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(54) **FLOW THROUGH GAUGE FOR DRILL BIT**

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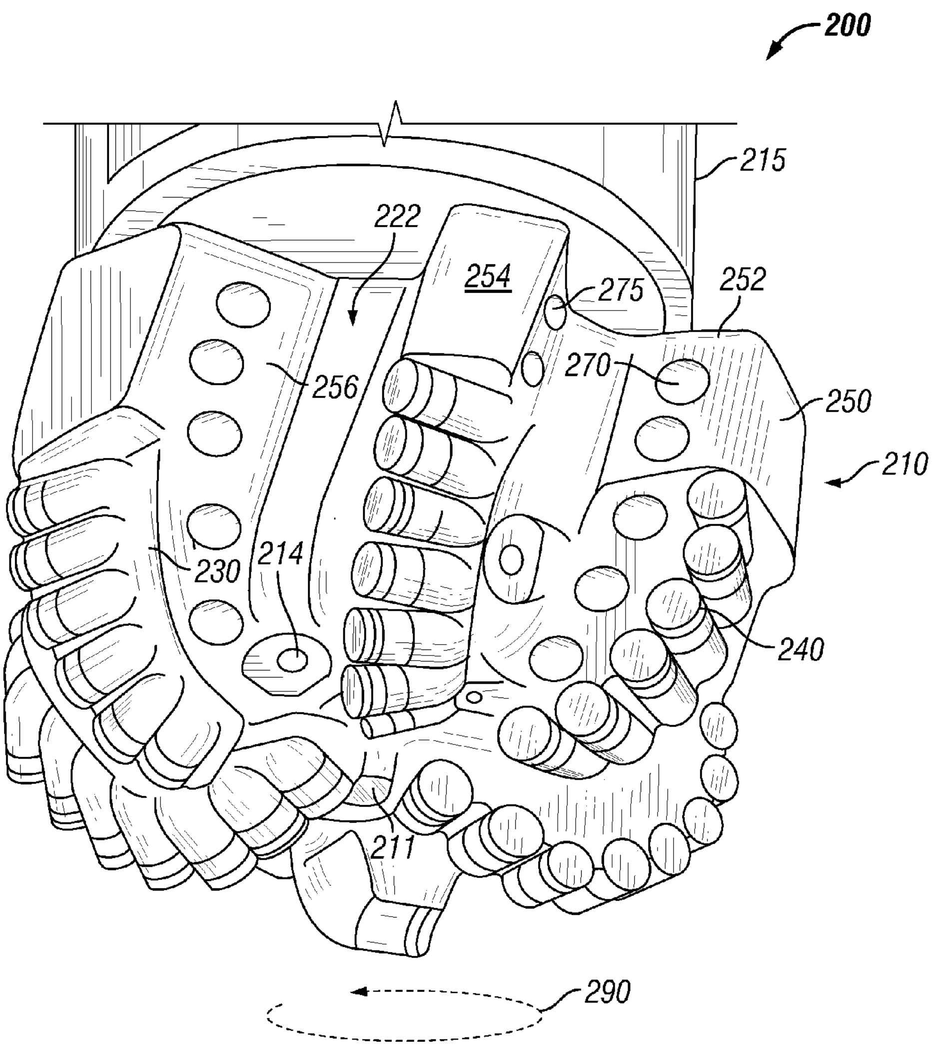
USPC **175/393**

(57) **ABSTRACT**

An apparatus that includes one or more flow channels and method for fabricating such flow channels. The apparatus includes a body, one or more blades from one end of the body, and a corresponding gauge section disposed adjacently and in alignment with a respective blade. Each gauge section includes a leading section, a trailing section, a face section extending from one end of the leading section to an end of the trailing section, and at least one flow channel extending from the leading edge section to at least one of the trailing edge section or the face section.



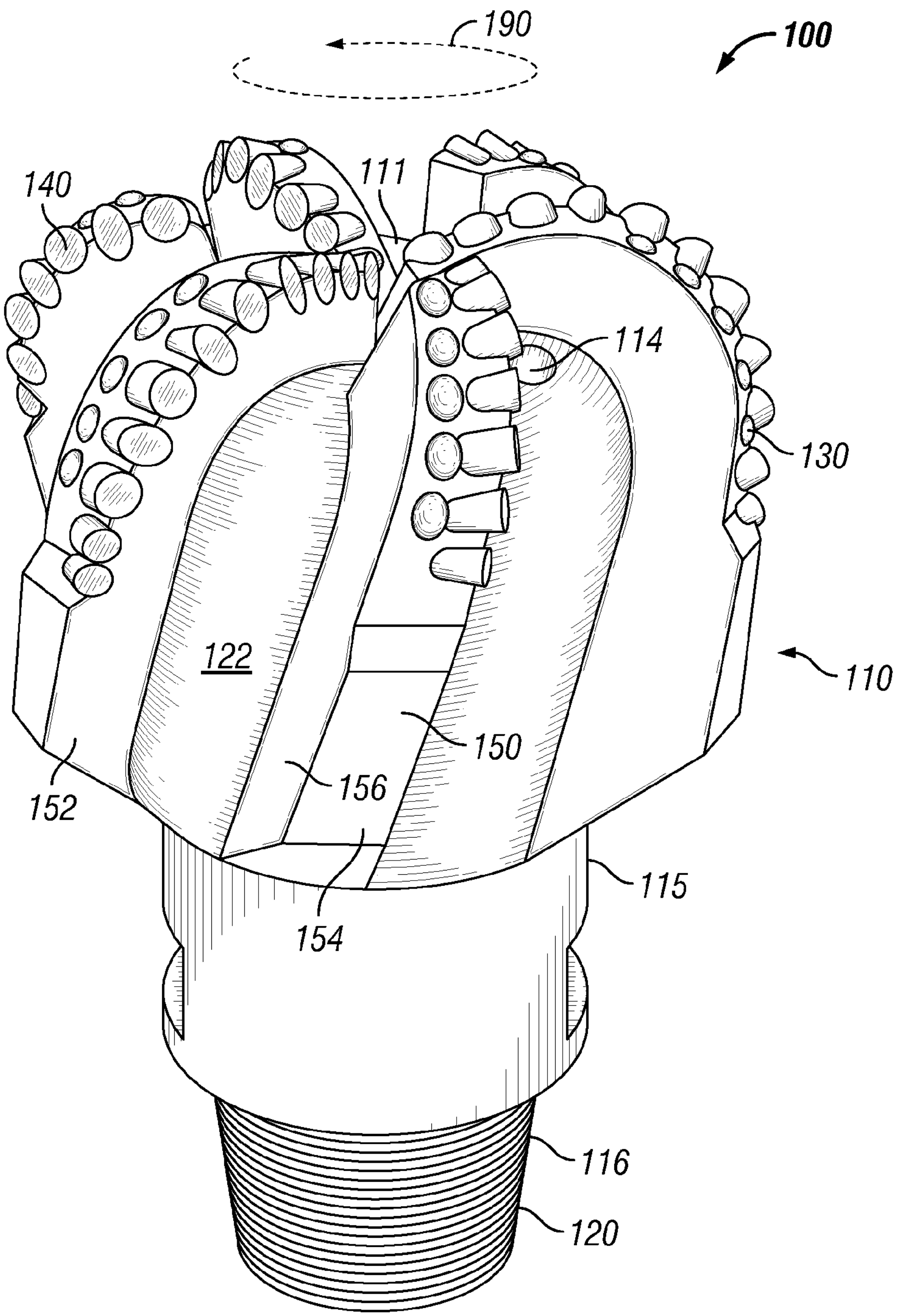


FIG. 1
(Prior Art)

