In the illustrated embodiment, the first arm 126 and the second arm 130 extend radially from the rotary axis 134. The first arm 126 and second arm 130 are spaced apart by an angle of 180° , and the first arm 126 and second arm 130 are formed as a unitary member. In other embodiments, the first arm 126 and, optionally, the second arm 130 may extend in an arcuate manner from the rotary axis 134, such that the first arm 126 and the second arm 130 have a spiral shape when viewed along the rotary axis 134. The first arm 126 and second arm 130 may also be formed to have a straight portion and an arcuate portion. In other embodiments, the first arm 126 and the second arm 130 may be spaced apart by a different angle, and the first arm 126 and second arm 130 may be formed as two separate pieces. In other embodiments, the boring cutter head 26 may include fewer or more arms.

[0027] As shown in FIG. 8, the first arm 126 and the second arm 130 define a mounting surface 202 proximate the front of the boring cutter head 26. In the illustrated embodiment, the mounting surface 202 has a convex shape defined by the first arm 126 and the second arm 130. The mounting surface 202 extends farther forward of the vehicle frame 18 proximate the first end 170 of the first arm 126 and proximate the first end 186 of the second arm 130. The

mounting surface 202 tapers toward the vehicle frame 18 near the second end 174 of the first arm 126 and the second end 190 of the second arm 130. This convex shape relieves stress on the disc cutters 178 as they bore into the wall of material. In other embodiments, the mounting surface 202 may be more or less tapered to form a more deep or shallow convex shape, or the mounting surface 202 may have a flat shape.

[0028] The disc cutters 178 are mounted in the first arm 126 and the second arm 130 for engaging the wall. Each disc cutter 178 is independently rotatable in order to provide for a uniform contact and a symmetrical extraction pattern. The disc cutters 178 minimize uncut benches or steps and provide a clean face profile. Referring again to FIG. 3, the disc cutters 178 are oriented at an attack angle 210 with respect to a plane 206 that is tangent to the mounting surface 202, and the disc cutters 178 engage the wall as the first arm 126 and the second arm 130 rotate about the rotary axis 134. In the illustrated embodiment, the first arm 126 and the second arm 130 each includes four disc cutters 178, and the attack angle is approximately 10° with respect to the plane 206. In other embodiments, each arm may include fewer or more disc cutters 178.

[0029] The boring cutter head 26 includes an inertial mass that is integrated into the body 118 for absorbing the dynamic load of the disc cutters 178. The mass is positioned to provide relative stiffness and damping properties to the boring cutter head 26 in order to maintain the overall shock and vibration levels within acceptable machine design limits. The mass isolates the dynamic load from the rest of the boring machine 10.

[0030] As the boring cutter head 26 rotates (counterclockwise as shown in FIG. 6), the leading edge of each disc cutter 178 is angled forward. This is best illustrated in FIG. 8. Each disc cutter 178 rotates about an axis (not shown) that is perpendicular to the mounting surface 202, and the disc cutter 178 chips and breaks apart material in the wall. Each disc cutter 178 is coupled to an inertial mass, such as lead, held within each arm 126, 130. In the illustrated embodiment, four disc cutters 178 are coupled to each arm 126, 130, and the attack angle 210 is approximately 10°. In other embodiments, fewer or more disc cutters 178 may be mounted on each arm 126 and 130, and the disc cutters 178 may be oriented at a different attack angle 210.

[0031] In another embodiment (not shown), each disc cutter 178 may include a load cell equipped with a strain gauge that measures the cutting force on the disc cutter 178, 194. The load cell includes multiple measuring points to quantify linear forces in three dimensions as well as torque about the axis of rotation of the disc cutter 178. This data is sent to a control system (not shown) that receives feedback from the load cell in order to control cutting speeds.

[0032] As shown in FIGS. 3 and 9, the profiling cutter heads 30 are positioned behind the boring cutter head 26 and proximate the floor. Each profiling cutter head 30 includes an integrated inertial mass, which provides relative stiffness and damping properties to the profiling cutter head 30. The inertial mass maintains the overall shock and vibration levels within acceptable machine design limits. In the illustrated embodiment, each profiling cutter head 30 includes five disc cutters 178, and each profiling cutter head 30 is rotatable by hydraulic cylinders 218 to change the orientation of the disc cutters 178 with respect to the wall and adjust the angle of attack 210. In other embodiments, the profiling cutter head 30 may include fewer or more disc cutters 178, and the profiling cutter head 30 may be rotatable by a rotary actuator, such as a gear drive. Referring to FIG. 6, as the boring cutter head 26 penetrates through the material wall, the profiling cutter heads 30 clear away material near the floor in order to provide a rectangular section in the lower part of an excavation profile 222, creating a pathway for the tracks 50 and forming a flat floor and flat walls. Stated another way, the profiling cutter heads 30 square off the sides of the tunnel as the boring machine 10 advances. Each profiling cutter head 30 is independently rotatable in order to provide for a uniform contact and a symmetrical extraction pattern even if the boring cutter head 26 is turned. The profiling cutter heads 30 minimize uncut steps and provides a clean face profile.

[0033] As shown in FIGS. 1-3, the stabilization system 34 includes four stabilizer cylinders 230 and six grippers 234. Each of the stabilizer cylinders 230 is positioned at a corner of the vehicle frame 18. In other embodiments, the stabilization system 34 may include fewer or more stabilizer cylinders 230 and grippers 234. Each stabilizer cylinder 230 includes a headboard 238 for engaging the floor or support surface. The cylinders 230 are extendable to permit the boring machine 10 to be supported off the tracks 50 during the boring operation. Similarly, the grippers 234 are extendable from the top of the vehicle frame 18 to support the roof or tunnel portion that is above the boring machine 10.

[0034] As shown in FIG. 2, the material handling system 38 includes a suction source 242, a vacuum duct 246 in fluid communication with the interior cavity 158 of the body 118, a collector 250, and a conveyor 254 mounted on the rear of the vehicle frame 18. The suction source 242 is positioned on the vehicle frame 18 and provides vacuum pressure within the intake ducts 162, the interior cavity 158 and the vacuum duct 246. The vacuum duct 246 extends from the interior cavity 158 of the body 118 through the rotary base joint 110 and into the collector 250. The vacuum duct 246 may be constructed of a flexible material to accommodate the movement of the boring cutter head 26. The collector 250 is positioned on the vehicle frame 18 and separates the liberated material from any water in the collector 250. After separation, the material is transferred to the conveyor 254, which in turn transports the material to a conveyor system (not shown) for transportation away from the boring machine 10.

