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(54) Title: SYSTEM AND METHOD FOR LEG RETENTION ON HYBRID BITS

(57) Abstract: An earth boring drill bit comprising: one or more legs; a bit body having a blade and a slot for receiving the leg; and one or more wedge between the leg and the slot fixing the leg within the slot. The slot may have two parallel sidewalls with one of the sidewalls forming an acute angle and the other forming an obtuse angle. The wedge may be secured immediately next to the ob - ruse angled sidewalk The wedge may have two obtuse angled sides. One or more bolts through each wedge may secure both the wedge and the leg to the bit body. In a preferred embodiment, an obtuse angled sidewall of the wedge is preferably secured immedi - ately next to an acute angled side of the leg.

[0001] TITLE OF THE INVENTION

[0002] System and Method for Leg Retention on Hybrid Bits

[0003] CROSS REFERENCE TO RELATED APPLICATIONS

[0004] The present application claims priority benefit of U.S. Application Serial No. 12/1 14,537, filed May 2, 2008 and entitled "System and Method for Leg Retention on Hybrid Bits", which is incorporated herein by specific reference.

[0005] STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0006] Not applicable.

[0007] REFERENCE TO APPENDIX

[0008] Not applicable.

[0009] BACKGROUND OF THE INVENTION

[0010] Field of the Invention. The present inventions relate in general to earth-boring drill bits and, in particular, to a bit having a combination of rolling and fixed cutters and cutting elements and a method of drilling with same.

[001 1] Description of the Related Art.

[0012] U.S. Pat. No. 3,294,1 86 discloses the use of nickel shims for brazing of rock bit components.

[0013] U.S. Pat. No. 3,907,1 91 discloses a "rotary rock bit is constructed from a multiplicity of individual segments. Each individual segment includes two parting faces and a gage cutting surface. The individual segments are positioned adjacent each other with the parting faces of the adjacent segments in abutting relationship to one another. A ring gage is positioned around the segments and the individual segments are moved

relative to one another causing the parting faces of an individual segment to slide against the parting faces of the adjacent segments. The segments are moved until the gage cutting surfaces of the segments contact the ring gage thereby insuring that the finished bit will have the desired gage size. The segments are welded together over a substantial portion of the parting faces."

[0014] U.S. Pat. No. 5,439,067 discloses a "rotary cone drill bit for forming a borehole having a one-piece bit body with a lower portion having a convex exterior surface and an upper portion adapted for connection to a drill string. A number of support arms are preferably attached to the bit body and depend therefrom. Each support arm has an inside surface with a spindle connected thereto and an outer surface. Each spindle projects generally downwardly and inwardly with respect to the associated support arm. A number of cone cutter assemblies equal to the number of support arms are mounted on each of the spindles. The support arms are spaced on the exterior of the bit body to provide enhanced fluid flow between the lower portion of the bit body and the support arms. Also, the length of the support arms is selected to provide enhanced fluid flow between the associated cutter cone assembly and the lower portion of the bit body. The same bit body may be used with various rotary cone drill bits having different gauge diameters."

[0015] U.S. Pat. No. 5,439,068 discloses a "rotary cone drill bit for forming a borehole having a one-piece bit body with a lower portion having a convex exterior surface and an upper portion adapted for connection to a drill string. The drill bit will generally rotate around a central axis of the bit body. A number of support arms are preferably attached to pockets formed in the bit body and depend therefrom. Each support arm has an inside surface with a spindle connected thereto and an outer surface. Each spindle projects generally downwardly and inwardly with respect to the longitudinal axis of the associated support arm and the central axis of the bit body. A number of cone cutter assemblies equal to the number of support arms are mounted respectively on each of the spindles. The spacing between each of the support arms along with their respective length and width dimensions are selected to enhance fluid flow between the cutter cone assemblies mounted

on the respective support arms and the lower portion of the bit body. A lubricant reservoir is preferably provided in each support arm to supply lubricant to one or more bearing assemblies disposed between each cutter cone assembly and its associated spindle. Either matching openings and posts or matching keyways and keys may be used to position and align a portion of each support arm within its associated pocket during fabrication of the resulting drill bit."

[0016] U.S. Pat. No. 5,595,255 discloses a "rotary cone drill bit for forming a borehole having a bit body with an upper end portion adapted for connection to a drill string. The drill bit rotates around a central axis of the body. A number of support arms are preferably extend from the bit body. The support arms may either be formed as an integral part of the bit body or attached to the exterior of the bit body in pockets sized to receive the associated support arm. Each support arm has a lower portion with an inside surface and a spindle connected thereto and an outer shirttail surface. Each spindle projects generally downwardly and inwardly with respect to its associated support arm. A number of cutter cone assemblies equal to the number of support arms are mounted respectively on the spindles. A throat relief area is provided on the lower portion of each support arm adjacent to the associated spindle to increase fluid flow between the support arm and the respective cutter cone assembly."

[0017] U.S. Pat. No. 5,606,895 discloses a "rotary cone drill bit having a one-piece bit body with a lower portion having a convex exterior surface and an upper portion adapted for connection to a drill string. The drill bit will generally rotate around a central axis of the bit body to form a borehole. A number of support arms are preferably attached to pockets formed in the bit body and depend therefrom. The bit body and support arms cooperate with each other to reduce initial manufacturing costs and to allow rebuilding of a worn drill bit. Each support arm has an inside surface with a spindle connected thereto and an outer shirttail surface. Each spindle projects generally downwardly and inwardly with respect to the longitudinal axis of the associated support arm and the central axis of the bit body. A number of cone

cutter assemblies equal to the number of support arms are mounted respectively on each of the spindles. The radial spacing of the support arms on the perimeter of the associated bit body along with their respective length and width dimensions are selected to enhance fluid flow between the cutter cone assemblies mounted on the respective support arms and the lower portion of the bit body. The resulting drill bit provides enhanced fluid flow, increased seal and bearing life, improved downhole performance and standardization of manufacturing and design procedures."

[0018] U.S. Pat. No. 5,624,002 discloses a "rotary cone drill bit having a one-piece bit body with a lower portion having a convex exterior surface and an upper portion adapted for connection to a drill string. The drill bit will generally rotate around a central axis of the bit body to form a borehole. A number of support arms are preferably attached to pockets formed in the bit body and depend therefrom. The bit body and support arms cooperate with each other to reduce initial manufacturing costs and to allow rebuilding of a worn drill bit. Each support arm has an inside surface with a spindle connected thereto and an outer shirttail surface. Each spindle projects generally downwardly and inwardly with respect to the longitudinal axis of the associated support arm and the central axis of the bit body. A number of cone cutter assemblies equal to the number of support arms are mounted respectively on each of the spindles. The radial spacing of the support arms on the perimeter of the associated bit body along with their respective length and width dimensions are selected to enhance fluid flow between the cutter cone assemblies mounted on the respective support arms and the lower portion of the bit body. The resulting drill bit provides enhanced fluid flow, increased seal and bearing life, improved downhole performance and standardization of manufacturing and design procedures."

[0019] U.S. Design Patent No. D372,253 shows a support arm and rotary cone for modular drill bit.