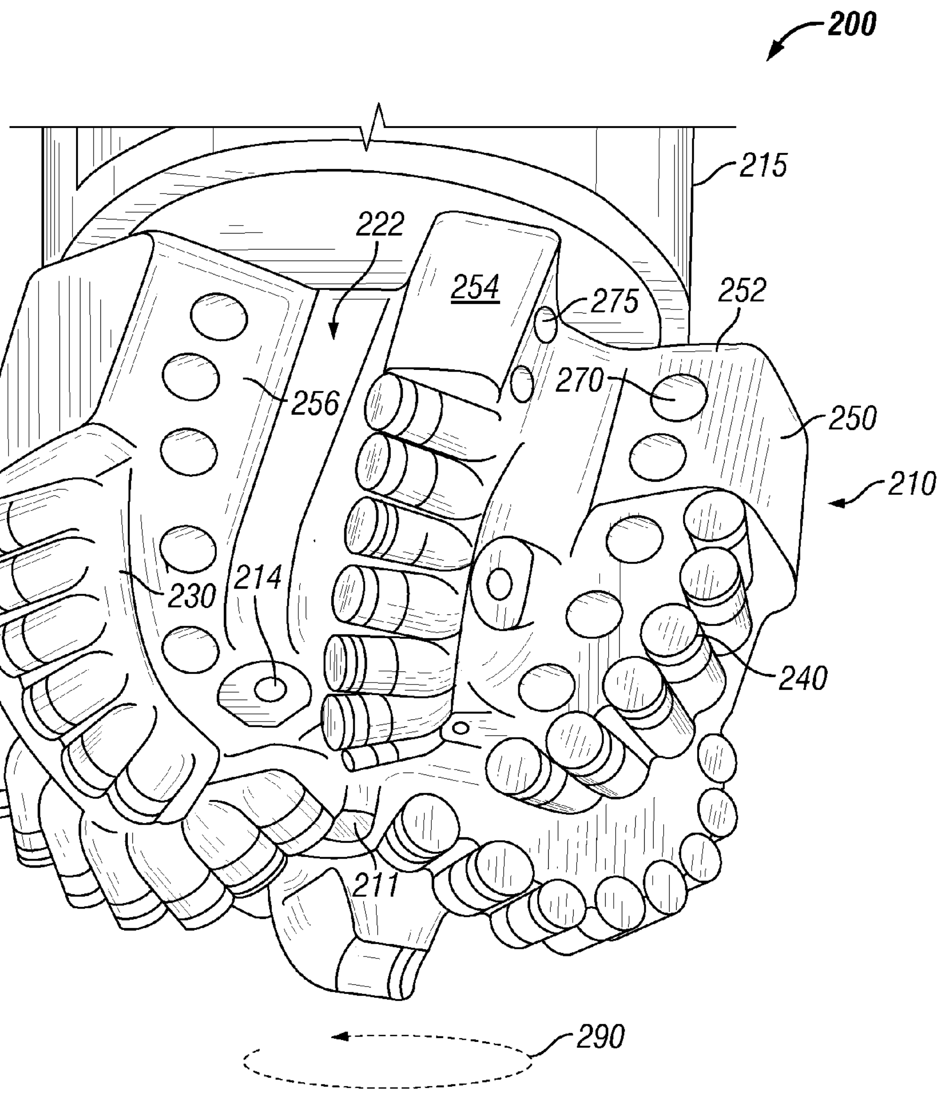


FIG. 2

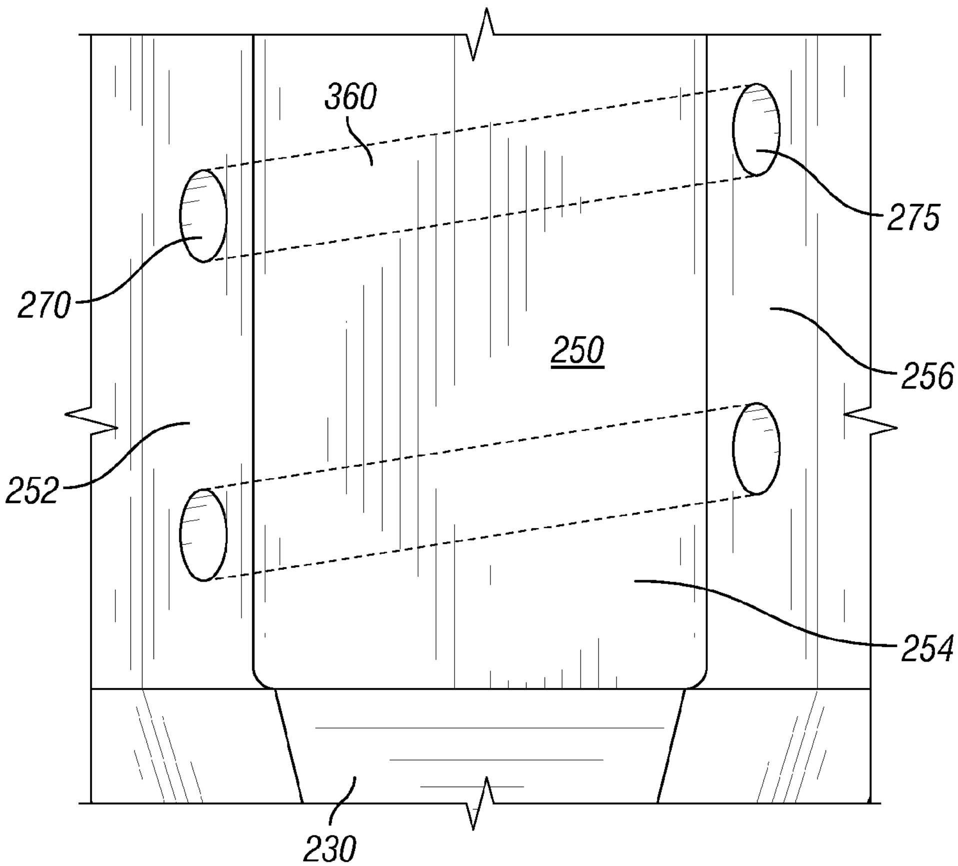


FIG. 3

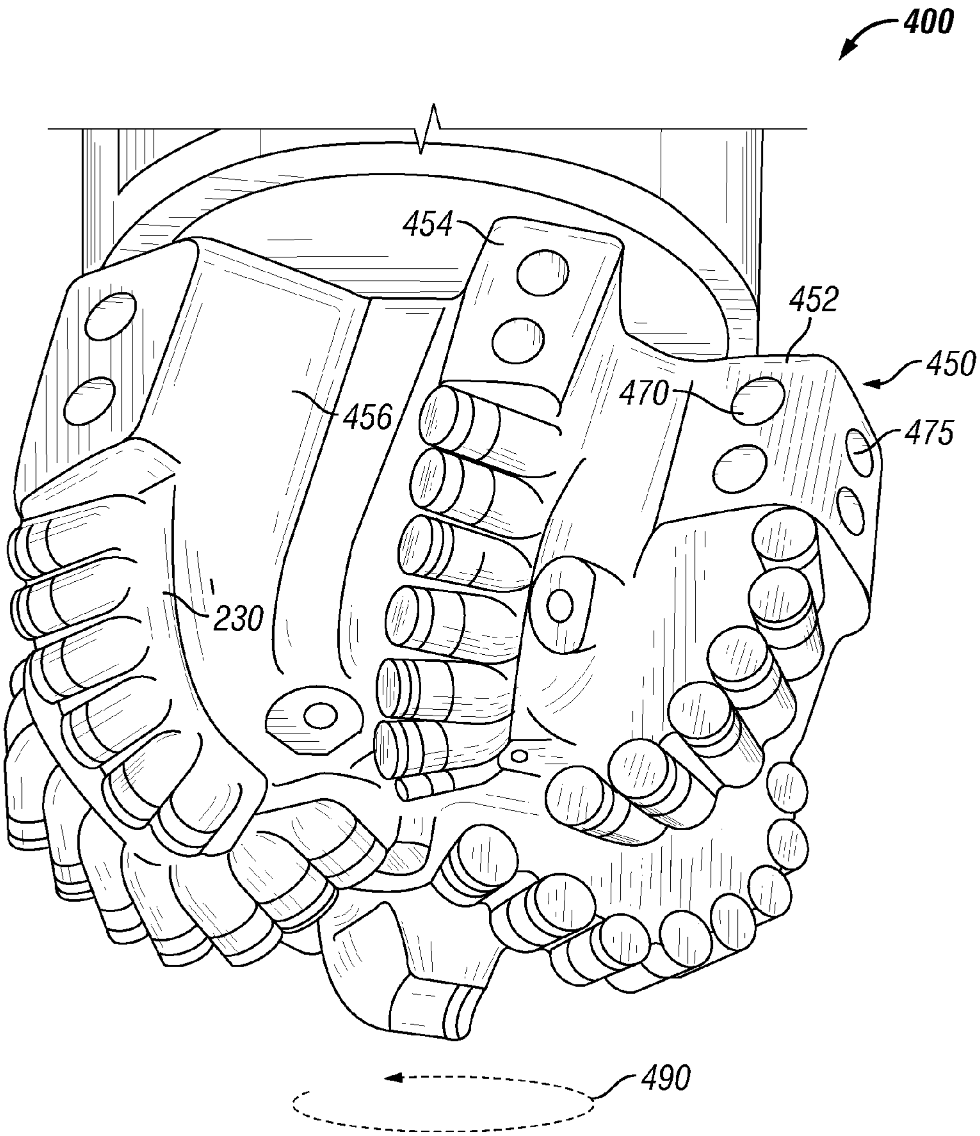


FIG. 4

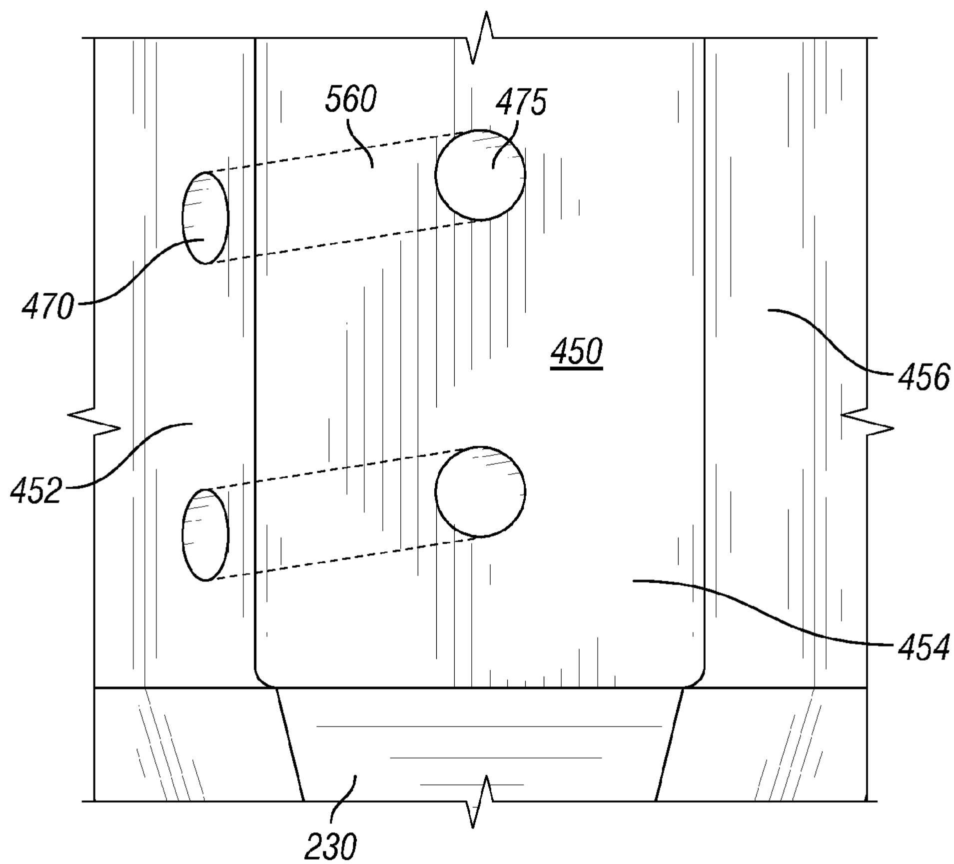


FIG. 5

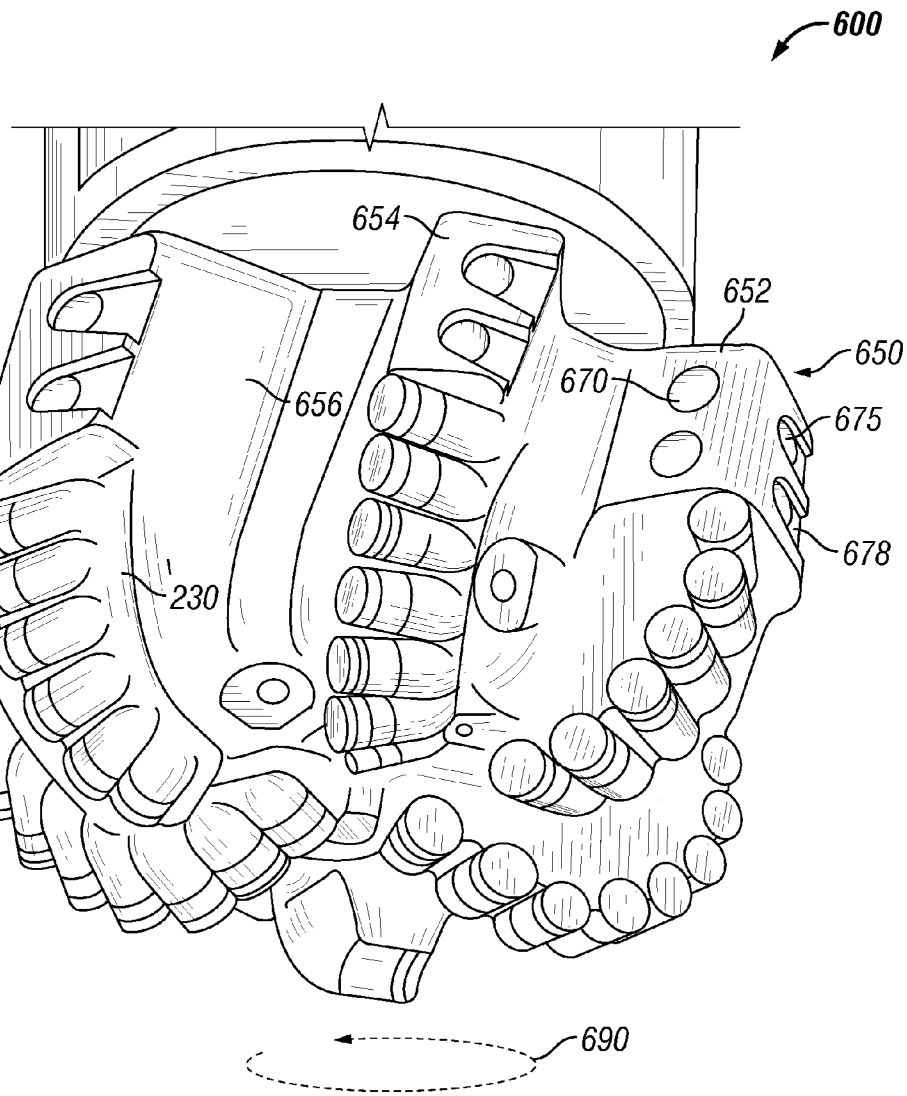


FIG. 6

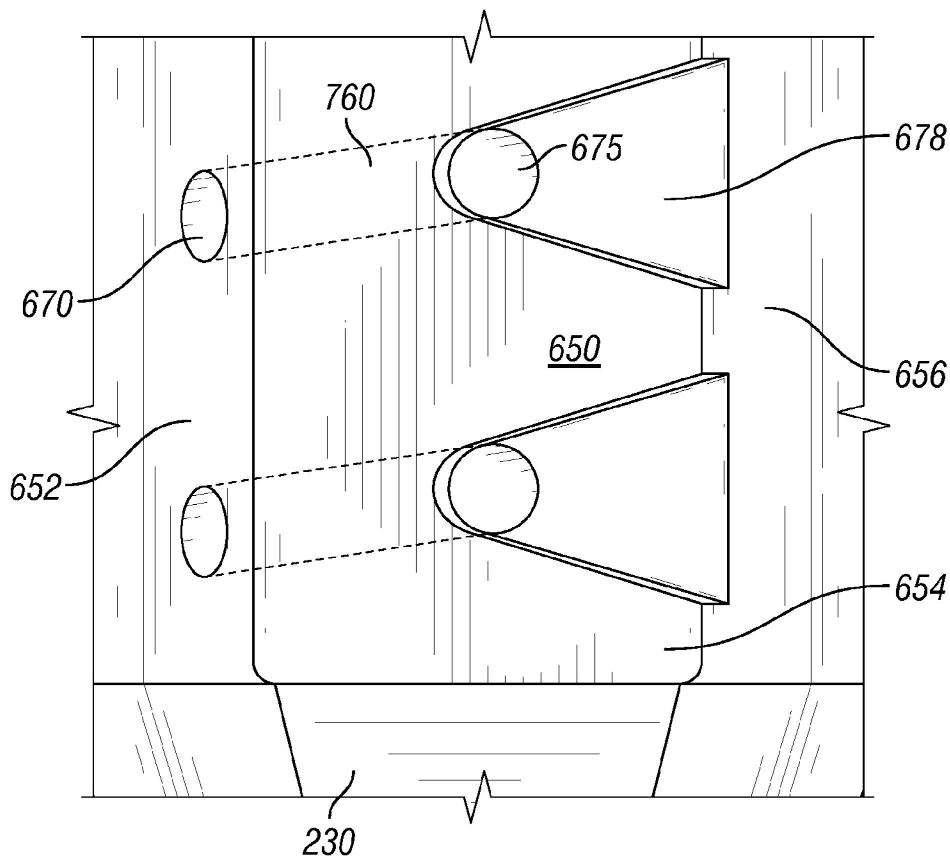


FIG. 7

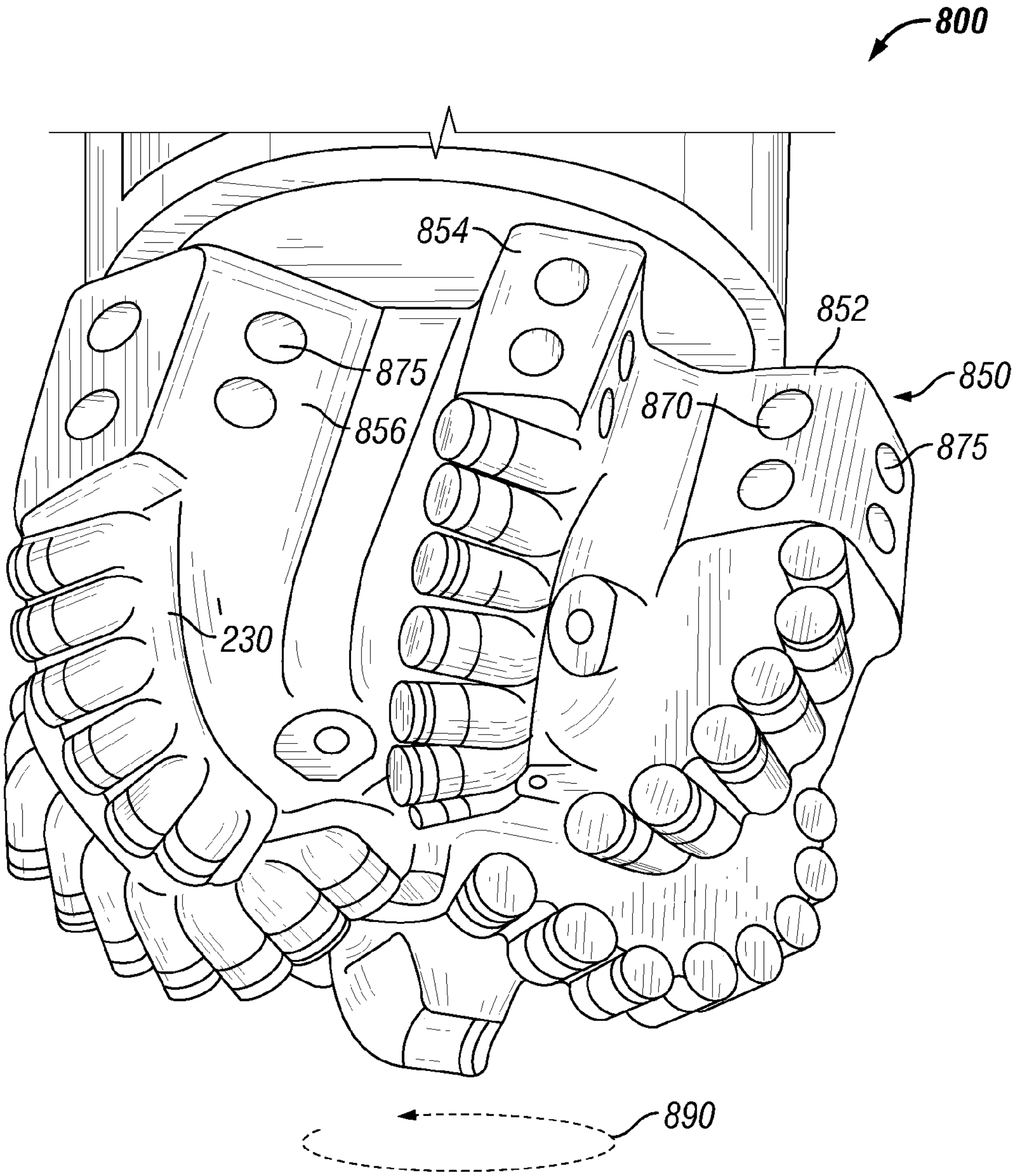


FIG. 8

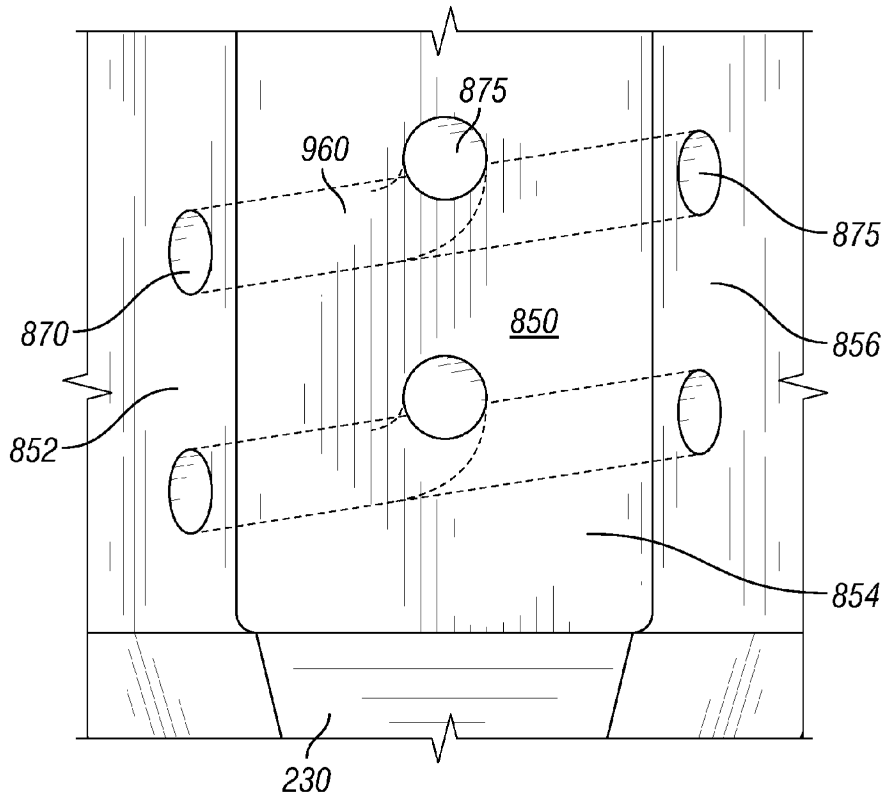


FIG. 9

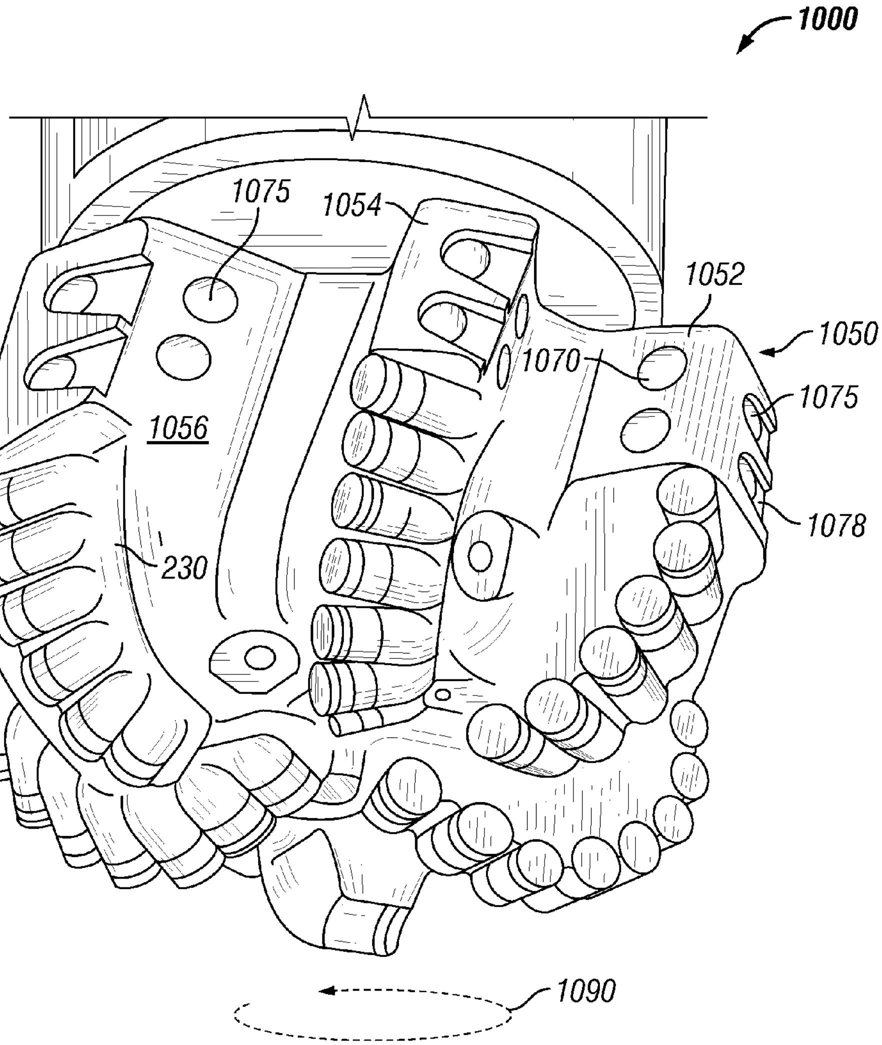


FIG. 10

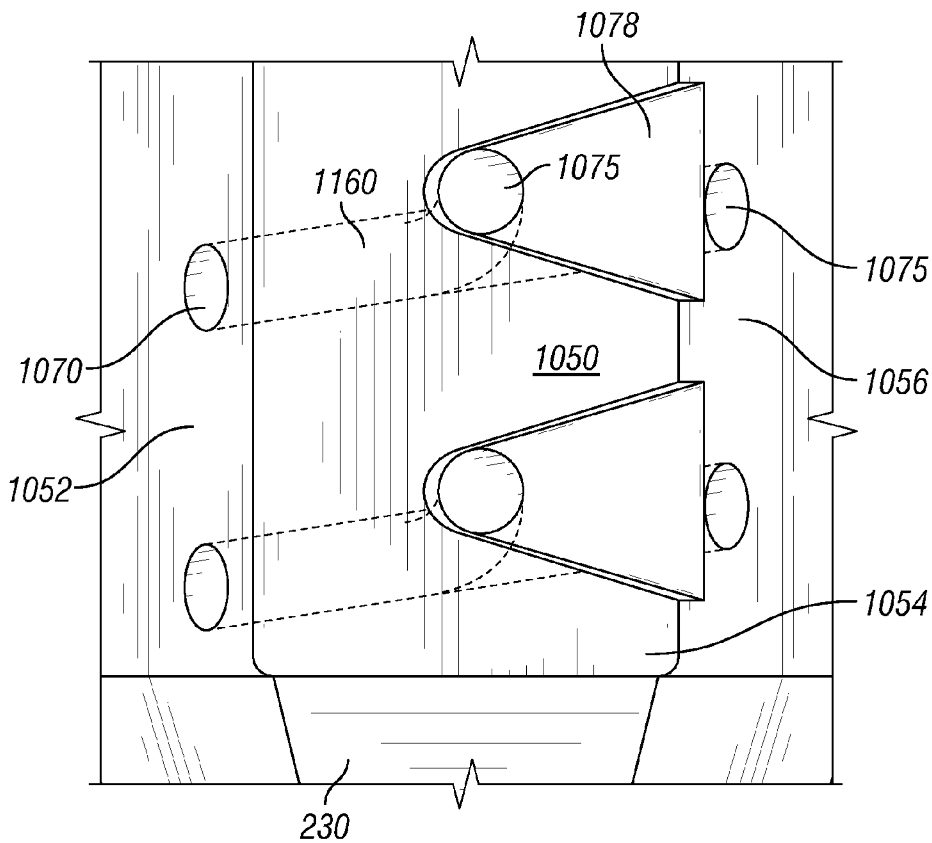


FIG. 11

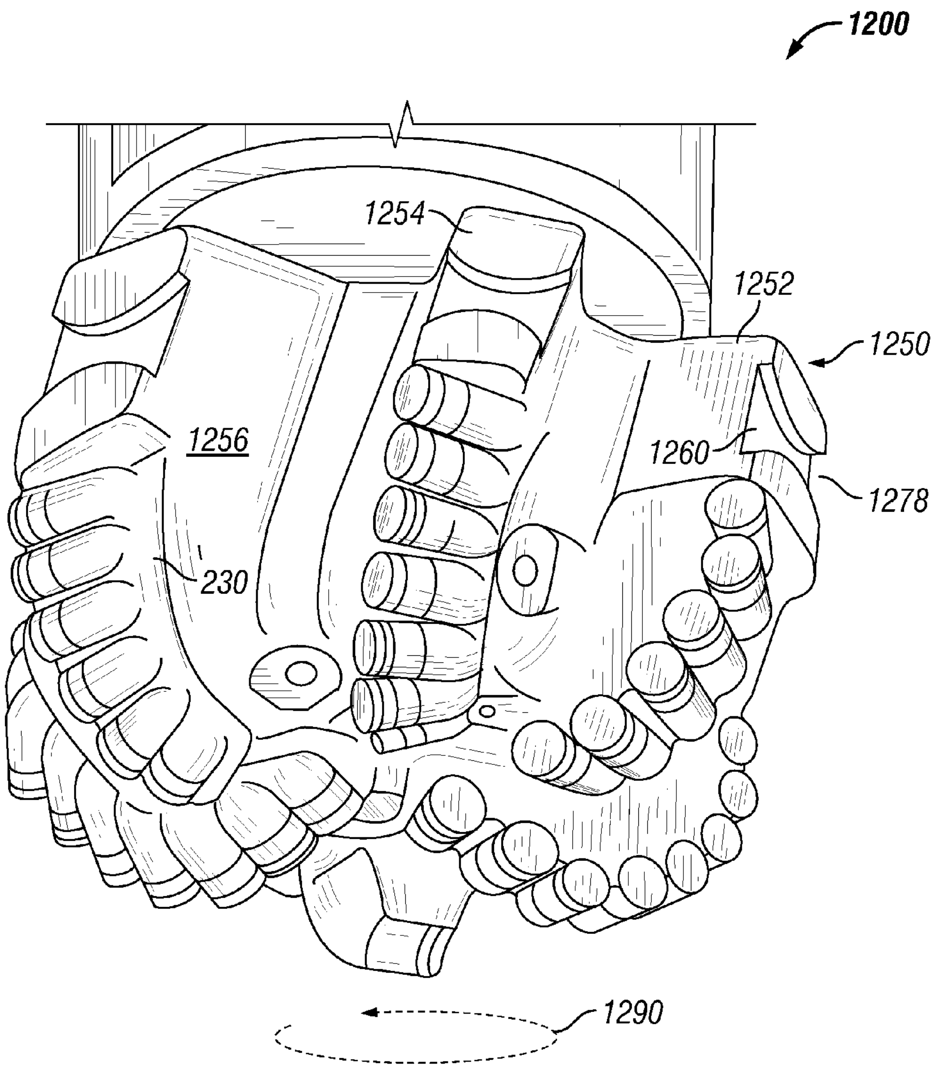


FIG. 12

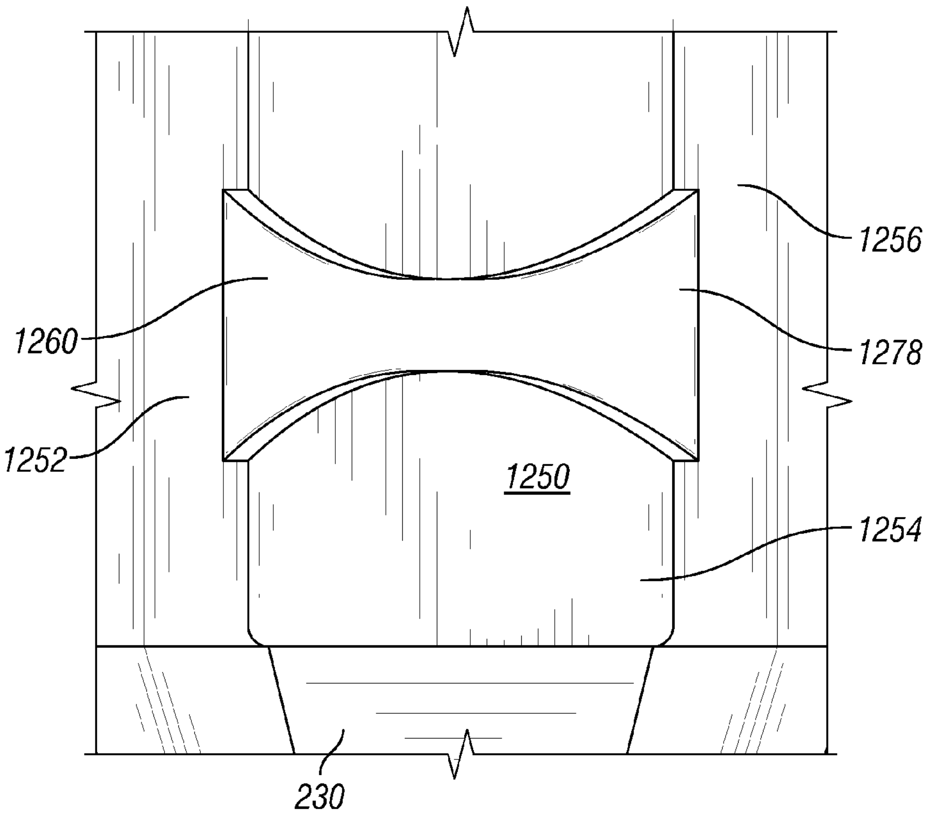


FIG. 13

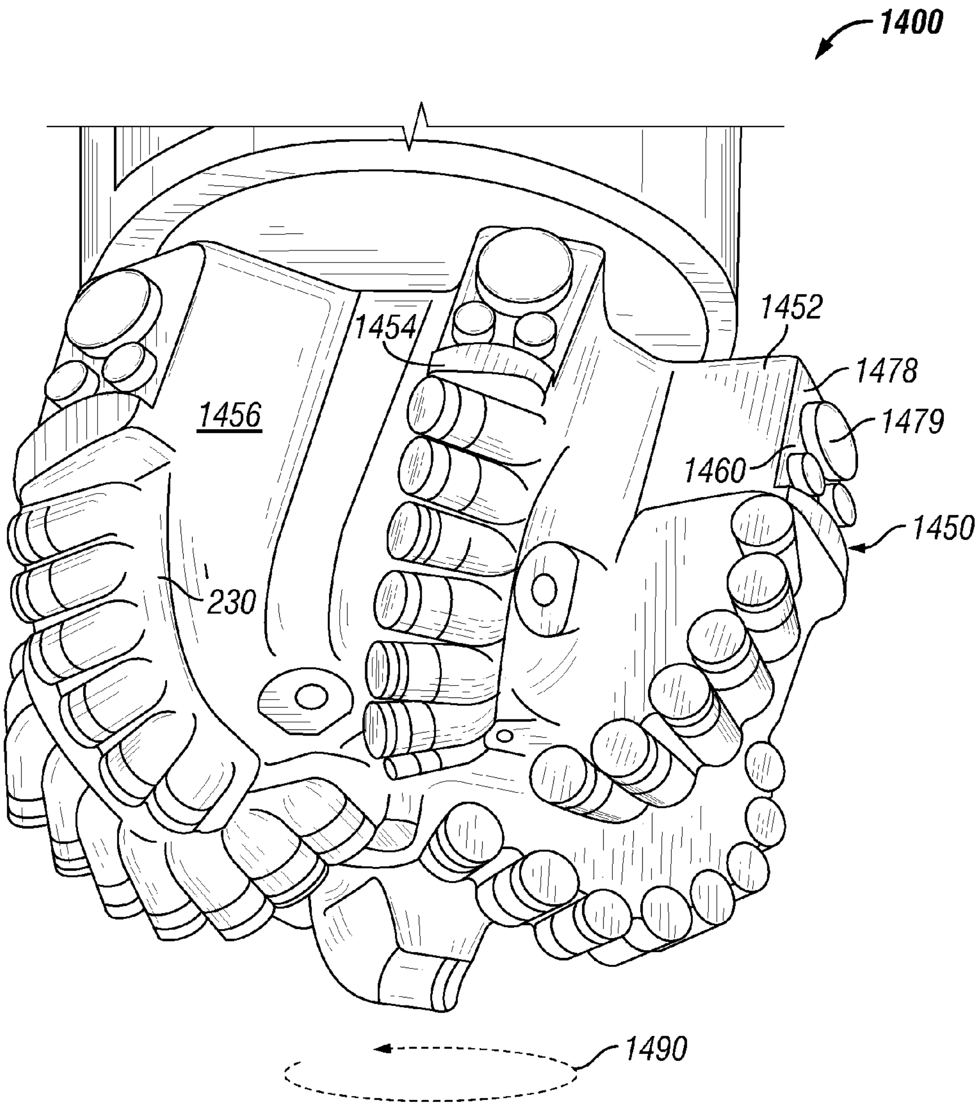


FIG. 14

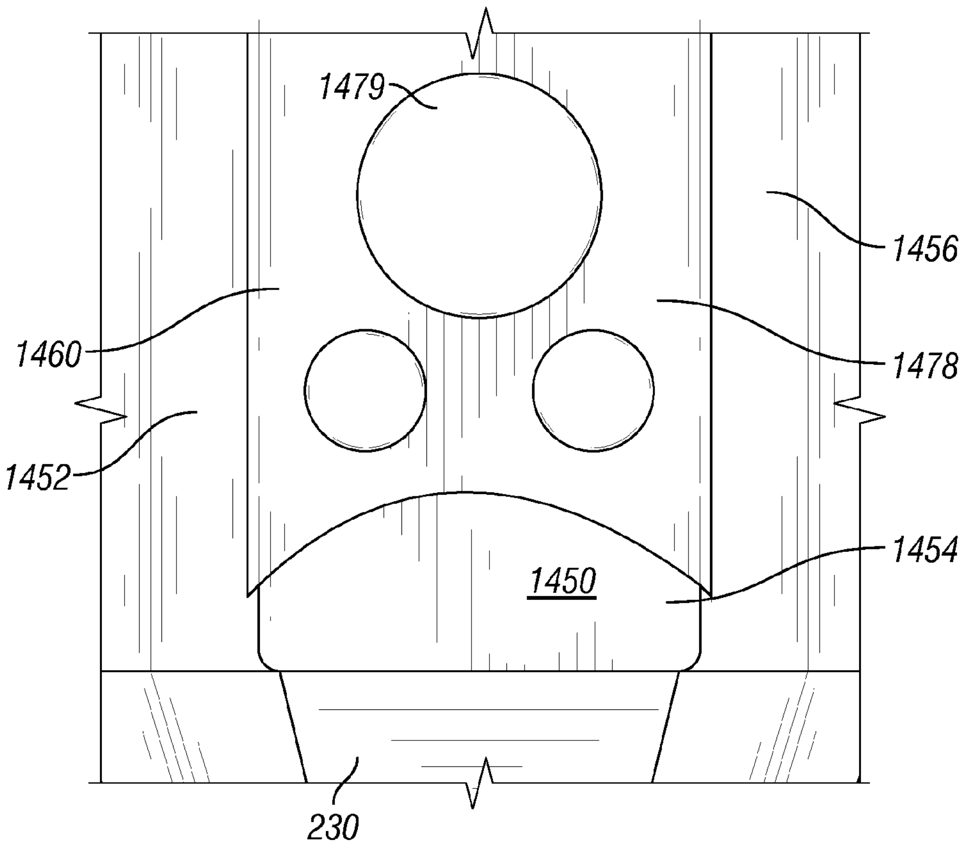


FIG. 15

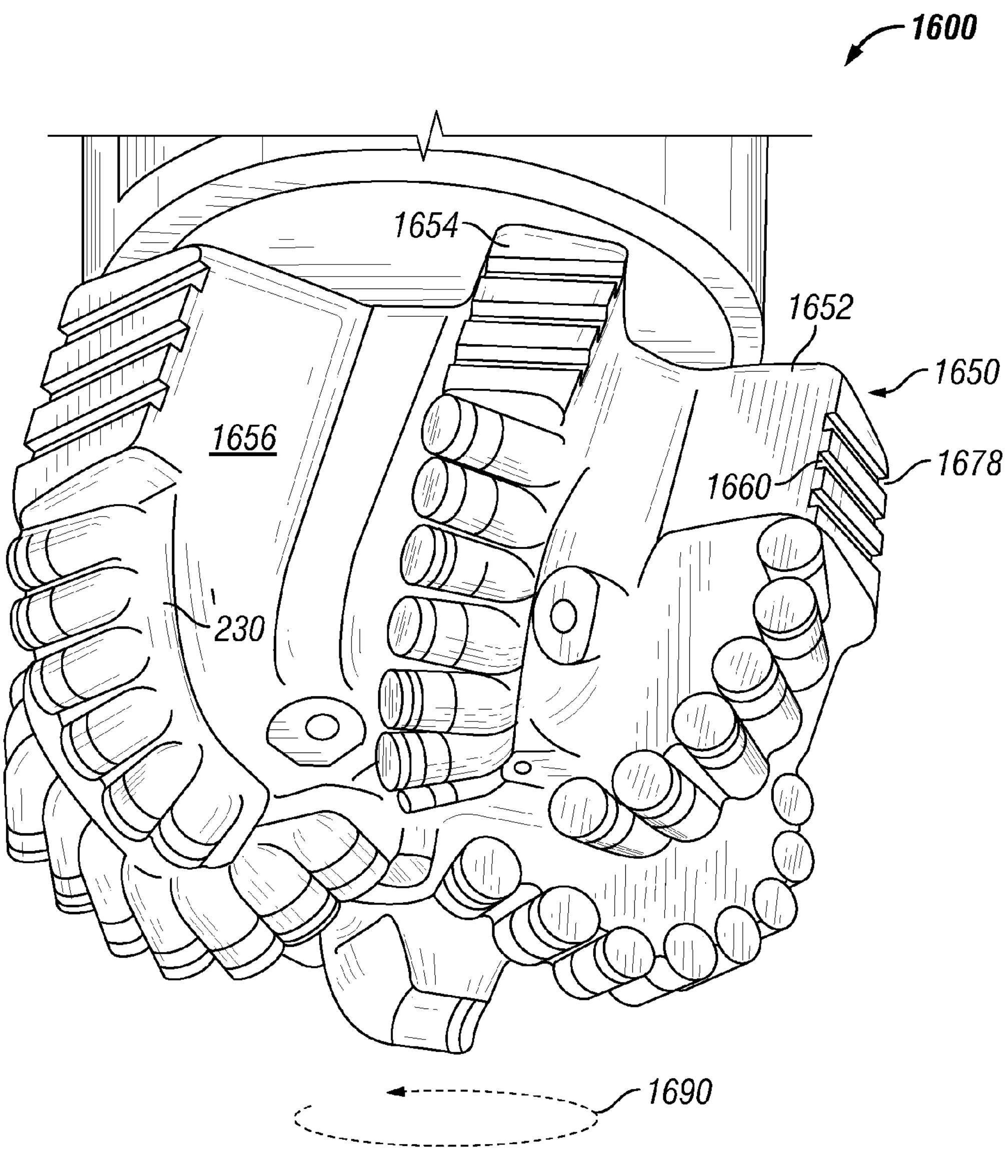


FIG. 16

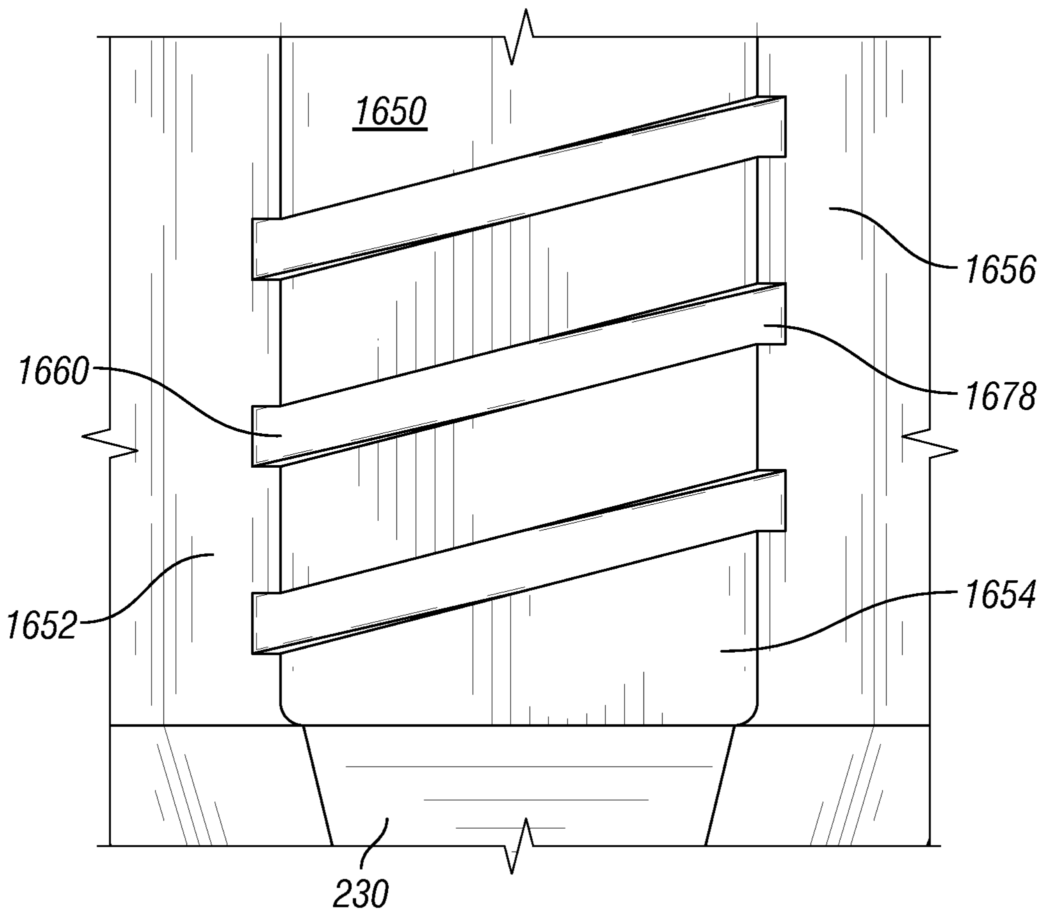


FIG. 17

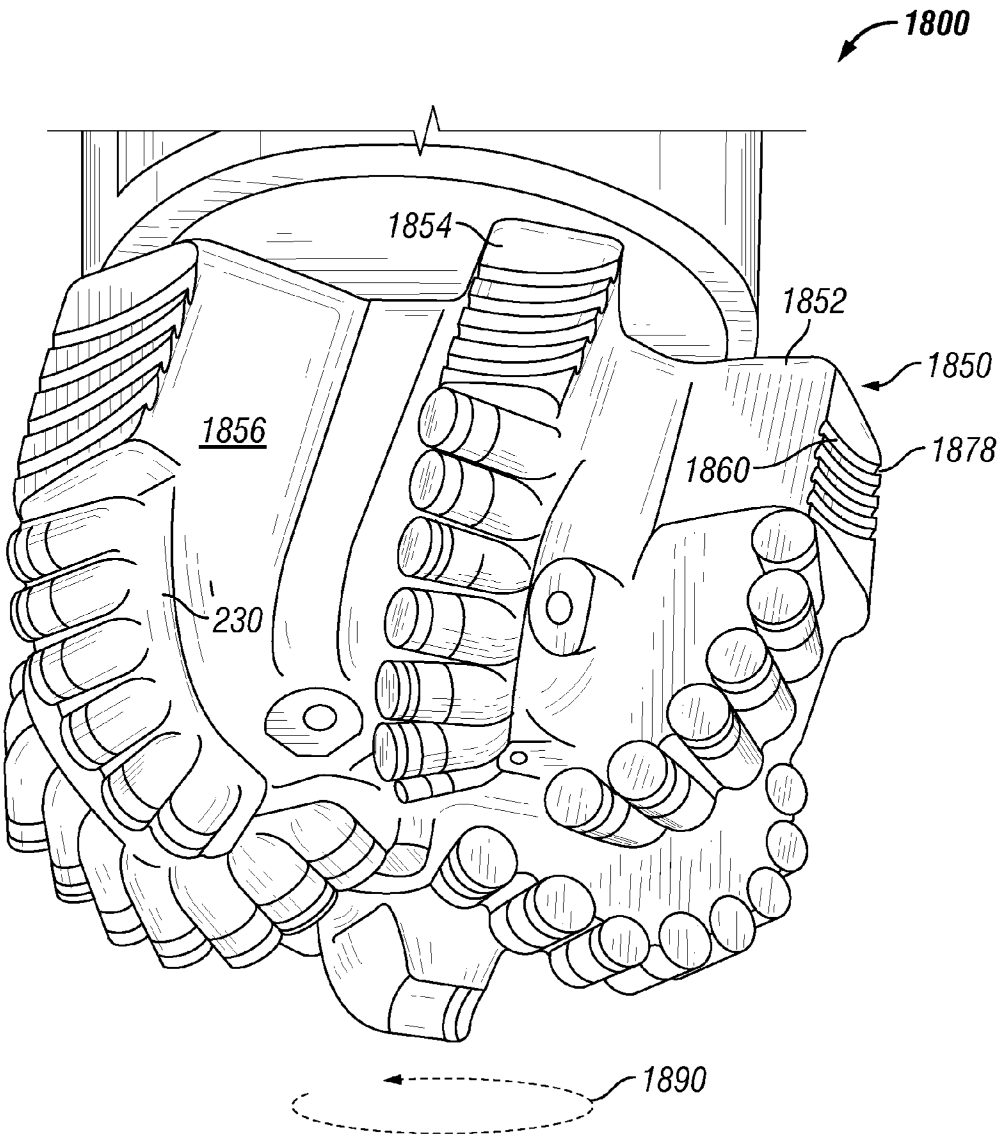


FIG. 18

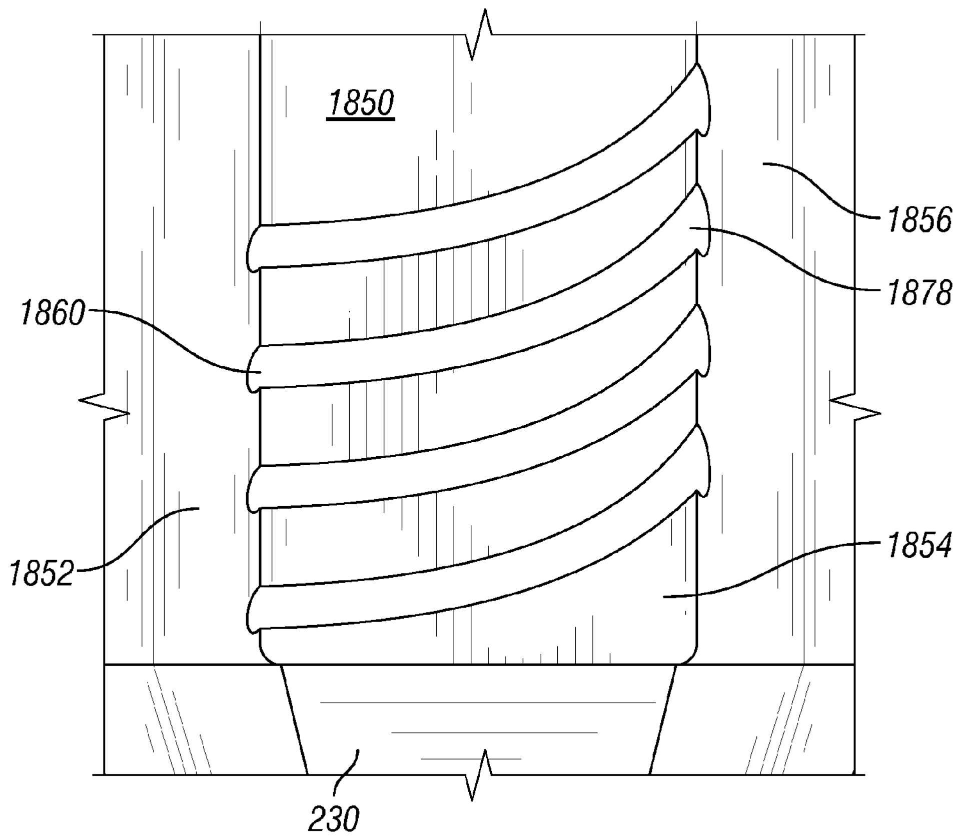


FIG. 19

FLOW THROUGH GAUGE FOR DRILL BIT

RELATED APPLICATIONS

[0001] The present application is a non-provisional application of and claims priority under 35 U.S.C. §119 to U.S. Provisional Application No. 61/709,063, entitled "Flow Through Gauge For Drill Bit" and filed on Oct. 2, 2012, the entirety of which is incorporated by reference herein.

[0002] The present application is related to U.S. Non-Provisional patent application Ser. No. ______, entitled "Blade Flow PDC Bits" and filed on September ______, 2013, and U.S. Non-Provisional patent application Ser. No. ______, entitled "Machined High Angle Nozzle Sockets For Steel Body Bits" and filed on September ______, 2013, both of which are hereby incorporated by reference herein.

BACKGROUND

[0003] This invention relates generally to drill bits and/or other downhole tools. More particularly, this invention relates to drill bits that include one or more flow management channels formed within one or more gauge sections of the drill bits and/or other downhole tools.

[0004] FIG. **1** shows a perspective view of a drill bit **100** in accordance with the prior art. Referring to FIG. **1**, the drill bit **100** includes a bit body **110** that is coupled to a shank **115** and is designed to rotate in a counter-clockwise direction **190**. The shank **115** includes a threaded connection **116** at one end **120**. The threaded connection **116** couples to a drill string (not shown) or some other equipment that is coupled to the drill string. The threaded connection **116** is shown to be positioned on the exterior surface of the one end **120**. This positioning assumes that the drill bit **100** is coupled to a corresponding threaded connection located on the interior surface of a drill string (not shown). However, the threaded connection **116** at the one end **120** is alternatively positioned on