[0035] In another embodiment (not shown), after the material is separated from the water, it may be transported away from the boring machine 10 by a conduit under suction pressure. In another embodiment (not shown), the boring cutter head 26 includes an entrainment system for trapping material liberated by the disc cutters 178 against the wall. The entrainment system may include multiple water spray blocks for dampening the dirt and dust from the wall and preventing the dirt from traveling past the boring cutter head 26 and profiling cutter heads 30 toward the rear of the machine 10.

[0036] During operation, the stabilizer cylinders 230 are extended to lift the boring machine 10 off of the tracks 50 and make sure the vehicle frame 18 is level. In addition, the grippers 234 are extended to engage the roof and provide support above the boring machine 10. While the vehicle frame 18 is in the supported position, the boom 22 is pivoted to orient the boring cutter head 26 in the proper direction for excavating an entry or tunnel. The boom 22 slides with respect to the vehicle frame 18 in order to extend the boring cutter head 26 along the rotary axis 134 and bore deeper into the wall. Alternatively, the boring machine 10 may be operated while the vehicle frame 18 is supported on the tracks (i.e., without extending the stabilizer cylinders and grippers), such that the weight of the boring machine 10 stabilizes the boring cutter head 26. The profiling cutter heads 30 are also positioned to engage the portion of the wall between the boring cutter head 26 and the floor.

[0037] The boring cutter head 26 is driven by the motor to rotate about the rotary axis 134. As the boring cutter head 26 rotates, the disc cutters 178 engage the wall at the attack angle 210, causing material to chip and break away from the wall. FIG. 8 shows the orientation of the disc cutters 178 on each arm 126 and 130. In the illustrated embodiment, the disc cutters 178 proximate the rotary axis 134 engage the wall first, and the disc cutters 178 that are progressively farther away from the rotary base joint 110 engage the wall as the boring cutter head 26 is moved into the wall. As the boring machine 10 advances through the wall, the profiling cutter heads 30 engage a portion of the wall below the boring cutter head 26 and above the floor, forming the excavation profile 222 illustrated in FIG. 6. The profiling cutter heads 30 extend the cutting profile of the boring cutter head 26, permitting the vehicle frame 18 to advance through the wall. The profiling cutter heads 30 may be extended or retracted to change the width of the lower portion.

[0038] As material is liberated from the wall, suction pulls the material through the intake ducts 162 and into the interior cavity 158. The material then passes into the vacuum duct 246 and is transported to the collector 250. After the collector 250 separates the material from any water, the material is deposited on the conveyor 254 at the rear of the machine 10. The conveyor 254 transports the material to the conveyor system, which transports the material away from the boring machine 10.

[0039] The machine 10 is provided with an onboard control and automation system that operates the machine as described above, including controlling orientation of the boom 22, by remote control, onboard operators, or both. The pivot joints 90, 98 may include sensors for monitoring the magnitude of the reaction forces while cutting, such that the automation system controls the position of the advance cylinders 78 based on feedback from the cutting force sensors. Such sensors may include, for example, angular transducers, load cells and/or strain gauges. This increases the life of the disc cutters 178.

[0040] Thus, the invention provides, among other things, an underground boring machine. Various features and advantages of the invention are set forth in the following claims.

CLAIMS

What is claimed is:

1. An underground boring machine for creating a tunnel in a wall, the machine comprising:
a vehicle frame;
a boom including a first end coupled to the vehicle frame and a second end;
a boring cutter head including a rotary joint, a first arm, and a second arm angularly spaced apart from the first arm, the rotary joint defining an axis of rotation and supporting the boring cutter head for rotation with respect to the second end of the boom, the first arm including a first end coupled to the rotary joint, a second end, and at least one disc cutter coupled to the first arm and oriented to engage the wall, the first arm extending from the first end toward the second end in a plane that is perpendicular to the axis of rotation, the second arm including a first end coupled to the rotary joint, a second end, and at least one disc cutter coupled to the second arm and oriented to engage the wall, the second arm extending from the first end toward the second end in a plane that is perpendicular to the axis of rotation.
2. The underground boring machine of claim 1, wherein the first arm extends radially from the axis of rotation.
3. The underground boring machine of claim 2, wherein the second arm extends radially from the axis of rotation, and the first arm and the second arm are spaced apart by an angle of approximately 180°.
4. The underground boring machine of claim 1, wherein the at least one disc cutter of the first arm is oriented such that the at least one disc cutter engages the wall at an attack angle as the first arm rotates about the axis of rotation.
5. The underground boring machine of claim 4, wherein the at least one disc cutter of the second arm is oriented such that the at least one disc cutter engages the wall at the attack angle as the second arm rotates about the axis of rotation.

6. The underground boring machine of claim 5, wherein first arm and the second arm define a first surface proximate the wall, and wherein the attack angle is approximately 10° with respect to a plane that is tangent to the first surface.
7. The underground boring machine of claim 1, wherein the first arm and second arm define a first surface proximate the wall, wherein the first surface has a convex shape.
8. The underground boring machine of claim 1, and further comprising at least one intake duct proximate the boring cutter head for collecting material that is liberated from the wall.
9. The underground boring machine of claim 8, wherein the at least one intake duct is in fluid communication with a suction source.
10. The underground boring machine of claim 8, wherein the material that is liberated from the wall is transported through a vacuum duct to a conveyor positioned behind the vehicle frame.
11. The underground boring machine of claim 8, wherein the material that is liberated from the wall is transported through a vacuum duct to a collector.
12. The underground boring machine of claim 1, and further comprising a profiling cutter head positioned behind the boring cutter head and proximate a floor of the tunnel.
13. The underground boring machine of claim 12, wherein the profiling cutter head is pivotably coupled to the vehicle frame.
14. The underground boring machine of claim 1, and further comprising at least one stabilizer cylinder for supporting the boring machine off of the floor and at least one gripper for supporting a roof portion above the boring machine.