[0020] The inventions disclosed and taught herein are directed to an improved hybrid bit having a combination of rolling and fixed cutters and cutting elements.

[0021] BRIEF SUMMARY OF THE INVENTION

[0022] The inventions disclosed and taught herein are directed to an earth boring drill bit comprising: one or more legs; a bit body having a blade and a slot for receiving the leg; and one or more wedge between the leg and the slot fixing the leg within the slot. The slot may have two parallel sidewalls with one of the sidewalls forming an acute angle and the other forming an obtuse angle. The wedge may be secured immediately next to the obtuse angled sidewall. The wedge may have two obtuse angled sides. The bit may include one or more bolts through each wedge to secure both the wedge and the leg to the bit body. In alternative embodiments, the slot may have two sidewalls that are not parallel to each other, such as with a first one of the sidewalls extending about straight outwardly from an axial center of the bit body. In this case, the wedge is preferably secured immediately next to this first sidewall. In most cases, however, an obtuse angled sidewall of the wedge is preferably secured immediately next to an acute angled side of the leg.

[0023] BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0024] FIG. 1 is a bottom plan view of an embodiment of a hybrid earth-boring bit;

[0025] FIG. 2 is a side elevation view of an embodiment of the hybrid earth-boring bit of FIG. 1;

[0026] FIG. 3 is an exploded view of another embodiment of the hybrid earth-boring bit of FIG. 1 constructed in accordance with the present invention;

[0027] FIG. 4 is a composite rotational side view of the hybrid earth-boring drill bit of FIG. 1;

[0028] FIG. 5 is a simplified side view of the hybrid earth-boring drill bit of FIG. 1 constructed in accordance with the present invention; and

[0029] FIG. 6 is a simplified cross-sectional plan view of the hybrid earth-boring drill bit of FIG. 1 constructed in accordance with the present invention;

[0030] FIG. 7 is an exploded view of FIG. 6; and

[0031] FIG. 8 is an simplified cross-sectional elevation view of the hybrid earth-boring drill bit of FIG. 1 constructed in accordance with the present invention.

[0032] DETAILED DESCRIPTION OF THE INVENTION

[0033] The Figures described above and the written description of specific structures and functions below are not presented to limit the scope of what Applicants have invented or the scope of the appended claims. Rather, the Figures and written description are provided to teach any person skilled in the art to make and use the inventions for which patent protection is sought. Those skilled in the art will appreciate that not all features of a commercial embodiment of the inventions are described or shown for the sake of clarity and understanding. Persons of skill in this art will also appreciate that the development of an actual commercial embodiment incorporating aspects of the present inventions will require numerous implementation-specific decisions to achieve the developer's ultimate goal for the commercial embodiment. Such implementation-specific decisions may include, and likely are not limited to, compliance with system-related, business-related, government-related and other constraints, which may vary by specific implementation, location and from time to time. While a developer's efforts might be complex and time-consuming in an absolute sense, such efforts would be, nevertheless, a routine undertaking for those of skill in this art having benefit of this disclosure. It must be understood that the inventions disclosed and taught herein are susceptible to numerous and various modifications and alternative forms. Lastly, the use of a singular term, such as, but not limited to, "a," is not intended as limiting of the number of items. Also, the use of relational terms, such as, but not limited to, "top," "bottom," "left," "right," "upper," "lower," "down," "up," "side," and the like are used in the

written description for clarity in specific reference to the Figures and are not intended to limit the scope of the invention or the appended claims.

[0034] Applicants have created an earth boring drill bit comprising: one or more legs; a bit body having a blade and a slot for receiving the leg; and one or more wedge between the leg and the slot fixing the leg within the slot. The slot may have two parallel sidewalls with one of the sidewalls forming an acute angle and the other forming an obtuse angle. The wedge may be secured immediately next to the obtuse angled sidewall. The wedge may have two obtuse angled sides. The bit may include one or more bolts through each wedge to secure both the wedge and the leg to the bit body. In alternative embodiments, the slot may have two sidewalls that are not parallel to each other, such as with a first one of the sidewalls extending about straight outwardly from an axial center of the bit body. In this case, the wedge is preferably secured immediately next to this first sidewall. In most cases, however, an obtuse angled sidewall of the wedge is preferably secured immediately next to an acute angled side of the leg.

[0035] Referring to FIGS. 1-2, an illustrative embodiment of a modular hybrid earth-boring drill bit is disclosed. The bit 11 may be similar to that shown in U.S. Patent Application Publication No. 20090272582 and/or 20080296068, both of which are incorporated herein by specific reference. The bit 11 comprises a bit body 13 having a longitudinal axis 15 that defines an axial center of the bit body 13. A plurality (e.g., two shown) of bit legs or heads 17 extend from the bit body 13 in the axial direction, parallel to the longitudinal axis 15. Because the legs 17 are secured about the bit body 13, the legs may also protrude radially from the bit body 13. The bit body 13 also has a plurality of fixed blades 19 that extend in the axial direction.

[0036] Rolling cutters 21 are mounted to respective ones of the bit legs 17. Each of the rolling cutters 21 is shaped and located such that every surface of the rolling cutters 21 is radially spaced apart from the axial center 15 by a minimal radial distance 23. A plurality of rolling-cutter cutting inserts or elements 25 are mounted to the rolling cutters 21 and radially spaced apart from the axial center 15 by a minimal radial distance 27. The minimal radial

distances 23, 27 may vary according to the application, and may vary from cutter to cutter, and/or cutting element to cutting element.

[0037] In addition, a plurality of fixed cutting elements 31 are mounted to the fixed blades 19. At least one of the fixed cutting elements 31 may be located at the axial center 15 of the bit body 13 and adapted to cut a formation at the axial center. In one embodiment, the at least one of the fixed cutting elements 31 is within approximately 0.040 inches of the axial center. Examples of rolling-cutter cutting elements 25 and fixed cutting elements 31 include tungsten carbide inserts, cutters made of super-hard material such as polycrystalline diamond, and others known to those skilled in the art.

[0038] FIG. 3 illustrates the modular aspect of the bit 11. FIG. 3 is an exploded view of the various parts of the bit 111 disassembled. The illustrative embodiment of FIG. 3 is a three-cutter, three-blade bit. The modular construction principles of the present invention are equally applicable to the two-cutter, two-blade bit 11 of FIGS. 1 and 2, and hybrid bits with any combination of fixed blades and rolling cutters.

[0039] As illustrated, bit 111 comprises a shank portion or section 113, which is threaded or otherwise configured at its upper extent for connection into a drillstring. At the lower extent of shank portion 113, a generally cylindrical receptacle 115 is formed. Receptacle 115 receives a correspondingly shaped and dimensioned cylindrical portion 117 at the upper extent of a bit body portion 119. Shank 113 and body 119 portions are joined together by inserting the cylindrical portion 117 at the upper extent of body portion 119 into the cylindrical receptacle 115 in the lower extent of shank 113. For the 12-1/4 inch bit shown, the receptacle is a Class 2 female thread that engages with a mating male thread at the upper extent of the body. The circular seam or joint is then continuously bead welded to secure the two portions or sections together. Receptacle 115 and upper extent 117 need not be cylindrical, but could be other shapes that mate together, or could be a sliding or running fit relying on the weld for strength. Alternatively, the joint could be strengthened by a close interference fit between upper extent 119

and receptacle 115. Tack welding around, and/or fully welding, the seam could also be used.