the interior surface of the one end **120** if the corresponding threaded connection of the drill string (not shown) is positioned on its exterior surface in other exemplary embodiments. A bore (not shown) is formed longitudinally through the shank **115** and the bit body **110** for communicating drilling fluid from within the drill string to a drill bit face **111** via one or more nozzles **114** during drilling operations.

[0005] The bit body **110** includes a plurality of gauge sections **150** and a plurality of blades **130** extending from the drill bit face **111** of the bit body **110** towards the threaded connection **116**, where each blade **130** extends to and terminates at a respective gauge section **150**. The blade **130** and the respective gauge section **150** are formed as a single component, but are formed separately in certain drill bits **100**. The drill bit face **111** is positioned at one end of the bit body **110** furthest away from the shank **115**. The plurality of blades **130** form the cutting surface of the drill bit **100**. One or more of these plurality of blades **130** are either coupled to the bit body **110** or are integrally formed with the bit body **110**. The gauge sections **150** are positioned at an end of the bit body **110** adjacent the shank **115**. The gauge section **150** includes one or more gauge cutters (not shown) in certain drill bits **100**. The gauge sections **150** typically define and hold the full hole diameter of the drilled hole. Each of the blades **130** and gauge sections **150** include a leading edge section **152**, a face section **154**, and a trailing edge section **156**. The face section **154** extends from one end of the trailing edge section **156** to an end of the leading edge section **152**. The leading edge section **152** faces in the direction of rotation **190**, while the trailing edge faces in the opposite direction of rotation **190**. A junk slot **122** is formed between each consecutive blade **130**, which allows for cuttings and drilling fluid to return to the surface of the wellbore (not shown) once the drilling fluid is discharged from the nozzles **114**. A plurality of cutters **140** are coupled to each of the blades **130** and extend outwardly from the surface of the blades **130** to cut through earth formations when the drill bit **100** is rotated during drilling. One type of cutter **140** used within the drill bit **100** is a PDC cutter; however other types of cutters are contemplated as being used within the drill bit **100**. The cutters **140** and portions of the bit body **110** deform the earth formation by scraping and/or shearing depending upon the type of drill bit **100**. Although one embodiment of the drill bit has been described, other drill bit embodiments or other downhole tools that include one or more gauge sections, which are known to people having ordinary skill in the art, are applicable to exemplary embodiments of the present invention.