15. An underground boring machine for creating a tunnel in a wall, the underground boring machine being supported on a floor defining a floor plane, the underground boring machine comprising:

a vehicle frame for supporting the underground boring machine on the floor, the vehicle frame defining a frame axis that is parallel to the floor plane;

a boom including a first end slidably coupled to the vehicle frame, a second end, a first portion proximate the first end, a second portion pivotably coupled to the first portion, and a third portion proximate the second end and pivotably coupled to the second portion;

a boring cutter head including a rotary joint, a first arm, and a second arm angularly spaced apart from the first arm, the rotary joint defining a rotary axis and being rotatably coupled to the second end of the boom, the first arm including a first end coupled to the rotary joint, a second end, and at least one disc cutter coupled to the first arm and oriented to engage the wall, the second arm including a first end coupled to the rotary joint, a second end, and at least one disc cutter coupled to the second arm and oriented to engage the wall,

wherein the second boom portion pivots with respect to the first boom portion about a first axis that is substantially perpendicular to the frame axis,

wherein the third boom portion pivots with respect to the second boom portion about a second axis that is substantially perpendicular to the first axis, and

wherein the boring cutter head rotates with respect to the second end of the boom about the rotary axis.

16. The underground boring machine of claim 15, wherein the boom slides with respect to the vehicle frame in a direction parallel to the frame axis.

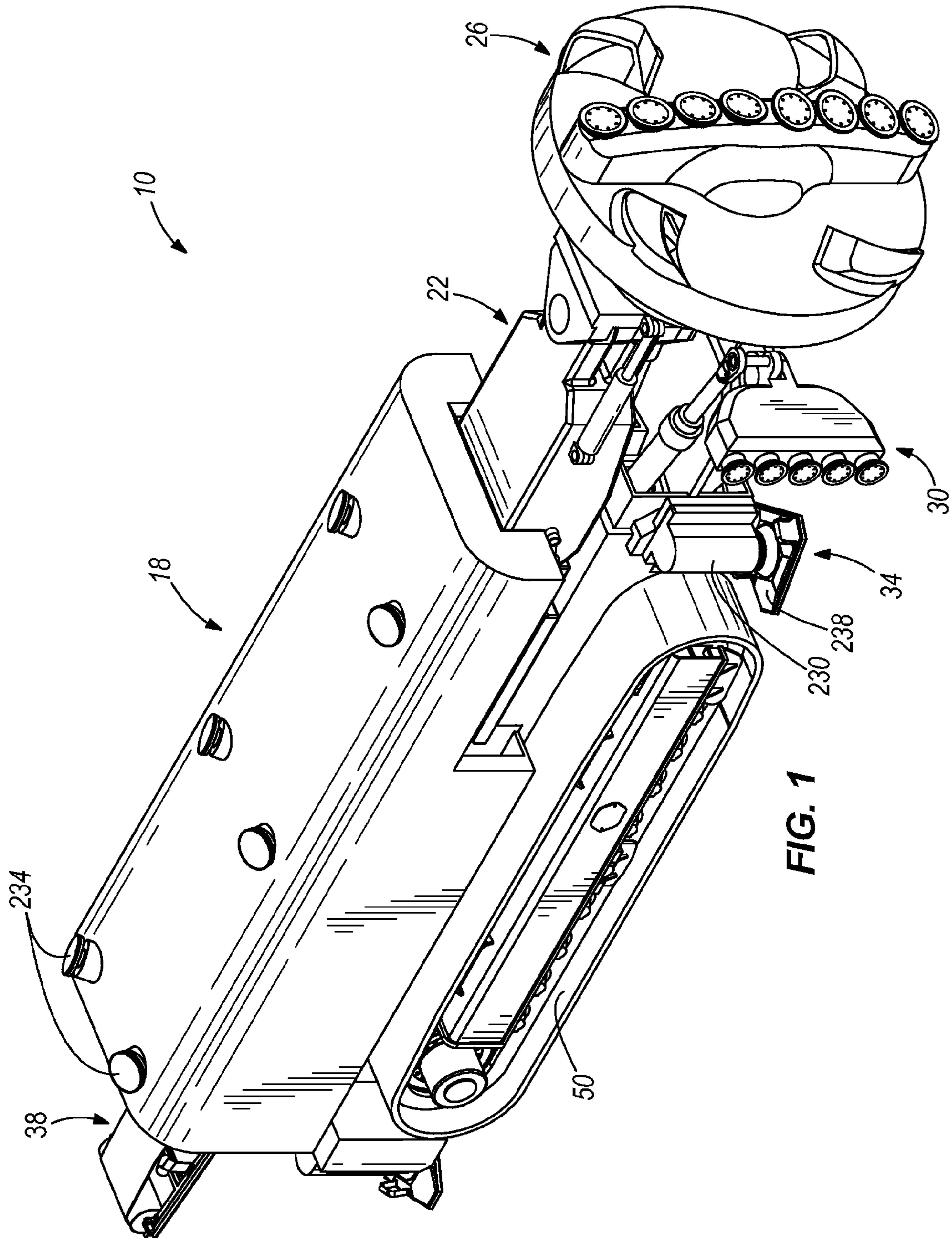
17. The underground boring machine of claim 15, wherein the first axis is substantially parallel to the floor.

18. The underground boring machine of claim 15, wherein the first arm and the second arm extend radially from the rotary axis, and the first arm and the second arm are spaced apart by an angle of approximately 180°.

19. The underground boring machine of claim 15, wherein the at least one disc cutter of the first arm is oriented to engage the wall at an attack angle as the first arm rotates about the rotary axis, and the at least one disc cutter of the second arm is oriented to engage the wall at the attack angle as the second arm rotates about the rotary axis.
20. The underground boring machine of claim 15, wherein the boring cutter head further includes at least one intake duct proximate the first arm for collecting material that is liberated from the wall, wherein the at least one intake duct is in fluid communication with a suction source.
21. The underground boring machine of claim 20, wherein the material that is liberated from the wall is transported through a vacuum duct to a conveyor positioned behind the vehicle frame.
22. The underground boring machine of claim 15, further comprising a profiling cutter head positioned behind the boring cutter head and proximate the floor.
23. The underground boring machine of claim 22, wherein the profiling cutter head is pivotably coupled to the vehicle frame.
24. The underground boring machine of claim 15, further comprising at least one stabilizer cylinder for supporting the boring machine off of the floor.