[0040] A bit leg or head 17,121 (three are shown) is received in an axially extending slot 123 (again, there is a slot 123 for each leg or head 121). The slot 123 may be dovetailed (and leg 121 correspondingly shaped) so that only axial sliding of leg 121 is permitted and leg 121 resists radial removal from slot 123. A plurality (four) of bolts 127 and washers secure each leg 121 in slot 123 so that leg 121 is secured against axial motion in and removal from slot 123. A rolling cutter 125 is secured on a bearing associated with each leg 121 by a ball lock and seal assembly 129. The apertures in leg 121 through which bolts 127 extend may be oblong and/or oversized, to permit the axial and/or radial positioning of leg 121 within slot 123, which in turn permits selection of the relative projection of the cutting elements on each rolling cutter. A lubricant compensator assembly 131 is also carried in each leg 121 and supplies lubricant to the bearing assembly and compensates for pressure variations in the lubricant during drilling operations. At least one nozzle 133 is received and retained in the bit body portion 119 to direct a stream of drilling fluid from the interior of bit 111 to selected locations proximate the cutters and blades of the bit.

[0041] The slot 123 preferably has a pair of adjacent opposing sides 135, 135a, 135b (FIG. 6). As will be discussed in further detail below, the sides 135 may be inclined. A third side 137 (FIG. 6), which may be curved or flat, connects the two opposing sides 135. A blind threaded hole or aperture 139 (FIG. 6) is formed in bit body 13,119 to receive each of the fasteners or bolts 127.

[0042] As shown in FIG. 4, the roller cone cutting elements 25 and the fixed cutting elements 31 combine to define a cutting profile 41 that extends from the axial center 15 to a radially outermost perimeter 43 with respect to the axis. In one embodiment, only the fixed cutting elements 31 form the cutting profile 41 at the axial center 15 and the radially outermost perimeter 43. However, the roller cone cutting elements 25 overlap with the fixed cutting elements 31 on the cutting profile 41 between the axial center 15 and the

radially outermost perimeter 43. The roller cone cutting elements 25 are configured to cut at the nose 45 and shoulder 47 of the cutting profile 41, where the nose 45 is the leading part of the profile (i.e., located between the axial center 15 and the shoulder 47) facing the borehole wall and located adjacent the radially outermost perimeter 43.

[0043] Thus, the roller cone cutting elements 25 and the fixed cutting elements 31 combine to define a common cutting face 51 (FIG. 2) in the nose 45 and shoulder 47, which are known to be the weakest parts of a fixed cutter bit profile. Cutting face 51 is located at a distal axial end of the hybrid drill bit 11. In one embodiment, at least one of each of the roller cone cutting elements 25 and the fixed cutting elements 31 extend in the axial direction at the cutting face 51 at a substantially equal dimension. In one embodiment, the roller cone cutting elements 25 and the fixed cutting elements 31 are radially offset from each other even though they axially align. However, the axial alignment between the distal most elements 25, 31 is not required such that elements 25, 31 may be axially spaced apart by a significant distance when in their distal most position. For example, the roller cone cutting elements 25 or the fixed cutting elements 31 may extend beyond, or may not fully extend to, the cutting face 51. In other words, the roller cone cutting elements 25 may extend to the cutting face 51 with the fixed cutting elements 31 axially offset from the cutting face 51.

[0044] Referring also to FIG. 5, while the legs 17,121 may be welded within the slots 123 of the bit body 13, the legs may additionally, or alternatively, be secured using one or more wedges 201. The wedges 201 may also be welded and/or bolted to the bit body 13, such as by using the fasteners or bolts 127.

[0045] As shown in FIGS. 6 and 7, the sides, sidewalls, 135 of the slot 123 may be inclined. More specifically, a first one of the sides 135a may be inclined toward the other at an acute angle 141, while the other side 135b may be inclined away from the first at an obtuse angle 143. With this construction, the leg 17 is bolted into the slot 123 with a first side 145a resting against the acute angled side 135a of the slot 123, thereby partially locking

the leg 17 in place. An acute angle 147 of the first side 145a of the leg 17,121 , preferably matches the acute angle 141 of the first side 135a of the slot 123. In the preferred embodiment, a second side 145b of the leg 17 is also aligned at an acute angle 149, which may be similar to or exactly the same as the acute angle 147 of the first side 145a of the leg 17. The wedge 201 is then bolted into the slot 123, between the second acute angled side 145b of the leg 17 and the obtuse angled side 135b of the slot 123. Because the wedge 201 preferably has two obtuse angled sides 203, 230a, 230b, which form the shown obtuse angles 151,153, the wedge 201 firmly secures the leg 17 within the slot 123 and the bolts 127 securing the wedge 201 are tightened. Plugs may then be welded over the bolts 127 to prevent rotation of the bolts 127 during operation, thereby further securing the wedge 201 and leg 17 within the slot 123.

[0046] The sidewalls 135 may be parallel, as shown. In this case, with the sidewalls 135 parallel as shown, the bolts 127 holding the leg 17 in place are expected to experience less tension than the bolts 127 holding the wedge 201 in place.

[0047] Alternatively, the side walls 135a, 135b may be angled differently, with respect to an offset from ninety degrees. For example, the first sidewall 135a and/or the second sidewall 135b may be aligned about straight outward from the axial center of the bit body 13, with the angles 141 , being essentially tangentially right angles rather than the shown acute and obtuse angles. In this manner, the sides 135 of the slot 123 may be closer near the axial center of the bit body 13 and angled outwardly and away from each other as they extend outwardly. This configuration would induce considerable tension loads on the bolts 127 holding both the leg 17 and the wedge 201 in place.

[0048] In still another embodiment, the first sidewall 135a may be angled as shown with the second sidewall 135b being aligned about straight outward from the axial center of the bit body 13. The angled sides 203 of the wedge 201 would still press the leg 17 against the first sidewall 135a, thereby pinning the leg 17 in place. Alternatively, a first side 203a of the wedge 201

may be angled as shown, with a second side 203b of the wedge 201 being aligned about straight outward from the axial center of the bit body 13, along with the second sidewall 135b. In this case, the angled side 203a of the wedge 201 would still press the leg 17 against the first sidewall 135a, thereby pinning the leg 17 in place. In any case, however, the sides 203, 203a, 203b of the wedge 201 are not expected to be parallel, but need not have similar angles, with respect to straight outward from the axial center of the bit body 13.

[0049] Referring also to FIG. 8, an axial end 301 of the leg 17 pressing against an axial end 303 of the slot is expected to carry a most, if not all, of the normal axial load of the drilling operation. In some embodiments, the leg 17 may include a radially inwardly extending key 305 that extends into a keyway 307 in the slot 123. In this case, a upper end 309 of the key 305, pressing against the bit body 13, may carry some of the normal axial load of the drilling operation. Perhaps more importantly, however, a lower end 311 of the key 305, pressing against the bit body 13, may carry any reverse axial load experienced by the leg 17, such as from back reaming. This key 305 may also prevent the bolts 127 from carrying much, or any shear loads. In some embodiments, the key 305 may be fixedly secured to the leg 17 and may even take the form of an integral raised area, or boss, which extends into the keyway 307 in the slot 123 to accommodate such loads.