[0006] During drilling of a borehole, the drill bit **100** rotates to cut through an earth formation to form a wellbore therein. This cutting is typically performed through scraping and/or shearing action according to certain drill bits **100**, but is performed through other means based upon the type of drill bit used. Drilling fluid (not shown) exits the drill bit **100** through one or more nozzles **114** and facilitates the removal of the cuttings from the borehole wall back towards the surface. As the drill bit **110** rotates and the drilling fluid with cuttings are at the bottom of the borehole, the gauge section **150** is eroded rapidly, which also causes the surface of the gauge section **150** to become rounded. Further, the cuttings are re-grinded, which thereby generated additional heat and reduces the cooling function performed by the drilling fluid on the blades **130** and on the gauge section **150**.

[0007] Gauge pad wear is a primary limiter of drill bit life. Cuttings regrinding, caused by cuttings getting squeezed into the small gap that can open up during drilling between the gauge pad and the borehole wall, acts to significantly increase cuttings regrinding and wear. In standard smooth gauge pad design, the faces of the gauge pads constitute a hydraulic "dead zone" limiting hydraulic cooling and accelerating thermal induced deterioration of the gauge pad surfaces.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The foregoing and other features and aspects of the invention will be best understood with reference to the following description of certain exemplary embodiments of the invention, when read in conjunction with the accompanying drawings, wherein:

[0009] FIG. **1** shows a perspective view of a drill bit in accordance with the prior art;

[0010] FIG. **2** shows a perspective view of a drill bit including one or more flow channels in a gauge section of the drill bit in accordance with an exemplary embodiment of the present invention;

[0011] FIG. **3** shows a schematic view of the one or more flow channels in the gauge section of the drill bit of FIG. **2** in accordance with an exemplary embodiment of the present invention;

[0012] FIG. **4** shows a perspective view of a drill bit including one or more flow channels in a gauge section of the drill bit in accordance with an exemplary embodiment of the present invention;

[0013] FIG. **5** shows a schematic view of the one or more flow channels in the gauge section of the drill bit of FIG. **4** in accordance with an exemplary embodiment of the present invention;