25. A cutter head for boring through a wall, the cutter head comprising:
a rotary union defining a rotary axis and supporting the cutter head for rotation about the rotary axis;
a first arm including a first end, a second end, and at least one disc cutter, the first end being coupled to the rotary union, the first arm extending from the first end toward the second end in a direction that is substantially perpendicular to the rotary axis, the at least one disc cutter being coupled to the first arm and oriented to engage the wall; and
a second arm angularly spaced apart from the first arm, the second arm including a first end, a second end, and at least one disc cutter, the first end being coupled to the rotary union, the second arm extending from the first end toward the second end in a manner that is substantially perpendicular to the rotary axis, the at least one disc cutter being coupled to the second arm and oriented to engage the wall.
26. The cutter head of claim 25, wherein the first arm defines a first axis and the second arm defines a second axis, the first axis and the second axis extending radially from the rotary axis.
27. The cutter head of claim 26, wherein the first axis and the second axis are spaced apart by approximately 180° .
28. The cutter head of claim 25, wherein the at least one disc cutter of the first arm is oriented to engage the wall at an attack angle as the first arm rotates about the rotary axis, and the at least one disc cutter of the second arm is oriented to engage the wall at the attack angle as the second arm rotates about the rotary axis.
29. The cutter head of claim 28, wherein first arm and the second arm define a first surface proximate the wall, and wherein the attack angle is approximately 10° with respect to a plane that is tangent to the first surface.
30. The cutter head of claim 25, further comprising at least one intake duct located proximate the first arm and positioned to collect material that is liberated from the wall.
31. The cutter head of claim 30, wherein the at least one intake duct is in fluid communication with a suction source.