[0050] In any case, the wedge 201 of the present invention overcomes tolerance problems normally associated with module parts and assembly thereof. The wedge 201, and other aspects, of the present invention also minimize or eliminate any need to weld the leg 17 to the bit body 13, thereby further facilitating the assembly processes, while still providing secure assembly of the bit 11. Furthermore, these features substantially simplify bit repair since the few, if any, welded components may be disposed of during rework of the bit 11, as the major components are merely bolted together. For example, the welded plugs may simply be drilled out, thereby providing access to the bolts 127 to remove and/or replace the legs 17, as needed.

[0051] Other and further embodiments utilizing one or more aspects of the inventions described above can be devised without departing from the spirit of the invention. Further, the various methods and embodiments of the present invention can be included in combination with each other to produce variations of the disclosed methods and embodiments. Discussion of singular elements can include plural elements and vice-versa. For example, multiple wedges 201 may be used with each leg 17.

[0052] The order of steps can occur in a variety of sequences unless otherwise specifically limited. The various steps described herein can be combined with other steps, interlineated with the stated steps, and/or split into multiple steps. Similarly, elements have been described functionally and can be embodied as separate components or can be combined into components having multiple functions.

[0053] The inventions have been described in the context of preferred and other embodiments and not every embodiment of the invention has been described. Obvious modifications and alterations to the described embodiments are available to those of ordinary skill in the art. The disclosed and undisclosed embodiments are not intended to limit or restrict the scope or applicability of the invention conceived of by the Applicants, but rather, in conformity with the patent laws, Applicants intend to fully protect all such modifications and improvements that come within the scope or range of equivalent of the following claims.

WHAT IS CLAIMED IS:

1. An earth boring drill bit comprising:
one or more legs;
a bit body having a slot for receiving the leg; and
one or more wedge between the leg and the slot fixing the leg within the slot.

2. The bit of claim 1, wherein the slot has two parallel sidewalls.

3. The bit of claim 2, wherein one of the sidewalls forms an acute angle and the other forms an obtuse angle.

4. The bit of claim 2, wherein the wedge is secured immediately next to the obtuse angled sidewall.

5. The bit of claim 1, wherein the wedge has two obtuse angled sides.

6. The bit of claim 1, further including one or more bolts through each wedge, securing both the wedge and the leg to the bit body.

7. The bit of claim 1, wherein the slot has two sidewalls that are not parallel to each other.

8. The bit of claim 7, wherein a first one of the sidewalls extends about straight outwardly from an axial center of the bit body.

9. The bit of claim 8, wherein the wedge is secured immediately next to the first sidewall.

10. The bit of claim 1, wherein an obtuse angled sidewall of the wedge is secured immediately next to an acute angled side of the leg.

11. The bit of claim 1, wherein a key extends from each leg into the bit body.

12. An earth boring drill bit comprising:

one or more legs with corresponding roller cones;

a bit body having a blade and a slot for receiving the leg, wherein the slot has two parallel sidewalls, such that one of the sidewalls forms an acute angle and the other forms an obtuse angle; and

one or more wedge between the leg and the slot fixing the leg within the slot.

13. The bit of claim 12, wherein the wedge is secured immediately next to the obtuse angled sidewall.

14. The bit of claim 12, further including one or more bolts through each wedge, securing both the wedge and the leg to the bit body.

15. The bit of claim 12, wherein an obtuse angled sidewall of the wedge is secured immediately next to an acute angled side of the leg.

16. The bit of claim 12, wherein a key extends from each leg into the bit body.

17. A method of assembling an earth boring drill bit, the method comprising the steps of:

selecting one or more legs from a plurality of pre-manufactured legs;

selecting a bit body from a plurality of pre-manufactured bit bodies, the bit body having a slot for receiving the leg;

bolting the leg within the slot; and

bolting a wedge, the wedge having at least one angled side, between the leg and a sidewall of the slot, thereby securing the leg within the slot without welding.

18. The method of claim 17, wherein tightening a bolt through the wedge presses the leg against the sidewall of the slot.

19. The method of claim 17, further including placing the wedge immediately next to an obtuse angled sidewall of the slot.