[0014] FIG. **6** shows a perspective view of a drill bit including one or more flow channels in a gauge section of the drill bit in accordance with an exemplary embodiment of the present invention;

[0015] FIG. **7** shows a schematic view of the one or more flow channels in the gauge section of the drill bit of FIG. **6** in accordance with an exemplary embodiment of the present invention;

[0016] FIG. **8** shows a perspective view of a drill bit including one or more flow channels in a gauge section of the drill bit in accordance with an exemplary embodiment of the present invention;

[0017] FIG. **9** shows a schematic view of the one or more flow channels in the gauge section of the drill bit of FIG. **8** in accordance with an exemplary embodiment of the present invention;

[0018] FIG. **10** shows a perspective view of a drill bit including one or more flow channels in a gauge section of the drill bit in accordance with an exemplary embodiment of the present invention;

[0019] FIG. **11** shows a schematic view of the one or more flow channels in the gauge section of the drill bit of FIG. **10** in accordance with an exemplary embodiment of the present invention;

[0020] FIG. **12** shows a perspective view of a drill bit including one or more flow channels in a gauge section of the drill bit in accordance with an exemplary embodiment of the present invention;

[0021] FIG. **13** shows a schematic view of the one or more flow channels in the gauge section of the drill bit of FIG. **12** in accordance with an exemplary embodiment of the present invention;

[0022] FIG. **14** shows a perspective view of a drill bit including one or more flow channels in a gauge section of the drill bit in accordance with an exemplary embodiment of the present invention;

[0023] FIG. **15** shows a schematic view of the one or more flow channels in the gauge section of the drill bit of FIG. **14** in accordance with an exemplary embodiment of the present invention;

[0024] FIG. **16** shows a perspective view of a drill bit including one or more flow channels in a gauge section of the drill bit in accordance with an exemplary embodiment of the present invention;

[0025] FIG. **17** shows a schematic view of the one or more flow channels in the gauge section of the drill bit of FIG. **16** in accordance with an exemplary embodiment of the present invention;

[0026] FIG. **18** shows a perspective view of a drill bit including one or more flow channels in a gauge section of the drill bit in accordance with an exemplary embodiment of the present invention; and

[0027] FIG. **19** shows a schematic view of the one or more flow channels in the gauge section of the drill bit of FIG. **18** in accordance with an exemplary embodiment of the present invention.