1/8



2/8

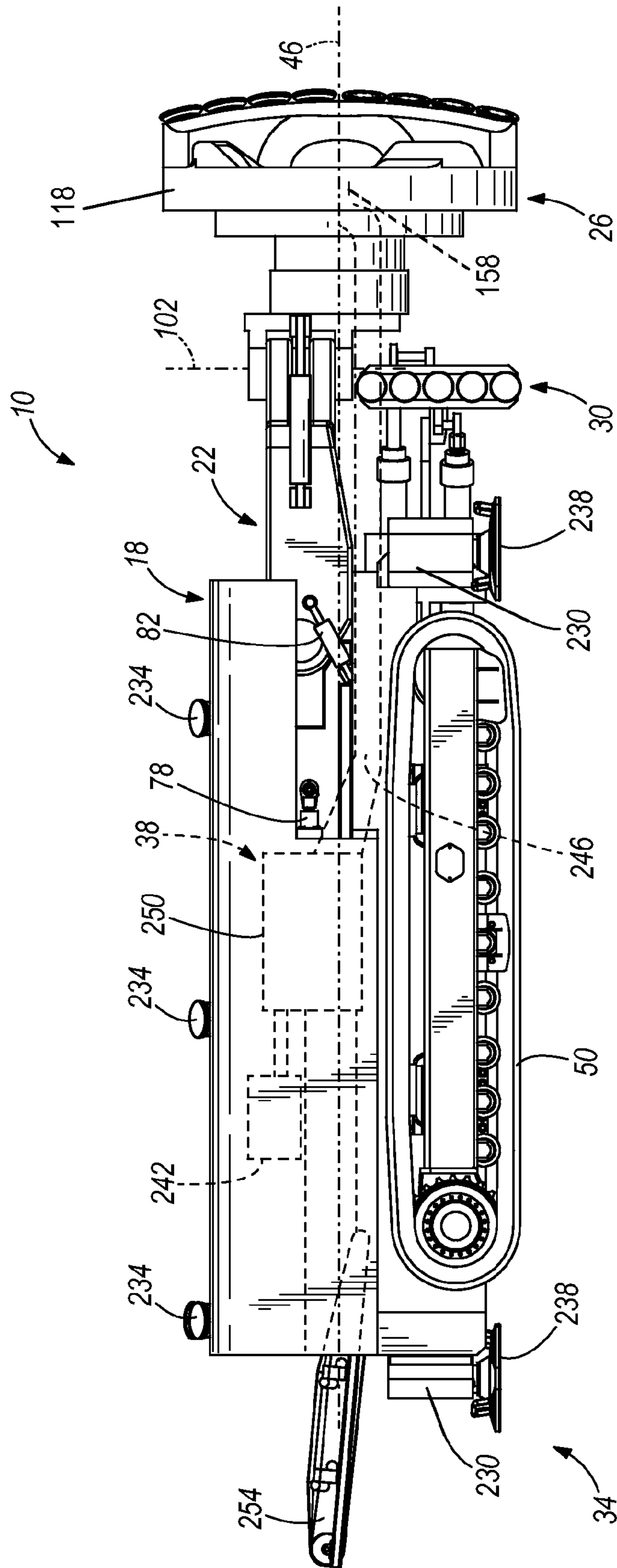
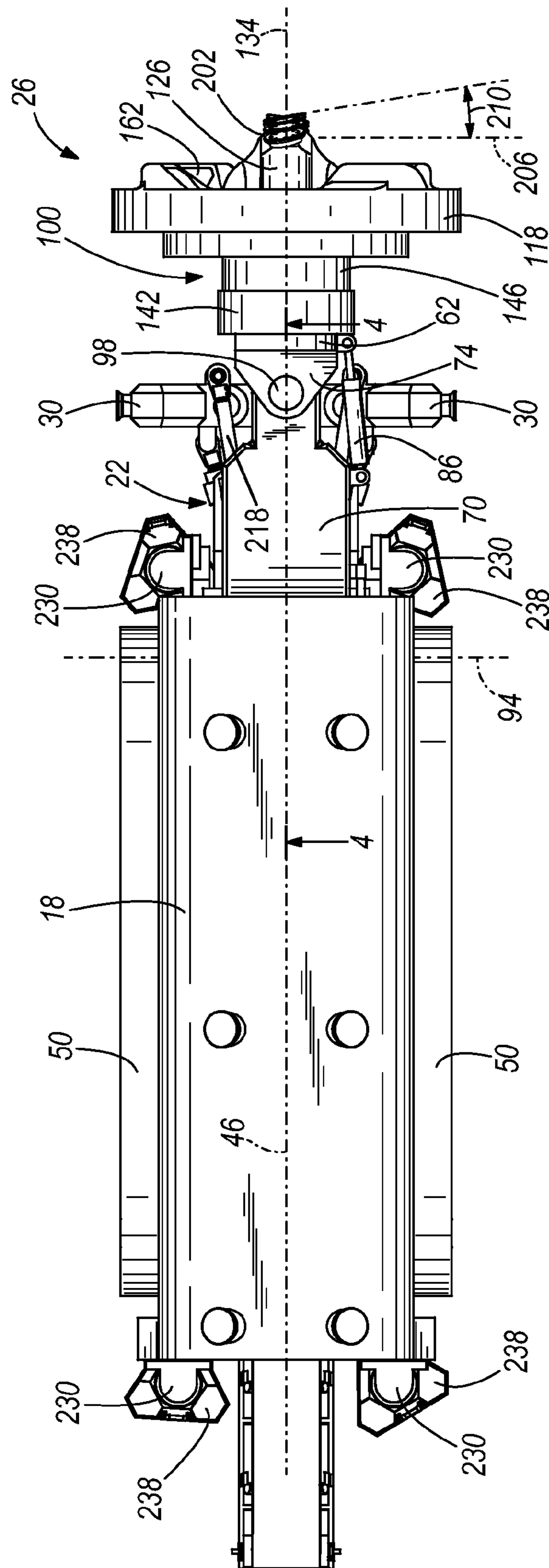
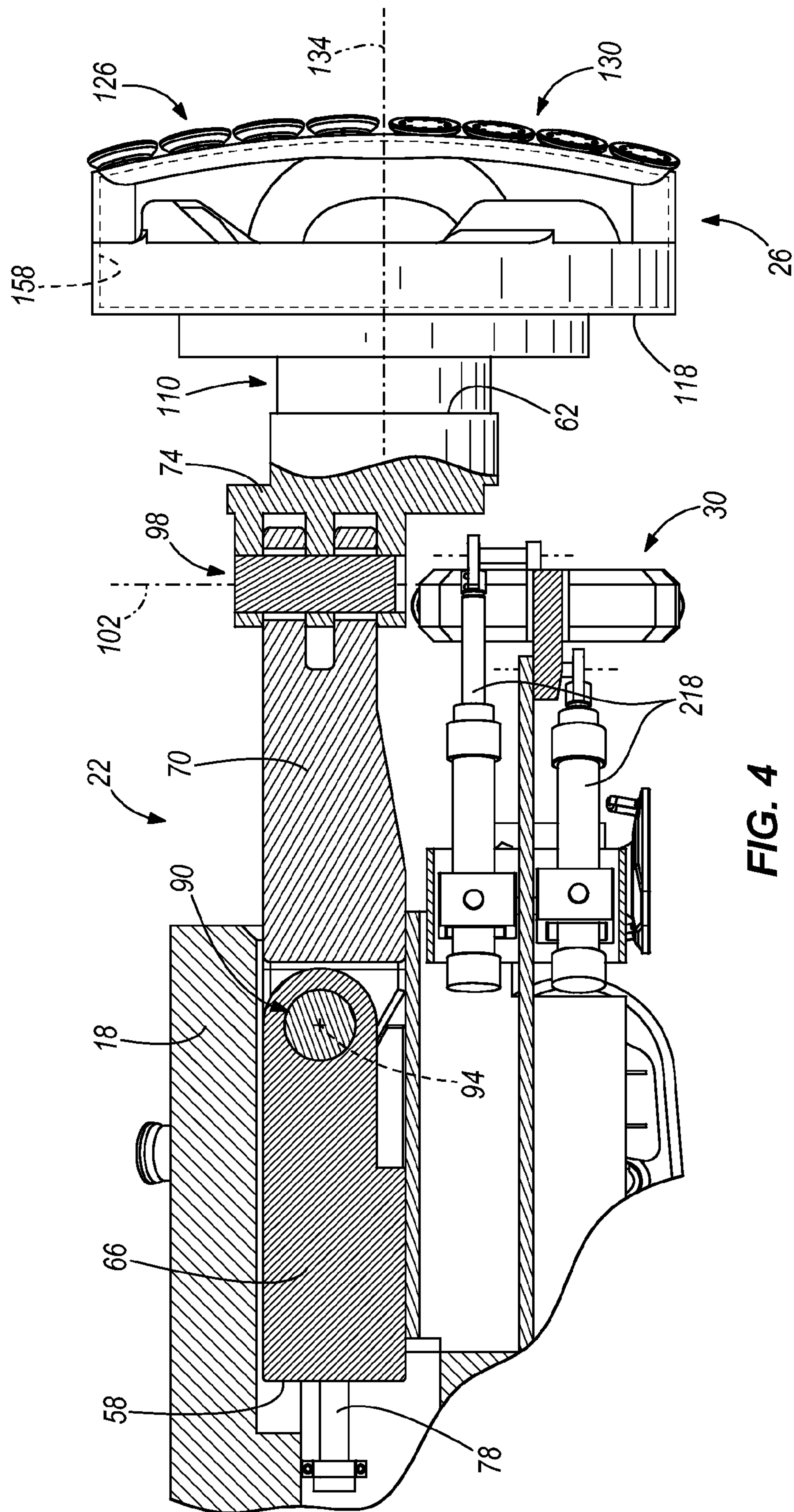