20. The method of claim 17, further including placing the wedge immediately next to an acute angled side of the leg.

FIG. 1

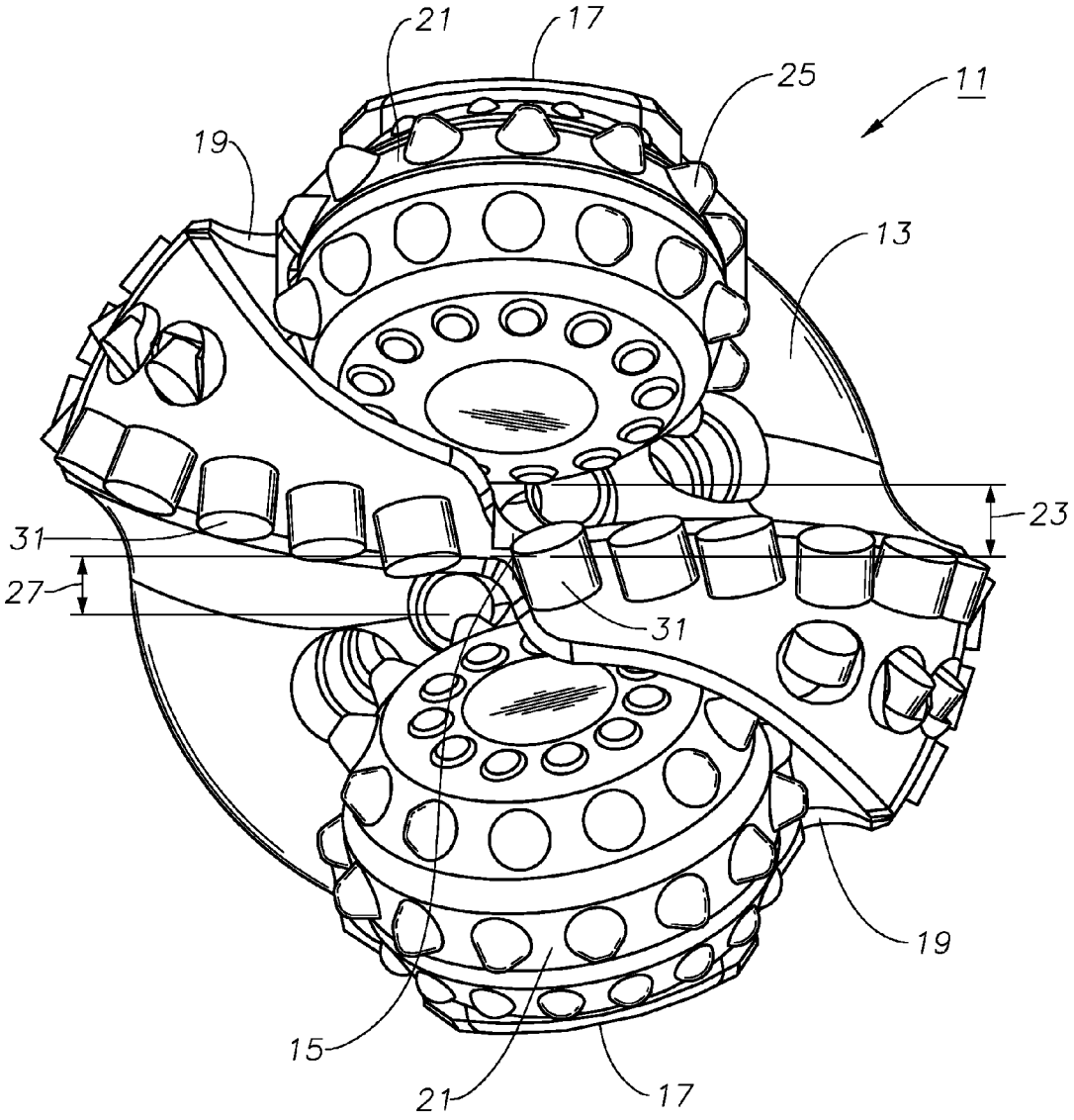


FIG. 2

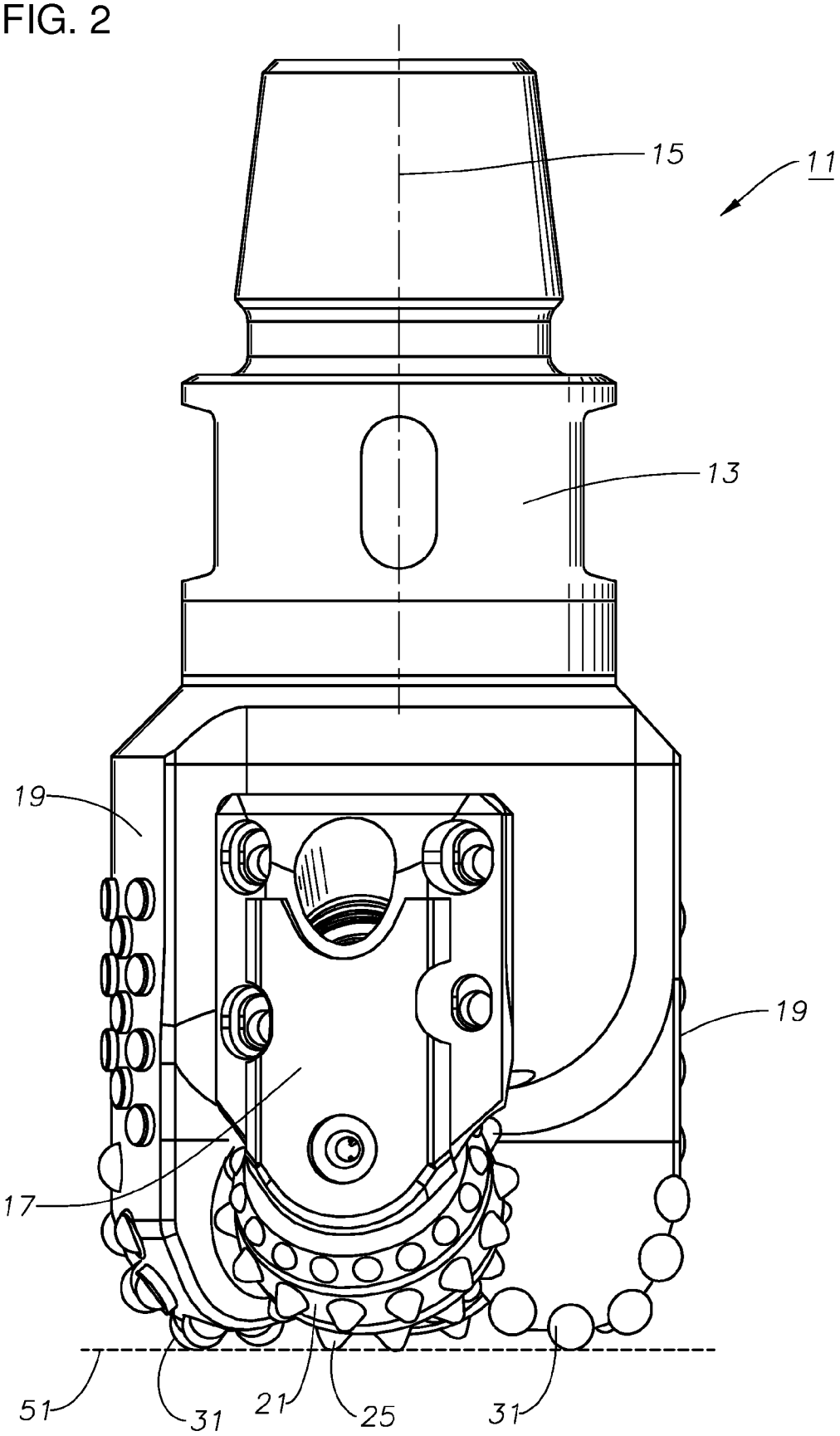
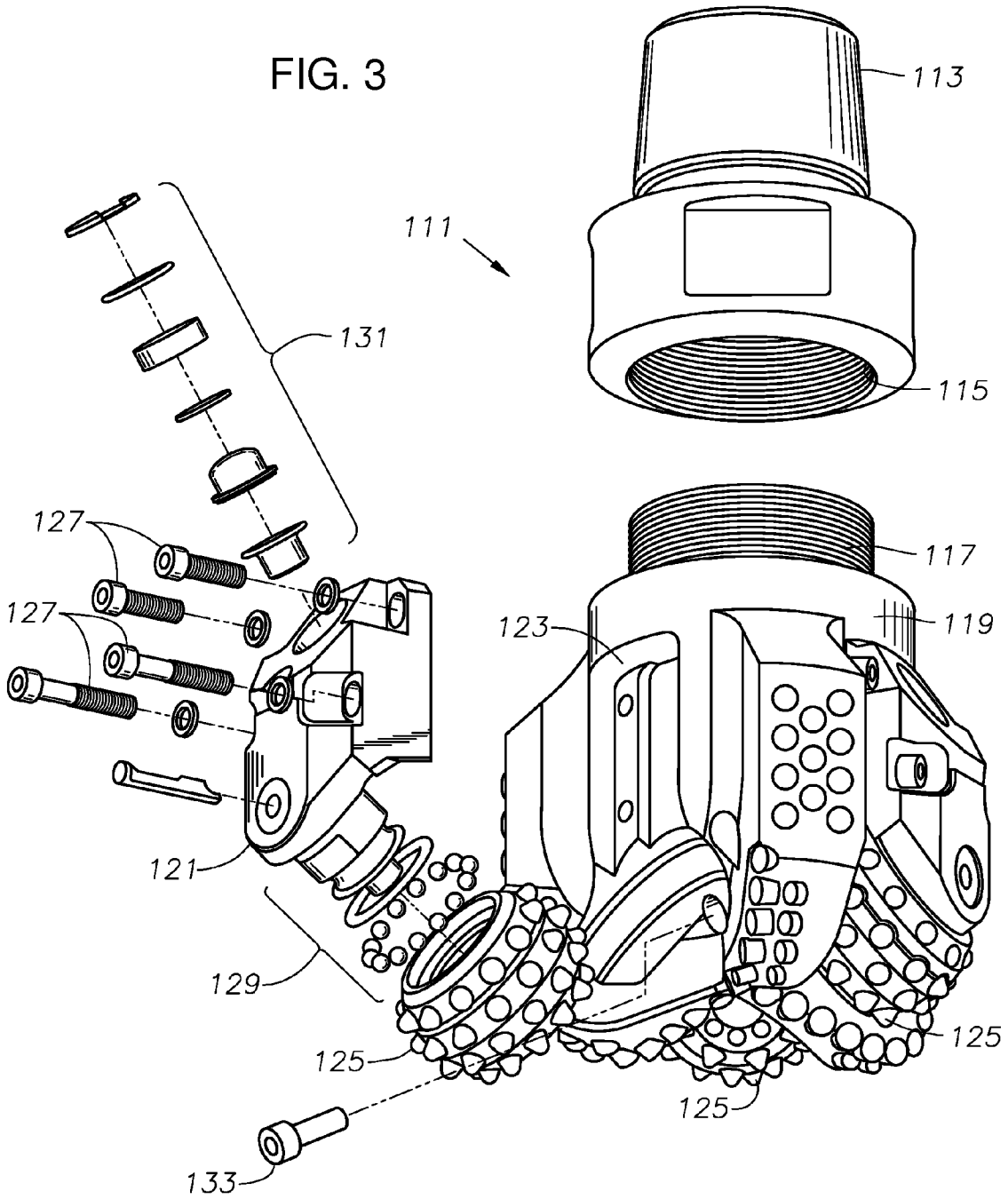