[0028] The drawings illustrate only exemplary embodiments of the invention and are therefore not to be considered limiting of its scope, as the invention may admit to other equally effective embodiments.

DETAILED DESCRIPTION OF THE INVENTION

[0029] This invention relates generally to drill bits and/or other downhole tools. More particularly, this invention relates to drill bits that include one or more flow management channels formed within one or more gauge sections of the drill bits and/or other downhole tools. Although the description provided below is related to a fixed cutter bit, exemplary embodiments of the invention relate to any downhole tool having one or more gauge sections, such as, but not limited to, steel body or matrix PDC bits, impregnated bits, and other fixed cutter bits.

[0030] According to exemplary embodiments of the present invention, one or more inlet holes are deployed on a leading edge section adjacent to a gauge section of a bit. Further one or more outlet holes are deployed on one or more of the face section and/or a trailing edge section, where one or more outlet holes are fluidly coupled to at least one inlet hole. The outlet hole and the corresponding inlet hole form a fluid channel extending therebetween. The fluid channels are deployed to allow fluid to flow beneath at least a portion of the face section of the gauge section to provide cooling to the face section. Alternatively, the fluid channels are deployed to allow fluid to flow along at least a portion of the face section of the gauge section, also providing cooling to the face section. These fluid channels are deployed at an upward angle, in certain exemplary embodiments, to facilitate the movement of entrained cuttings and drilling fluid in the uphole direction. However, in other exemplary embodiments, one or more fluid channels are deployed in a horizontal direction or a downward angle.

[0031] FIG. **2** shows a perspective view of a drill bit **200** including one or more flow channels **360** in a gauge section **250** of the drill bit **200** in accordance with an exemplary embodiment of the present invention. FIG. **3** shows a schematic view of the one or more flow channels **360** in the gauge section **250** of the drill bit **200** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **2** and **3**, the drill bit **200** is similar to drill bit **100** (FIG. **1**) and includes a bit body **210** that is coupled to a shank **215**. The drill bit **200** is designed to rotate in a counter-clockwise direction **290**. The shank **215** includes a threaded connection (not shown) at one end (not shown). This threaded connection is similar to threaded connection **116** (FIG. **1**). The threaded connection couples to a drill string (not shown) or some other equipment that is coupled to the drill string. A bore (not shown) is formed longitudinally through the shank and the bit body **210** for communicating drilling fluid from within the drill string to a drill bit face **211** via one or more nozzles **214** during drilling operations.

[0032] The bit body **210** includes a plurality of gauge sections **250** and a plurality of blades **230** extending from the drill bit face **211** of the bit body **210** towards the shank **215**, where each blade **230** extends to and terminates at a respective gauge section **250**. The blade **230** and the respective gauge section **250** are formed as a single component, but are formed separately in other drill bits. The drill bit face **211** is positioned at one end of the bit body **210** furthest away from the shank **215**. The plurality of blades **230** form the cutting surface of the drill bit **200**. One or more of these plurality of blades **230** are either coupled to the bit body **210** or are integrally formed with the bit body **210**. The gauge sections **250** are positioned at an end of the bit body **210** adjacent the shank **215**. The gauge section **250** includes one or more gauge cutters (not shown) in certain exemplary embodiments of drill bits. The gauge sections **250** typically define and hold the full hole diameter of the drilled hole. Each of the blades **230** and gauge sections **250** include a leading edge section **252**, a face section **254**, and a trailing edge section **256**. The face section **254** extends from one end of the trailing edge section **256** to an end of the leading edge section **252** and forms a front surface of the gauge section **250**. The leading edge section **252** faces in the direction of rotation **290**, while the trailing edge section **256** faces in the opposite direction of rotation **290**. A junk slot **222** is formed between each consecutive blade **230**, which allows for cuttings and drilling fluid to return to the surface of the wellbore (not shown) once the drilling fluid is discharged from the nozzles **214**. A plurality of cutters **240** are coupled to each of the blades **230** and extend outwardly from the surface of the blades **230** to cut through earth formations when the drill bit **200** is rotated during drilling. One type of cutter **240** used within the drill bit **200** is a PDC cutter; however, other types of cutters are contemplated as being used within the drill bit **200**. The cutters **240** and portions of the bit body **210** deform the earth formation by scraping and/or shearing depending upon the type of drill bit **200**.

[0033] According to some exemplary embodiments, as shown in FIGS. **2** and **3**, one or more inlet holes **270** are formed within the leading edge section **252** and one or more outlet holes **275** are formed within the trailing edge section **256**. The flow channel **360** extends from an inlet hole **270** to at least one corresponding outlet hole **275**. Hence, the drilling fluid and/or cuttings enter into the flow channel **360** through the inlet hole **270** and exits through the outlet hole **275**. The fluid flowing through this flow channel **360** facilitates cooling of the gauge section **250** and also reduces erosion of the gauge section **250**. In some exemplary embodiments, one inlet hole **270** corresponds to a single outlet hole **275**. However, in other exemplary embodiments, one inlet hole **270** corresponds and is fluidly communicable to a plurality of outlet holes **275**. Also, in certain exemplary embodiments, one or more outlet holes **275** is shaped and/or dimensioned differently than the corresponding inlet hole **270**. For example, the outlet hole **275** is sized larger, in perimeter or diameter, than the corresponding inlet hole **270**. This feature reduces plugging within the flow channel **360**. In certain exemplary embodiments, at least one flow channel **360** is directed in an upward angle from the inlet hole **270** to the outlet hole **275**. In other exemplary embodiments, the flow channel **360** is directed substantially horizontally or in a downward direction towards the bottom of the borehole (not shown). Hence, in this exemplary embodiment, the fluid flow within the flow channel **360** is beneath the face section **254**.

[0034] FIG. **4** shows a perspective view of a drill bit **400** including one or more flow channels **560** in a gauge section **450** of the drill bit **400** in accordance with an exemplary embodiment of the present invention. FIG. **5** shows a schematic view of the one or more flow channels **560** in the gauge section **450** of the drill bit **400** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **4** and **5**, the drill bit **400** is similar to drill bit **200** (FIG. **2**). However, gauge section **450** is different from gauge section **250** (FIG. **2**) in that the flow channel **560** is different than the flow channel **360** (FIG. **3**). Each of the gauge sections **450** and blades **230**, as described above with respect to drill bit **200** (FIG. **2**), include a leading edge section **452**, a face section **454**, and a trailing edge section **456**. The face section **454** extends from one end of the trailing edge section **456** to an end of the leading edge section **452** and forms a front surface of the gauge section **450**. The leading edge section **452** faces in the direction of rotation **490** of the drill bit **400**, while the trailing edge section **456** faces in the opposite direction of rotation **490**.

[0035] According to some exemplary embodiments, as shown in FIGS. **4** and **5**, one or more inlet holes **470** are formed within the leading edge section **452** and one or more outlet holes **475** are formed within the face section **454**. The flow channel **560** extends from an inlet hole **470** to at least one corresponding outlet hole **475**. Hence, the drilling fluid and/or cuttings enter into the flow channel **560** through the inlet hole **470** and exits through the outlet hole **475**. The fluid flowing through this flow channel **560** facilitates cooling of the gauge section **450** and also reduces erosion of the gauge section **450**. In some exemplary embodiments, one inlet hole **470** corresponds to and is in fluid communication with a single outlet hole **475**. However, in other exemplary embodiments, one inlet hole **470** corresponds to and is in fluid communication with a plurality of outlet holes **475**. Also, in certain exemplary embodiments, one or more outlet holes **475** is shaped and/or dimensioned differently than the corresponding inlet hole **470**. For example, the outlet hole **475** is sized larger, in perimeter or diameter, than the corresponding inlet hole **470**. This feature reduces plugging within the flow channel **560**. In certain exemplary embodiments, at least one flow channel **560** is directed in an upward angle from the inlet hole **470** to the outlet hole **475**. In other exemplary embodiments, the flow channel **560** is directed substantially horizontally or in a downward direction towards the bottom of the borehole (not shown).

[0036] FIG. **6** shows a perspective view of a drill bit **600** including one or more flow channels **760** in a gauge section **650** of the drill bit **600** in accordance with an exemplary embodiment of the present invention. FIG. **7** shows a schematic view of the one or more flow channels **760** in the gauge section **650** of the drill bit **600** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **6** and **7**, the drill bit **600** is similar to drill bit **200** (FIG. **2**). However, gauge section **650** is different from gauge section **250** (FIG. **2**) in that the flow channel **760** is different than the flow channel **360** (FIG. **3**). Each of the gauge sections **650** and blades **230**, as described above with respect to drill bit **200** (FIG. **2**), include a leading edge section **652**, a face section **654**, and a trailing edge section **656**. The face section **654** extends from one end of the trailing edge section **656** to an end of the leading edge section **652** and forms a front surface of the gauge section **650**. The leading edge section **652** faces in the direction of rotation **690** of the drill bit **600**, while the trailing edge section **656** faces in the opposite direction of rotation **690**.

[0037] According to some exemplary embodiments, as shown in FIGS. **6** and **7**, one or more inlet holes **670** are formed within the leading edge section **652** and one or more outlet holes **675** are formed within the face section **654**. Further, a deep groove **678** is formed within the face section **654** extending from the one or more outlet holes **675** to the trailing edge section **656**. The deep groove **678** is substantially trapezoidal shaped in some exemplary embodiments; however, in other exemplary embodiments, the deep groove **678** is formed in any other geometric shape, such as rectangular or triangular, or non-geometric shape. The deep groove **678** is about ¼" deep in some exemplary embodiments but is greater in depth in other exemplary embodiments. However, according to certain exemplary embodiments, deep groove **678** is less than ¼" deep. In some exemplary embodiments, the depth of the deep groove **678** is substantially constant throughout the deep groove **678**; however, the depth varies in other exemplary embodiments. For example, the depth of the deep groove **678** is shallower near the outlet holes **675** and deeper near the trailing edge section **656**. The flow channel **760** extends from an inlet hole **670** to at least one corresponding outlet hole **675**. Hence, the drilling fluid and/or cuttings enter into the flow channel **760** through the inlet hole **670** and exits through the outlet hole **675**. The fluid flowing through this flow channel **760** facilitates cooling of the gauge section **650** and also reduces erosion of the gauge section **650**. In some exemplary embodiments, one inlet hole **670** corresponds to and is in fluid communication with a single outlet hole **675**. However, in other exemplary embodiments, one inlet hole **670** corresponds to and is in fluid communication with a plurality of outlet holes **675**. Also, in certain exemplary embodiments, one or more outlet holes **675** is shaped and/or dimensioned differently than the corresponding inlet hole **670**. For example, the outlet hole **675** is sized larger, in perimeter or diameter, than the corresponding inlet hole **670**. This feature reduces plugging within the flow channel **760**. In certain exemplary embodiments, at least one flow channel **760** is directed in an upward angle from the inlet hole **670** to the outlet hole **675**. In other exemplary embodiments, the flow channel **760** is directed substantially horizontally or in a downward direction towards the bottom of the borehole (not shown).

[0038] FIG. **8** shows a perspective view of a drill bit **800** including one or more flow channels **960** in a gauge section **850** of the drill bit **800** in accordance with an exemplary embodiment of the present invention. FIG. **9** shows a schematic view of the one or more flow channels **960** in the gauge section **850** of the drill bit **800** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **8** and **9**, the drill bit **800** is similar to drill bit **200** (FIG. **2**). However, gauge section **850** is different from gauge section **250** (FIG. **2**) in that the flow channel **960** is different than the flow channel **360** (FIG. **3**). Each of the gauge sections **850** and blades **230**, as described above with respect to drill bit **200** (FIG. **2**), include a leading edge section **852**, a face section **854**, and a trailing edge section **856**. The face section **854** extends from one end of the trailing edge section **856** to an end of the leading edge section **852** and forms a front surface of the gauge section **850**. The leading edge section **852** faces in the direction of rotation **890** of the drill bit **800**, while the trailing edge section **856** faces in the opposite direction of rotation **890**.

[0039] According to some exemplary embodiments, as shown in FIGS. **8** and **9**, one or more inlet holes **870** are formed within the leading edge section **852** and one or more outlet holes **875** are formed within both the face section **854** and the trailing edge section **856**. The flow channel **960** extends from an inlet hole **870** to corresponding outlet holes **875**, at least one formed in the face section **854** and at least one formed in the trailing edge section **856**. Hence, the drilling fluid and/or cuttings enter into the flow channel **960** through the inlet hole **870** and exits through each of the corresponding outlet holes **875**, one of which is positioned on the face section **854** and one of which is positioned on the trailing edge section **856**. The fluid flowing through this flow channel **960** facilitates cooling of the gauge section **850** and also reduces erosion of the gauge section **850**. In some exemplary embodiments, one inlet hole **870** corresponds to and is in fluid communication with a single outlet hole **875** on the face section **854** and a single outlet hole **875** on the trailing edge section **856**. However, in other exemplary embodiments, one inlet hole **870** corresponds to and is in fluid communication with one outlet hole **875** on the face section **854**, one outlet hole **875** on the trailing edge section **856**, and at least one additional outlet hole **875** on either or both of the face section **854** and the trailing edge section **856**. Also, in certain exemplary embodiments, one or more outlet holes **875** is shaped and/or dimensioned differently than the corresponding inlet hole **870**. For example, the outlet hole **875** is sized larger, in perimeter or diameter, than the corresponding inlet hole **870**. This feature reduces plugging within the flow channel **960**. In certain exemplary embodiments, at least one flow channel **960** is directed in an upward angle from the inlet hole **870** to at least one outlet hole **875**. In other exemplary embodiments, at least one flow channel **960** is directed substantially horizontally or in a downward direction towards the bottom of the borehole (not shown).