FIG. 2

3/8

**FIG. 3**

4/8

**FIG. 4**

5/8

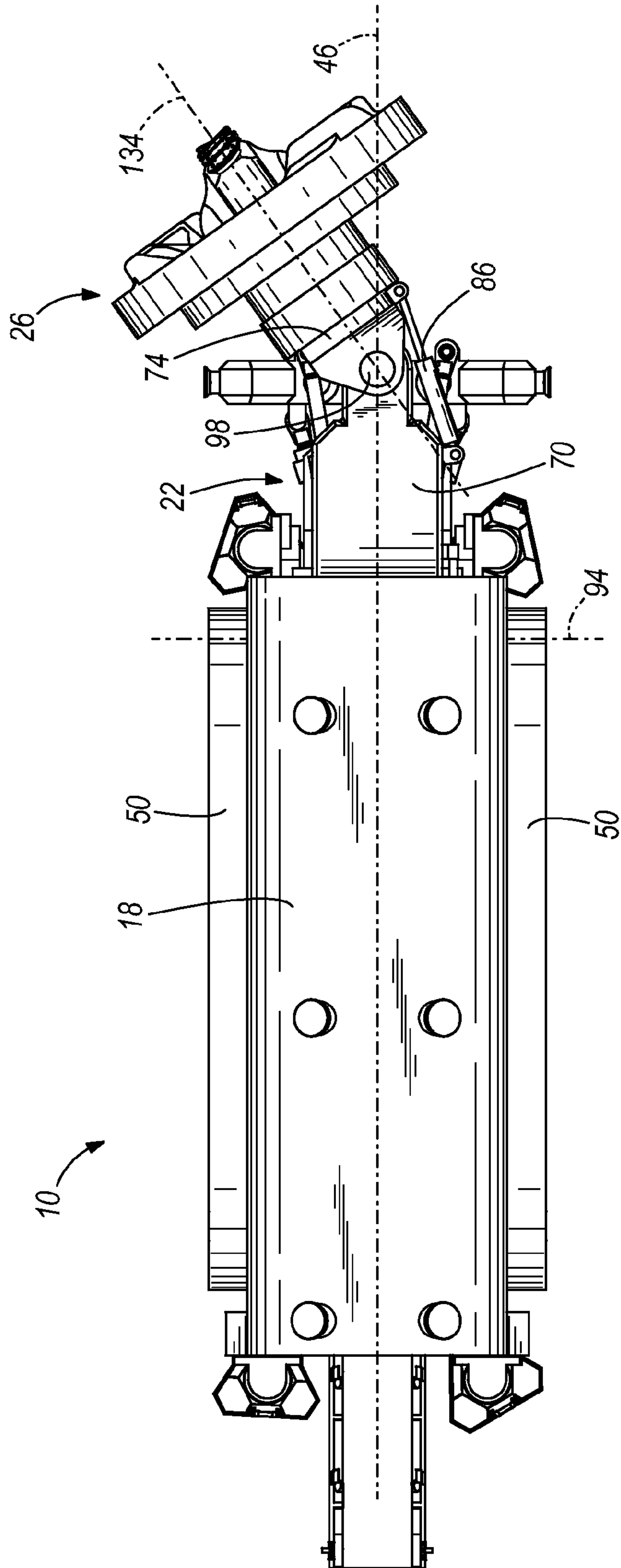