FIG. 3



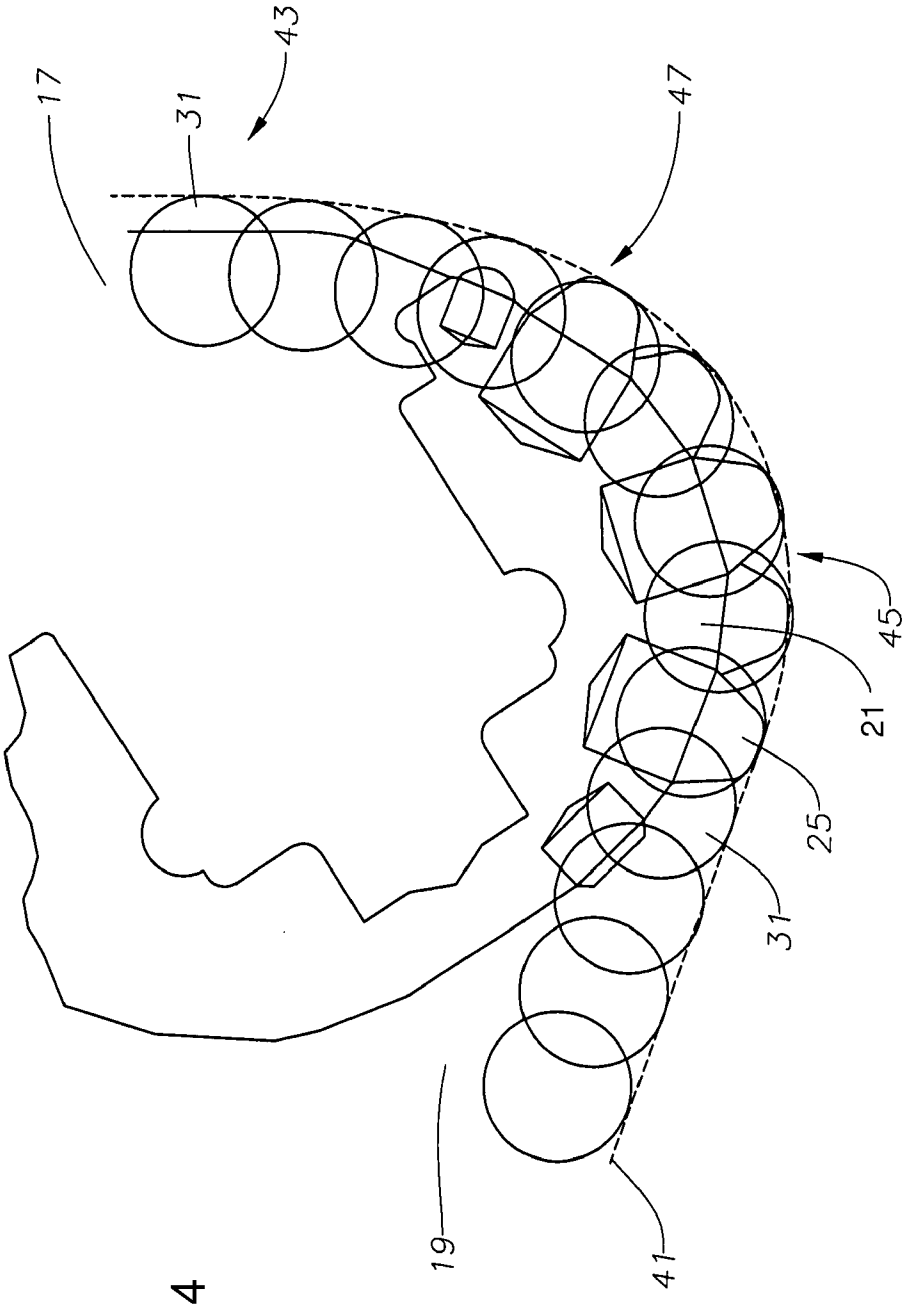


FIG. 4

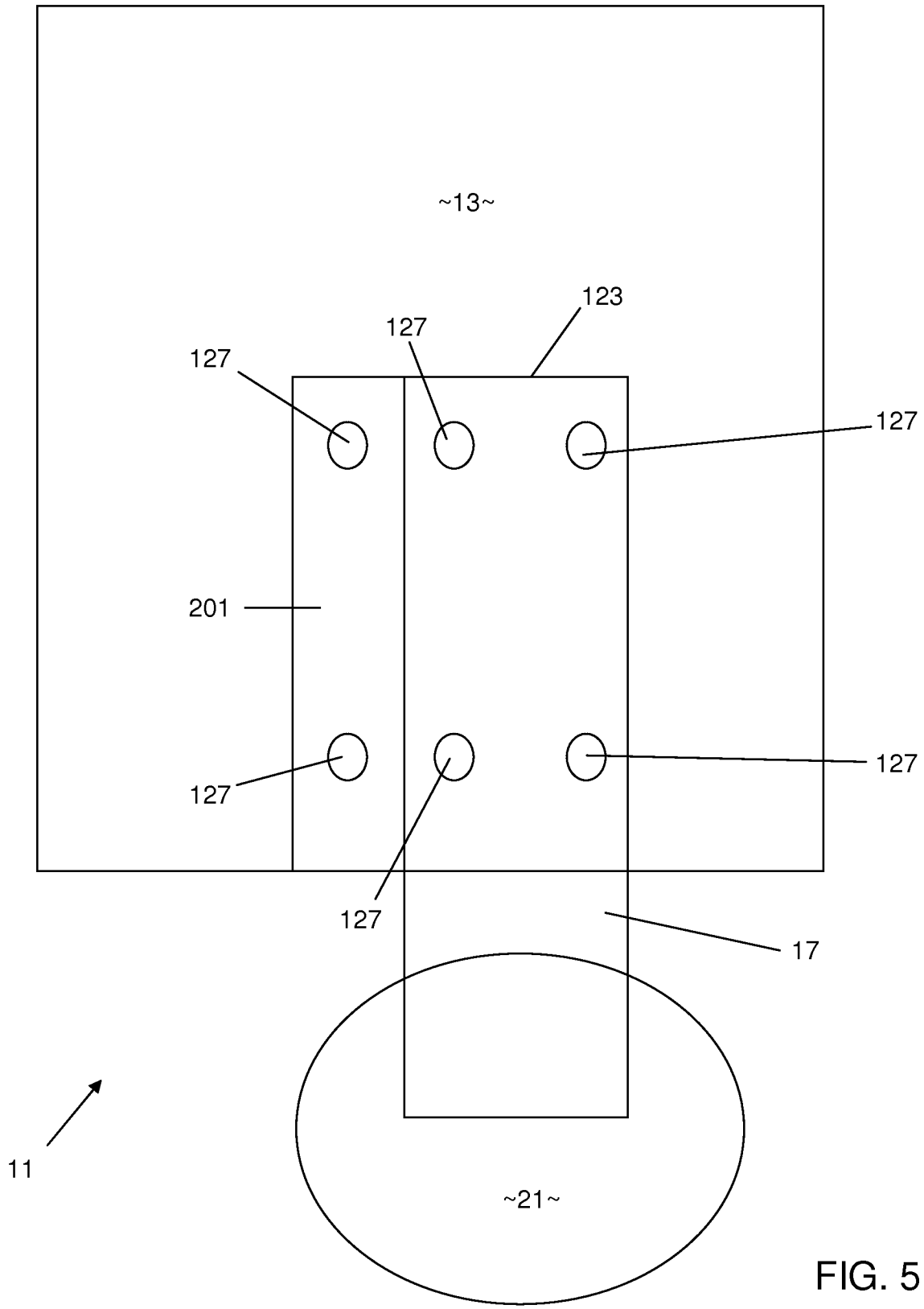