[0040] FIG. **10** shows a perspective view of a drill bit **1000** including one or more flow channels **1160** in a gauge section **1050** of the drill bit **1000** in accordance with an exemplary embodiment of the present invention. FIG. **11** shows a schematic view of the one or more flow channels **1160** in the gauge section **81050** of the drill bit **1000** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **10** and **11**, the drill bit **1000** is similar to drill bit **200** (FIG. **2**). However, gauge section **1050** is different from gauge section **250** (FIG. **2**) in that the flow channel **1160** is different than the flow channel **360** (FIG. **3**). Each of the gauge sections **1050** and blades **230**, as described above with respect to drill bit **200** (FIG. **2**), include a leading edge section **1052**, a face section **1054**, and a trailing edge section **1056**. The face section **1054** extends from one end of the trailing edge section **1056** to an end of the leading edge section **1052** and forms a front surface of the gauge section **1050**. The leading edge section **1052** faces in the direction of rotation **1090** of the drill bit **1000**, while the trailing edge section **1056** faces in the opposite direction of rotation **1090**.

[0041] According to some exemplary embodiments, as shown in FIGS. **10** and **11**, one or more inlet holes **1070** are formed within the leading edge section **1052** and one or more outlet holes **1075** are formed within both the face section **1054** and the trailing edge section **1056**. Further, a deep groove **1078** is formed within the face section **1054** extending from the one or more outlet holes **1075** formed in the face section **1054** to the trailing edge section **1056**. The deep groove **1078** is substantially trapezoidal shaped in some exemplary embodiments; however, in other exemplary embodiments, the deep groove **1078** is formed in any other geometric shape, such as rectangular or triangular, or non-geometric shape. The deep groove **1078** is about ¼" deep in some exemplary embodiments but is greater in depth in other exemplary embodiments. However, according to certain exemplary embodiments, deep groove **1078** is less than ¼" deep. In some exemplary embodiments, the depth of the deep groove **1078** is substantially constant throughout the deep groove **1078**; however, the depth varies in other exemplary embodiments. For example, the depth of the deep groove **1078** is shallower near the outlet holes **1075** formed within the face section **1054** and deeper near the trailing edge section **1056**. The flow channel **1160** extends from an inlet hole **1070** to corresponding outlet holes **1075**, at least one formed in the face section **1054** and at least one formed in the trailing edge section **1056**. Hence, the drilling fluid and/or cuttings enter into the flow channel **1160** through the inlet hole **1070** and exits through each of the corresponding outlet holes **1075**, one of which is positioned on the face section **1054** and one of which is positioned on the trailing edge section **1056**. The fluid flowing through this flow channel **1160** facilitates cooling of the gauge section **1050** and also reduces erosion of the gauge section **1050**. In some exemplary embodiments, one inlet hole **1070** corresponds to and is in fluid communication with a single outlet hole **1075** on the face section **1054** and a single outlet hole **1075** on the trailing edge section **1056**. However, in other exemplary embodiments, one inlet hole **1070** corresponds to and is in fluid communication with one outlet hole **1075** on the face section **1054**, one outlet hole **1075** on the trailing edge section **1056**, and at least one additional outlet hole **1075** on either or both of the face section **1054** and the trailing edge section **1056**. Also, in certain exemplary embodiments, one or more outlet holes **1075** is shaped and/or dimensioned differently than the corresponding inlet hole **1070**. For example, the outlet hole **1075** is sized larger, in perimeter or diameter, than the corresponding inlet hole **1070**. This feature reduces plugging within the flow channel **1160**. In certain exemplary embodiments, at least one flow channel **1160** is directed in an upward angle from the inlet hole **1070** to at least one outlet hole **1075**. In other exemplary embodiments, at least one flow channel **1160** is directed substantially horizontally or in a downward direction towards the bottom of the borehole (not shown).

[0042] FIG. **12** shows a perspective view of a drill bit **1200** including one or more flow channels **1260** in a gauge section **1250** of the drill bit **1200** in accordance with an exemplary embodiment of the present invention. FIG. **13** shows a schematic view of the one or more flow channels **1260** in the gauge section **1250** of the drill bit **1200** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **12** and **13**, the drill bit **1200** is similar to drill bit **200** (FIG. **2**). However, gauge section **1250** is different from gauge section **250** (FIG. **2**) in that the flow channel **1260** is different than the flow channel **360** (FIG. **3**). Each of the gauge sections **1250** and blades **230**, as described above with respect to drill bit **200** (FIG. **2**), include a leading edge section **1252**, a face section **1254**, and a trailing edge section **1256**. The face section **1254** extends from one end of the trailing edge section **1256** to an end of the leading edge section **1252** and forms a front surface of the gauge section **1250**. The leading edge section **1252** faces in the direction of rotation **1290** of the drill bit **1200**, while the trailing edge section **1256** faces in the opposite direction of rotation **1290**.

[0043] According to some exemplary embodiments, as shown in FIGS. **12** and **13**, one or more deep grooves **1278** are formed within the face section **1254** extending from the leading edge section **1252** to the trailing edge section **1256**. The deep groove **1278** is substantially hour-glass shaped in some exemplary embodiments; however, in other exemplary embodiments, the deep groove **1278** is formed in any other geometric shape, such as rectangular, triangular, or inverted triangular shapes, or non-geometric shape. In some exemplary embodiments, the flow channel **1260** is wider at the leading edge section **1252** and the trailing edge section **1256**, but narrower therebetween. Alternatively, the flow channel **1260** is narrower at the leading edge section **1252** and wider at the trailing edge section **1256**. Further, in other exemplary embodiments, the flow channel **1260** is wider at the leading edge section **1252** and narrower at the trailing edge section **1256**. The deep groove **1278** is about ¼" deep in some exemplary embodiments but is greater in depth in other exemplary embodiments. However, according to certain exemplary embodiments, deep groove **1278** is less than ¼" deep. In some exemplary embodiments, the depth of the deep groove **1278** is substantially constant throughout the deep groove **1278**; however, the depth varies in other exemplary embodiments. For example, the depth of the deep groove **1278** is shallower near the leading edge section **1252** and deeper near the trailing edge section **1256**. The deep grooves **1278** is formed by milling, casting, or using any other known technique. The flow channel **1260**, defined by the one or more deep grooves **1278**, extends from the leading edge section **1252** to the trailing edge section **1256**. Hence, the drilling fluid and/or cuttings enter into the flow channel **1260** through the leading edge section **1252** and exits through the trailing edge section **1256**. The fluid flowing through this flow channel **1260** facilitates cooling of the gauge section **1250** and also reduces erosion of the gauge section **1250**. In certain exemplary embodiments, at least one flow channel **1260** is directed in an upward angle from the leading edge section **1252** to the trailing edge section **1256**. In other exemplary embodiments, the flow channel **1260** is directed substantially horizontally or in a downward direction towards the bottom of the borehole (not shown). Here, the flow channel **1260** is disposed adjacently and along the face section **1254**.

[0044] FIG. **14** shows a perspective view of a drill bit **1400** including one or more flow channels **1460** in a gauge section **1450** of the drill bit **1400** in accordance with an exemplary embodiment of the present invention. FIG. **15** shows a schematic view of the one or more flow channels **1460** in the gauge section **1450** of the drill bit **1400** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **14** and **15**, the drill bit **1400** is similar to drill bit **200** (FIG. **2**). However, gauge section **1450** is different from gauge section **250** (FIG. **2**) in that the flow channel **1460** is different than the flow channel **360** (FIG. **3**). Each of the gauge sections **1450** and blades **230**, as described above with respect to drill bit **200** (FIG. **2**), include a leading edge section **1452**, a face section **1454**, and a trailing edge section **1456**. The face section **1454** extends from one end of the trailing edge section **1456** to an end of the leading edge section **1452** and forms a front surface of the gauge section **1450**. The leading edge section **1452** faces in the direction of rotation **1490** of the drill bit **1400**, while the trailing edge section **1456** faces in the opposite direction of rotation **1490**.

[0045] According to some exemplary embodiments, as shown in FIGS. **14** and **15**, one or more deep grooves **1478** are formed within the face section **1454** extending from the leading edge section **1452** to the trailing edge section **1456**. The deep groove **1478** is substantially any non-geometric shape and forms one or more pods **1479** in some exemplary embodiments; however, in other exemplary embodiments, the deep groove **1478** is formed in any geometric shape still forming one or more pods **1479**. The deep groove **1478** surrounds the pods **1479**, or islands. In some exemplary embodiments, one or more pods **1479** are circular shaped, but are shaped into other geometric shape, such as oval, diamond, or square, or non-geometric shapes in other exemplary embodiments. The deep groove **1478** is about ¼" deep in some exemplary embodiments but is greater in depth in other exemplary embodiments. However, according to certain exemplary embodiments, deep groove **1478** is less than ¼" deep. In some exemplary embodiments, the depth of the deep groove **1478** is substantially constant throughout the deep groove **1478**; however, the depth varies in other exemplary embodiments. For example, the depth of the deep groove **1478** is shallower near the leading edge section **1452** and deeper near the trailing edge section **1456**. The deep grooves **1478** is formed by milling, casting, or using any other known technique. The flow channel **1460**, defined by the one or more deep grooves **1478**, extends from the leading edge section **1452** to the trailing edge section **1456** and surrounds the one or more pods **1479**. Hence, the drilling fluid and/or cuttings enter into the flow channel **1460** through the leading edge section **1452**, passes around the pods **1479**, and exits through the trailing edge section **1456**. The fluid flowing through this flow channel **1460** facilitates cooling of the gauge section **1450** and also reduces erosion of the gauge section **1450**. In certain exemplary embodiments, at least one flow channel **1460** is directed in an upward angle from the leading edge section **1452** to the trailing edge section **1456**. In other exemplary embodiments, the flow channel **1460** is directed substantially horizontally or in a downward direction towards the bottom of the borehole (not shown). Here, the flow channel **1460** is disposed adjacently and along the face section **1454**.

[0046] FIG. **16** shows a perspective view of a drill bit **1600** including one or more flow channels **1660** in a gauge section **1650** of the drill bit **1600** in accordance with an exemplary embodiment of the present invention. FIG. **17** shows a schematic view of the one or more flow channels **1660** in the gauge section **1650** of the drill bit **1600** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **16** and **17**, the drill bit **1600** is similar to drill bit **200** (FIG. **2**). However, gauge section **1650** is different from gauge section **250** (FIG. **2**) in that the flow channel **1660** is different than the flow channel **360** (FIG. **3**). Each of the gauge sections **1650** and blades **230**, as described above with respect to drill bit **200** (FIG. **2**), include a leading edge section **1652**, a face section **1654**, and a trailing edge section **1656**. The face section **1654** extends from one end of the trailing edge section **1656** to an end of the leading edge section **1652** and forms a front surface of the gauge section **1650**. The leading edge section **1652** faces in the direction of rotation **1690** of the drill bit **1600**, while the trailing edge section **1656** faces in the opposite direction of rotation **1690**.

[0047] According to some exemplary embodiments, as shown in FIGS. **16** and **17**, one or more deep grooves **1678** are formed within the face section **1654** extending from the leading edge section **1652** to the trailing edge section **1656**. The deep groove **1678** is substantially rectangularly shaped, or linearly, in some exemplary embodiments; however, in other exemplary embodiments, the deep groove **1678** is formed in any other geometric shape, such as curve-shaped, triangular or inverted triangular shapes, or non-geometric shape. In some exemplary embodiments, the flow channel **1660** is wider at the leading edge section **1652** and the trailing edge section **1656**, but narrower therebetween. Alternatively, the flow channel **1660** is narrower at the leading edge section **1652** and wider at the trailing edge section **1656**. Further, in other exemplary embodiments, the flow channel **1660** is wider at the leading edge section **1652** and narrower at the trailing edge section **1656**. The deep groove **1678** is about ¼" deep in some exemplary embodiments but is greater in depth in other exemplary embodiments. However, according to certain exemplary embodiments, deep groove **1678** is less than ¼" deep. In some exemplary embodiments, the depth of the deep groove **1678** is substantially constant throughout the deep groove **1678**; however, the depth varies in other exemplary embodiments. For example, the depth of the deep groove **1678** is shallower near the leading edge section **1652** and deeper near the trailing edge section **1656**. The deep grooves **1678** is formed by milling, casting, or using any other known technique. The flow channel **1660**, defined by the one or more deep grooves **1678**, extends from the leading edge section **1652** to the trailing edge section **1656**. Hence, the drilling fluid and/or cuttings enter into the flow channel **1660** through the leading edge section **1652** and/or through the face section **1654** and exits through the trailing edge section **1656**. The fluid flowing through this flow channel **1660** facilitates cooling of the gauge section **1650** and also reduces erosion of the gauge section **1650**. In certain exemplary embodiments, at least one flow channel **1660** is directed in an upward angle from the leading edge section **1652** to the trailing edge section **1656**. In other exemplary embodiments, the flow channel **1660** is directed substantially horizontally or in a downward direction towards the bottom of the borehole (not shown). Here, the flow channel **1660** is disposed adjacently and along the face section **1654**. According to certain exemplary embodiments, none of the flow channels **1660** intersect with another flow channel **1660**. However, in other exemplary embodiments, at least one flow channel **1660** intersects with at least one other flow channel **1660**.