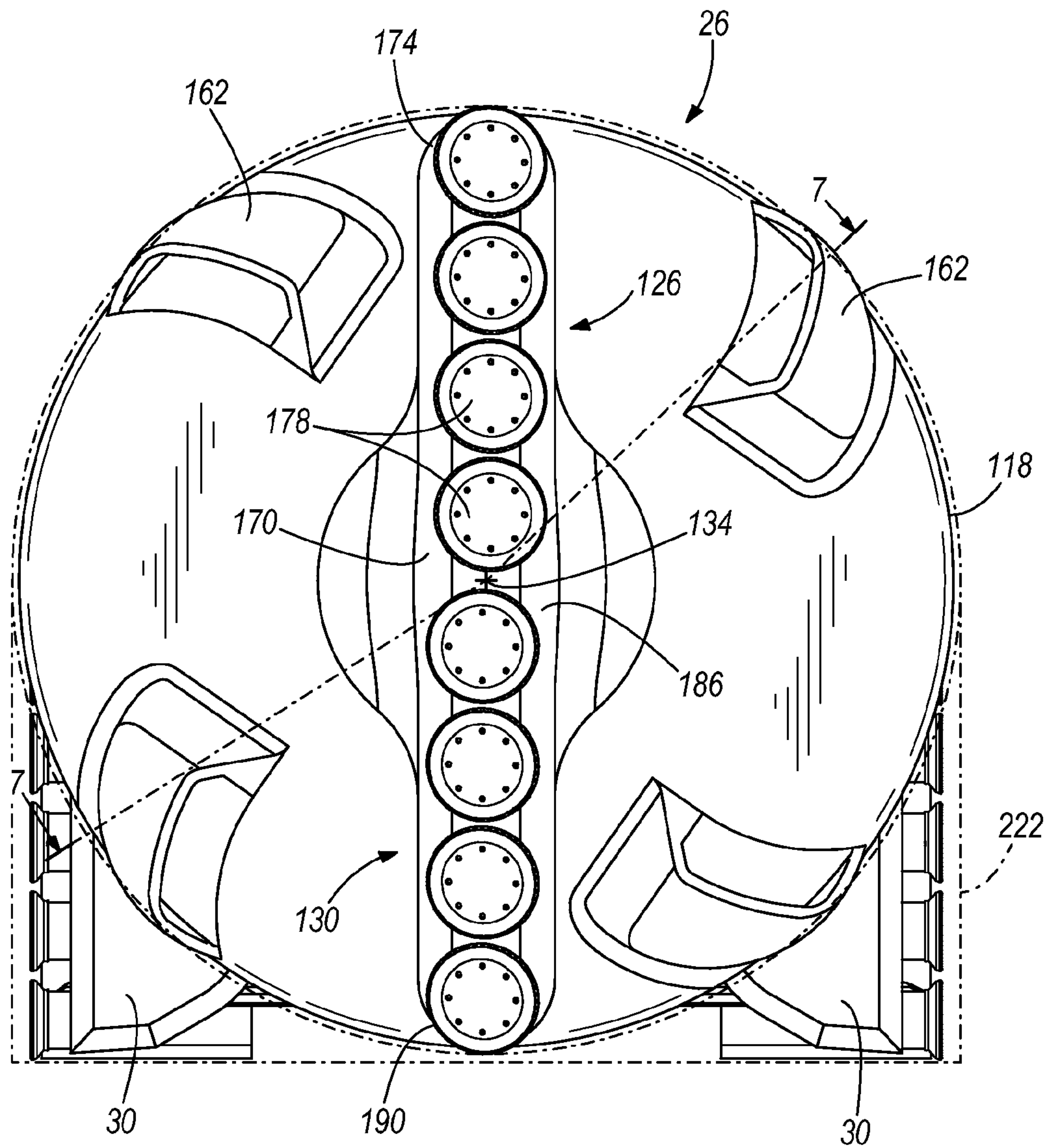
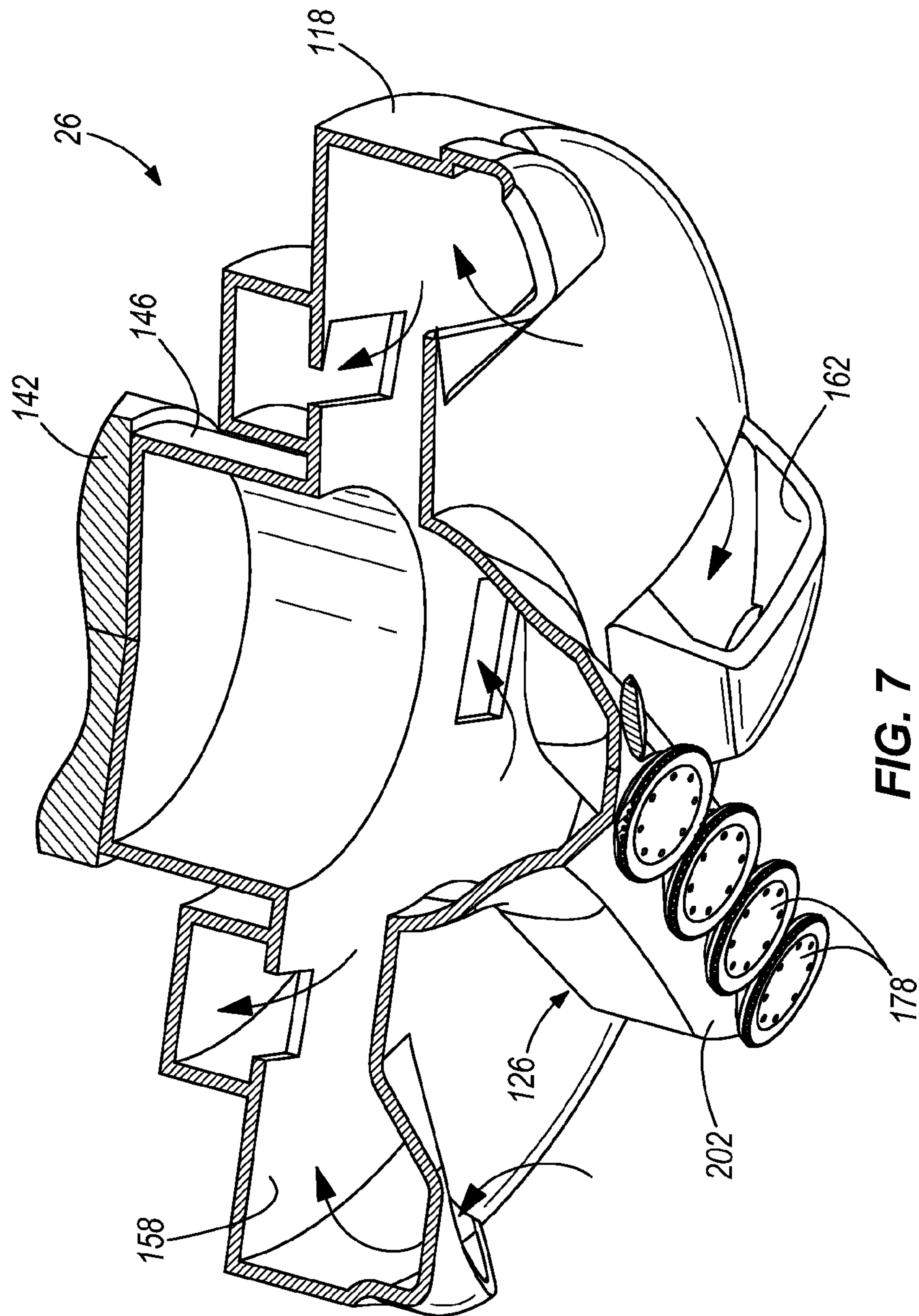