FIG. 5

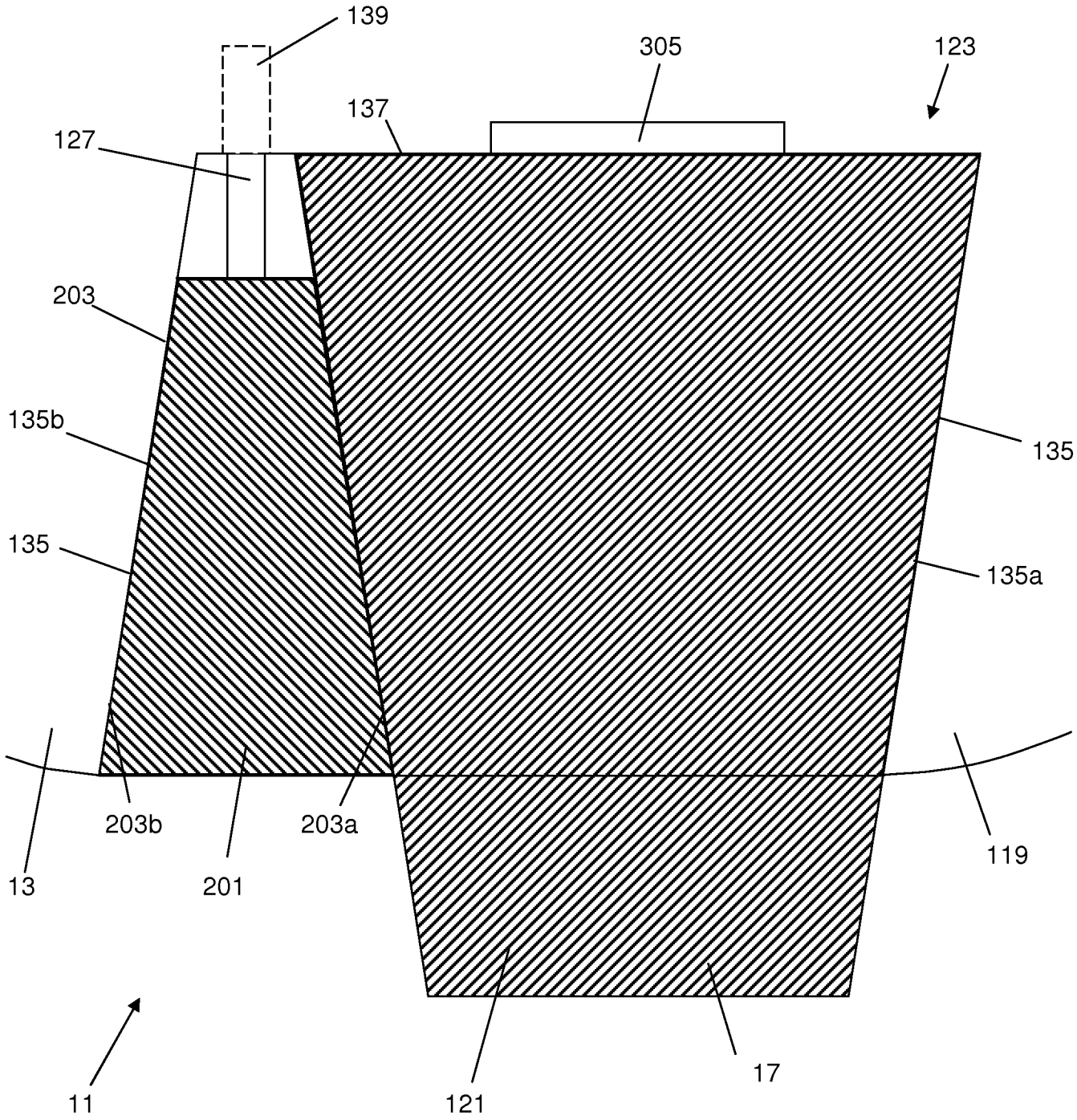
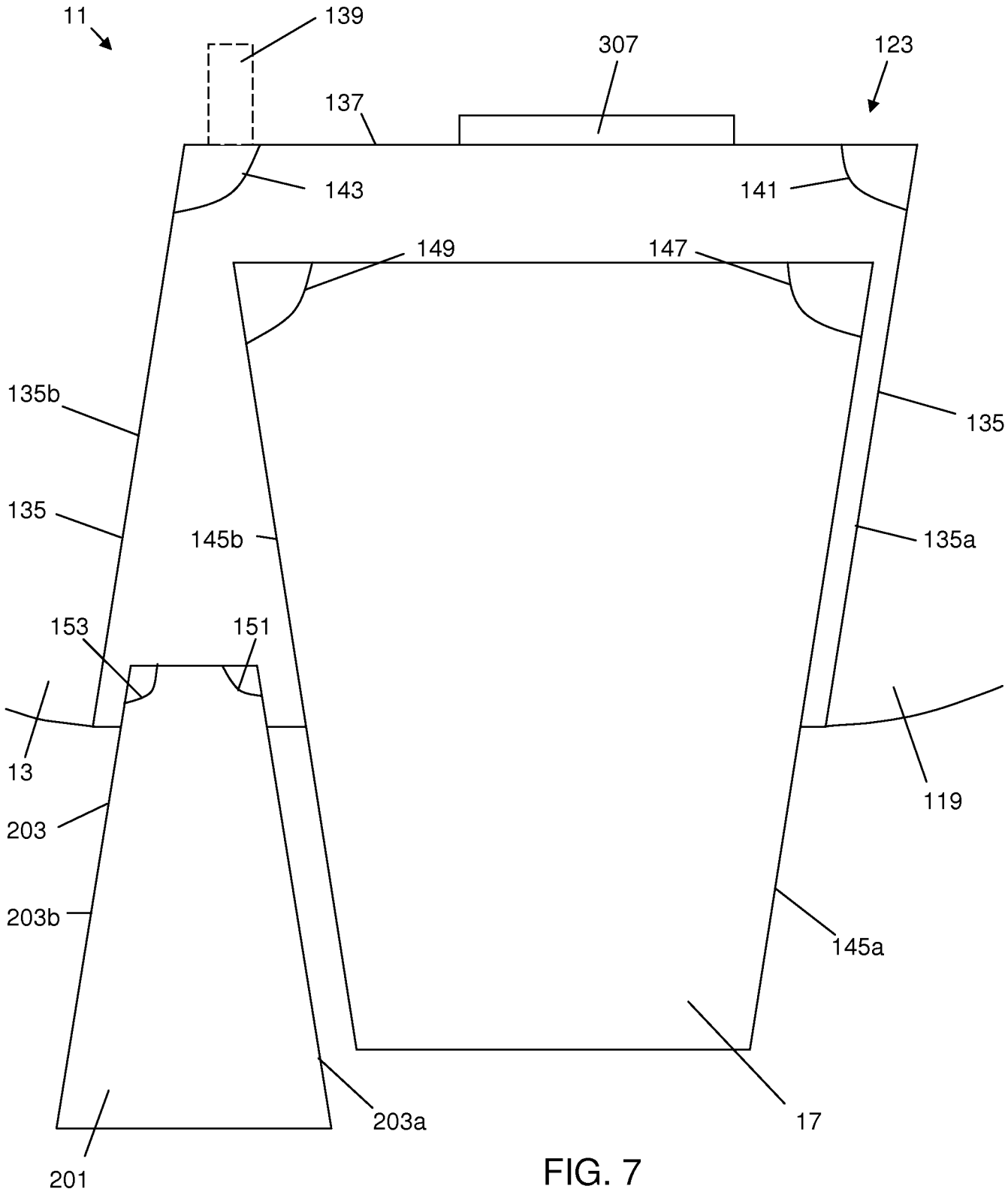