[0048] FIG. **18** shows a perspective view of a drill bit **1800** including one or more flow channels **1860** in a gauge section **1850** of the drill bit **1800** in accordance with an exemplary embodiment of the present invention. FIG. **19** shows a schematic view of the one or more flow channels **1860** in the gauge section **1850** of the drill bit **1800** in accordance with an exemplary embodiment of the present invention. Referring to FIGS. **18** and **19**, the drill bit **1800** is similar to drill bit **200** (FIG. **2**). However, gauge section **1850** is different from gauge section **250** (FIG. **2**) in that the flow channel **1860** is different than the flow channel **360** (FIG. **3**). Each of the gauge sections **1850** and blades **230**, as described above with respect to drill bit **200** (FIG. **2**), include a leading edge section **1852**, a face section **1854**, and a trailing edge section **1856**. The face section **1854** extends from one end of the trailing edge section **1856** to an end of the leading edge section **1852** and forms a front surface of the gauge section **1850**. The leading edge section **1852** faces in the direction of rotation **1890** of the drill bit **1800**, while the trailing edge section **1856** faces in the opposite direction of rotation **1890**.

[0049] According to some exemplary embodiments, as shown in FIGS. **18** and **18**, one or more deep grooves **1878** are formed within the face section **1854** extending from the leading edge section **1852** to the trailing edge section **1856**. The deep groove **1878** is substantially curved-shaped in some exemplary embodiments; however, in other exemplary embodiments, the deep groove **1878** is formed in any other geometric shape, such as linearly, triangular or inverted triangular shapes, or non-geometric shape. In some exemplary embodiments, the flow channel **1860** is wider at the leading edge section **1852** and the trailing edge section **1856**, but narrower therebetween. Alternatively, the flow channel **1860** is narrower at the leading edge section **1852** and wider at the trailing edge section **1856**. Further, in other exemplary embodiments, the flow channel **1860** is wider at the leading edge section **1852** and narrower at the trailing edge section **1856**. The deep groove **1878** is about ¼" deep in some exemplary embodiments but is greater in depth in other exemplary embodiments. However, according to certain exemplary embodiments, deep groove **1878** is less than ¼" deep. In some exemplary embodiments, the depth of the deep groove **1878** is substantially constant throughout the deep groove **1878**; however, the depth varies in other exemplary embodiments. For example, the depth of the deep groove **1878** is shallower near the leading edge section **1852** and deeper near the trailing edge section **1856**. The deep grooves **1878** is formed by milling, casting, or using any other known technique. The flow channel **1860**, defined by the one or more deep grooves **1878**, extends from the leading edge section **1852** to the trailing edge section **1856**. Hence, the drilling fluid and/or cuttings enter into the flow channel **1860** through the leading edge section **1852** and/or through the face section **1854** and exits through the trailing edge section **1856**. The fluid flowing through this flow channel **1860** facilitates cooling of the gauge section **1850** and also reduces erosion of the gauge section **1850**. In certain exemplary embodiments, at least one flow channel **1860** is directed in an upward angle from the leading edge section **1852** to the trailing edge section **1856**. In other exemplary embodiments, the flow channel **1860** is directed substantially horizontally or in a downward direction towards the bottom of the borehole (not shown). Here, the flow channel **1860** is disposed adjacently and along the face section **1854**. According to certain exemplary embodiments, none of the flow channels **1860** intersect with another flow channel **1860**. However, in other exemplary embodiments, at least one flow channel **1860** intersects with at least one other flow channel **1860**.

[0050] In some of the above exemplary embodiments, the flow channel is linear when extending from the leading edge section to the trailing edge section and curved when extending from the leading edge section to the face section. However, the flow channel is linear or curved regardless of the endpoint of the flow channel in other exemplary embodiments. Some drill bits and/or downhole tools include flow channels that are of a combination of any of the above mentioned flow channels. Although not specifically recited in each of the exemplary embodiments, any feature of one of the exemplary embodiments described above is combinable with any other exemplary embodiment to form a different exemplary embodiment, which is contemplated to be included as another exemplary embodiment of the present invention.

[0051] Exemplary embodiments of this invention also are combinable with one or more "High Angle Nozzle" feature as disclosed, or similarly disclosed, within U.S. Non-Provisional patent application Ser. No. ______, entitled "Machined High Angle Nozzle Sockets For Steel Body Bits" and filed on September ______, 2013, and/or one or more "Flow Through" blade features as disclosed within U.S. Non-Provisional patent application Ser. No. ______, entitled "Blade Flow PDC Bits" and filed on September ______, 2013, both of which have previously been hereby incorporated by reference herein.

[0052] Although the invention has been described with reference to specific embodiments, these descriptions are not meant to be construed in a limiting sense. Various modifications of the disclosed embodiments, as well as alternative embodiments of the invention will become apparent to persons skilled in the art upon reference to the description of the invention. It should be appreciated by those skilled in the art that the conception and the specific embodiments disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims. It is therefore, contemplated that the claims will cover any such modifications or embodiments that fall within the scope of the invention.

What is claimed is:

1. A downhole tool, comprising:
a body;
one or more blades extending from one end of the bit body, the plurality of blades forming a cutting surface; and
one or more gauge sections, each gauge section disposed adjacently and in alignment with a respective blade, each gauge section comprising:
a leading edge section;
a trailing edge section; and
a face section extending from one end of the leading edge section to one end of the trailing edge section,
wherein at least one flow channel is formed in the gauge section extending from the leading edge section to at least one of the trailing edge section or the face section.

2. The downhole tool of claim **1**, wherein the leading edge section comprises at least one inlet opening, the trailing edge section comprises at least one outlet opening, and the flow channel is formed extending from the inlet opening to the at least one outlet opening.

3. The downhole tool of claim **2**, wherein the flow channel is oriented at an upward angle.

4. The downhole tool of claim **2**, wherein at least one outlet opening is dimensioned larger than the corresponding inlet opening.

5. The downhole tool of claim **2**, wherein the flow channel is curved.

6. The downhole tool of claim **1**, wherein the leading edge section comprises at least one inlet opening, the face section comprises at least one outlet opening, and the flow channel is formed extending from the inlet opening to the at least one outlet opening.

7. The downhole tool of claim **6**, wherein the at least one outlet opening is dimensioned larger than the corresponding inlet opening.

8. The downhole tool of claim **6**, wherein the flow channel is curved.

9. The downhole tool of claim **6**, wherein the flow channel is oriented at an upward angle.

10. The downhole tool of claim **1**, wherein the leading edge section comprises at least one inlet opening, the face section comprises at least one outlet opening and a deep groove extending from the at least one outlet opening to the trailing edge section, and the flow channel is formed extending from the inlet opening to at least one outlet opening.

11. The downhole tool of claim **10**, wherein the deep groove comprises a depth of at least one-fourth inch.

12. The downhole tool of claim **10**, wherein the at least one outlet opening is dimensioned larger than the corresponding inlet opening.

13. The downhole tool of claim **10**, wherein the flow channel is curved.

14. The downhole tool of claim **10**, wherein the flow channel is oriented at an upward angle.

15. The downhole tool of claim **1**, wherein the leading edge section comprises at least one inlet opening, the face section comprises at least one outlet opening, the trailing edge section comprises at least one second outlet opening, and the flow channel is formed extending from the inlet opening to at least one outlet opening of the face section and to at least one second outlet opening of the trailing edge section.

16. The downhole tool of claim **15**, wherein at least a portion of the flow channel is curved.

17. The downhole tool of claim **15**, wherein at least a portion of the flow channel is oriented at an upward angle.

18. The downhole tool of claim **1**, wherein the leading edge section comprises at least one inlet opening, the face section comprises at least one outlet opening and a deep groove extending from the outlet opening to the trailing edge section, the trailing edge section comprises at least one second outlet opening, and the flow channel is formed extending from the inlet opening to at least one outlet opening of the face section and to at least one second outlet opening of the trailing edge section.

19. The downhole tool of claim **1**, wherein the flow channel is formed extending across a surface of the face section from the leading edge section to the trailing edge section.

20. The downhole tool of claim **19**, wherein the flow channel at the leading edge section and at the trailing edge section is wider than the flow channel therebetween.

21. The downhole tool of claim **19**, wherein the at least one flow channel comprises a plurality of flow channels, a first flow channel being parallel to a second flow channel.

22. The downhole tool of claim **19**, wherein the flow channel is oriented at an upward angle.

23. The downhole tool of claim **19**, wherein the flow channel is curved.

24. The downhole tool of claim **19**, wherein the flow channel is linear.

25. The downhole tool of claim **1**, wherein the face section comprises at least one pod and wherein the flow channel is formed extending across the face section from the leading edge section to the trailing edge section and surrounding the at least one pod.

26. The downhole tool of claim **25**, wherein the at least one pod is selected from the group consisting of circular-shaped, diamond-shaped, rectangular-shaped, triangular-shaped, and a non-geometric shape.

27. A gauge section of a downhole tool, comprising:

a leading edge section;

a trailing edge section; and

a face section extending from one end of the leading edge section to one end of the trailing edge section,

wherein at least one flow channel is formed in the gauge section extending from the leading edge section to at least one of the trailing edge section or the face section.

28. The gauge section of claim **27**, wherein the leading edge section comprises at least one inlet opening, the trailing edge section comprises at least one outlet opening, and the flow channel is formed extending from the inlet opening to the at least one outlet opening.

29. The gauge section of claim **28**, wherein the flow channel is oriented at an upward angle.

30. The gauge section of claim **28**, wherein at least one outlet opening is dimensioned larger than the corresponding inlet opening.

31. The gauge section of claim **28**, wherein the flow channel is curved.

32. The gauge section of claim **27**, wherein the leading edge section comprises at least one inlet opening, the face section comprises at least one outlet opening, and the flow channel is formed extending from the inlet opening to the at least one outlet opening.

33. The gauge section of claim **27**, wherein the leading edge section comprises at least one inlet opening, the face section comprises at least one outlet opening and a deep groove extending from the at least one outlet opening to the trailing edge section, and the flow channel is formed extending from the inlet opening to at least one outlet opening.

34. The gauge section of claim **27**, wherein the leading edge section comprises at least one inlet opening, the face section comprises at least one outlet opening, the trailing edge section comprises at least one second outlet opening, and the flow channel is formed extending from the inlet opening to at least one outlet opening of the face section and to at least one second outlet opening of the trailing edge section.

35. The gauge section of claim **27**, wherein the leading edge section comprises at least one inlet opening, the face section comprises at least one outlet opening and a deep groove extending from the outlet opening to the trailing edge section, the trailing edge section comprises at least one second outlet opening, and the flow channel is formed extending from the inlet opening to at least one outlet opening of the face section and to at least one second outlet opening of the trailing edge section.

36. The gauge section of claim **27**, wherein the flow channel is formed extending across a surface of the face section from the leading edge section to the trailing edge section.

37. The gauge section of claim **36**, wherein the flow channel at the leading edge section and at the trailing edge section is wider than the flow channel therebetween.

38. The gauge section of claim **27**, wherein the face section comprises at least one pod and wherein the flow channel is formed extending across the face section from the leading edge section to the trailing edge section and surrounding the at least one pod.

39. A method of fabricating one or more flow channels in a downhole tool, the method comprising:

obtaining a downhole tool, comprising:

a body;

one or more blades extending from one end of the body, the plurality of blades forming a cutting surface; and

one or more gauge sections, each gauge section disposed adjacently and in alignment with a respective blade, each gauge section comprising:

a leading edge section;

a trailing edge section; and

a face section extending from one end of the leading edge section to one end of the trailing edge section,

forming at least one flow channel in the gauge section, the flow channel extending from the leading edge section to at least one of the trailing edge section or the face section.

40. The method of claim **39**, wherein forming at least one flow channel in the gauge section comprises:

forming at least one inlet opening in the leading edge section;

forming at least one outlet opening in the trailing edge section; and

forming the flow channel to extend from the at least one inlet opening to the at least one outlet opening.

41. The method of claim **40**, wherein the flow channel is oriented at an upward angle.

42. The method of claim **40**, wherein at least one outlet opening is dimensioned larger than the corresponding inlet opening.

43. The method of claim **40**, wherein the flow channel is curved.

44. The method of claim **39**, wherein forming at least one flow channel in the gauge section comprises:

forming at least one inlet opening in the leading edge section;

forming at least one outlet opening in the face section; and

forming the flow channel to extend from the at least one inlet opening to the at least one outlet opening.

45. The method of claim **39**, wherein forming at least one flow channel in the gauge section comprises:

forming at least one inlet opening in the leading edge section;

forming at least one outlet opening in the face section;

forming a deep groove in the face section extending from the at least one outlet opening to the trailing edge section; and

forming the flow channel to extend from the at least one inlet opening to the at least one outlet opening.

46. The method of claim **39**, wherein forming at least one flow channel in the gauge section comprises:

forming at least one inlet opening in the leading edge section;

forming at least one outlet opening in the face section;

forming at least one second outlet opening in the trailing edge section; and

forming the flow channel to extend from the at least one inlet opening to the at least one outlet opening of the face section and to at least one second outlet opening of the trailing edge section.

47. The method of claim **39**, wherein forming at least one flow channel in the gauge section comprises:

forming at least one inlet opening in the leading edge section;

forming at least one outlet opening in the face section;

forming a deep groove in the face section extending from the at least one outlet opening to the trailing edge section;

forming at least one second outlet opening in the trailing edge section; and

forming the flow channel to extend from the at least one inlet opening to the at least one outlet opening of the face section and to at least one second outlet opening of the trailing edge section.

48. The method of claim **39**, wherein forming at least one flow channel in the gauge section comprises forming the flow channel to extend across a surface of the face section from the leading edge section to the trailing edge section.

49. The method of claim **48**, wherein the flow channel at the leading edge section and at the trailing edge section is wider than the flow channel therebetween.

50. The method of claim **39**, wherein forming at least one flow channel in the gauge section comprises forming the flow channel to extend across a portion of a surface of the face section from the leading edge section to the trailing edge section, the flow channel surrounding one or more pods formed therein.

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