FIG. 5

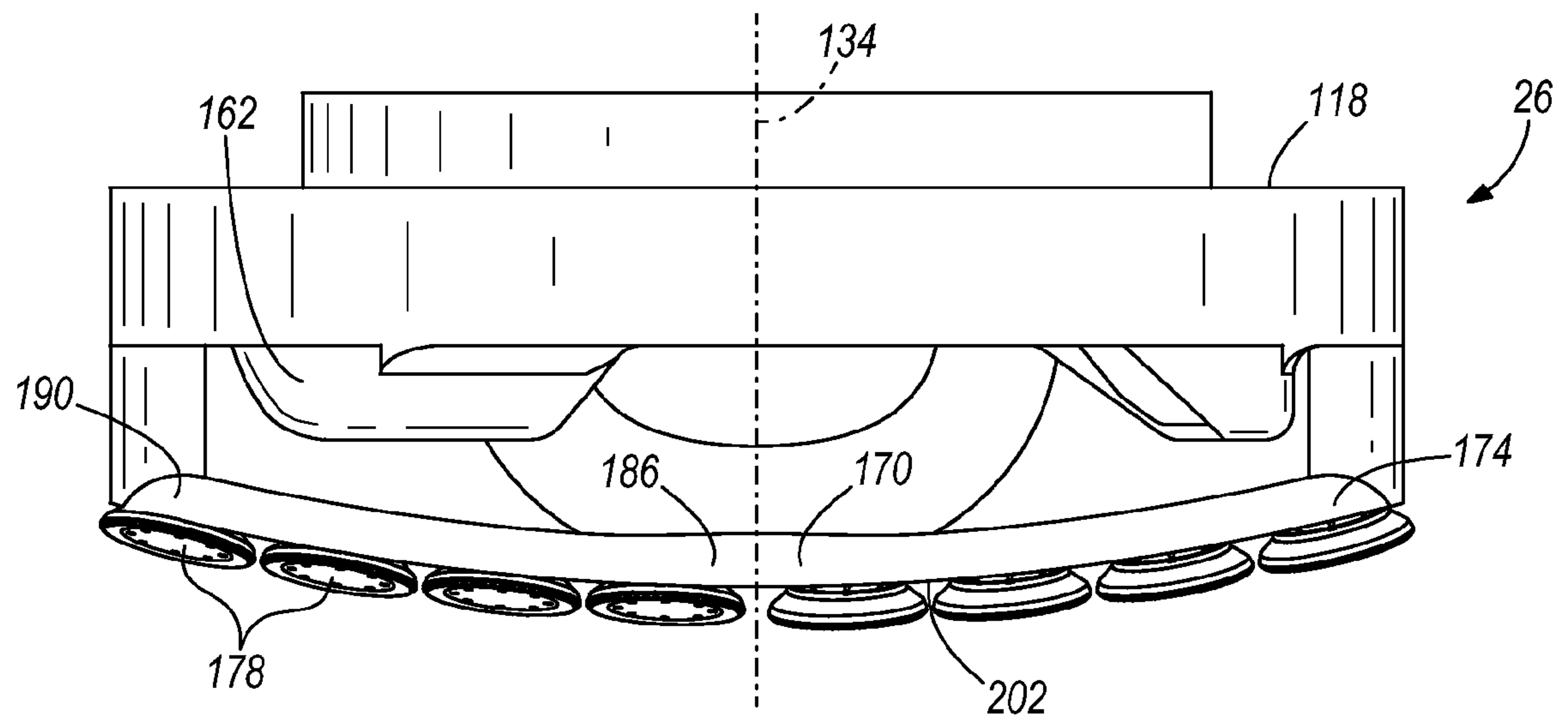
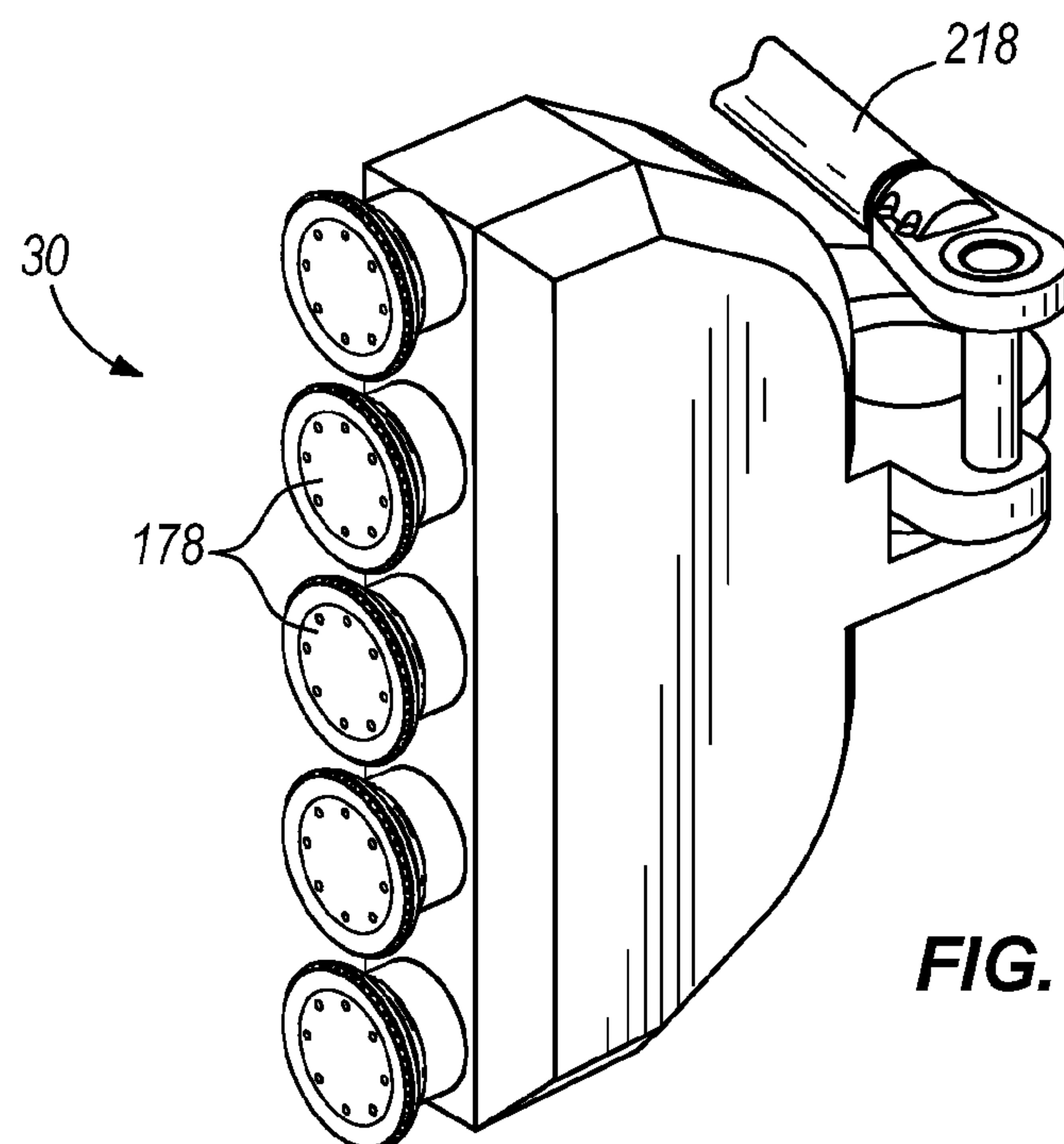
6/8

**FIG. 6**

7/8



8/8

**FIG. 8****FIG. 9**