139
305
123
137
127
203
135b
135
135
135a
203b
203a
13
201
119
11
121
17

FIG. 6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141
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145b
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153
151
13
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203
203b
145a
203a
17
201

FIG. 7

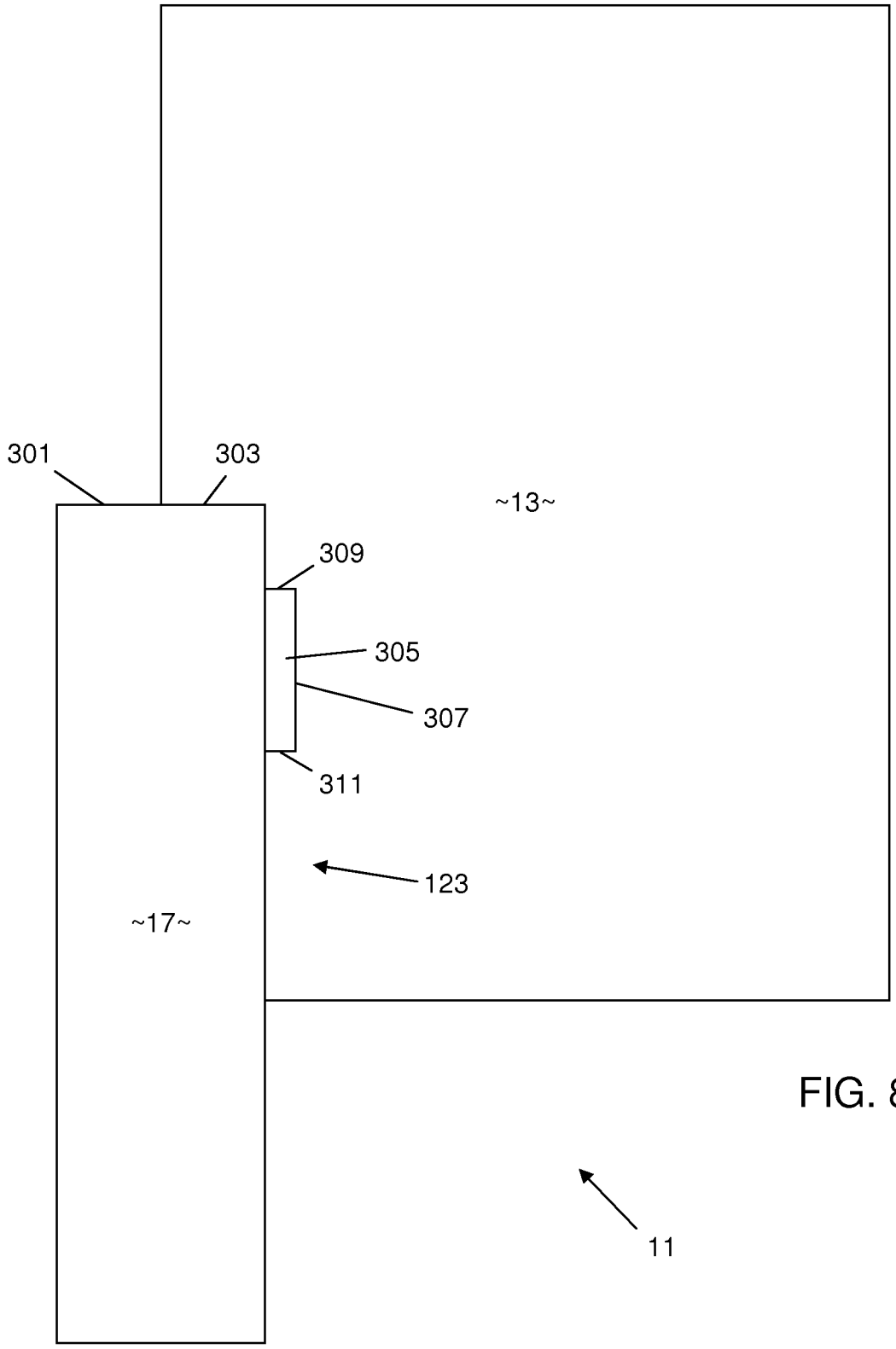

FIG. 8