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(54) **CUTTING ELEMENT POCKET WITH RELIEF FEATURES**

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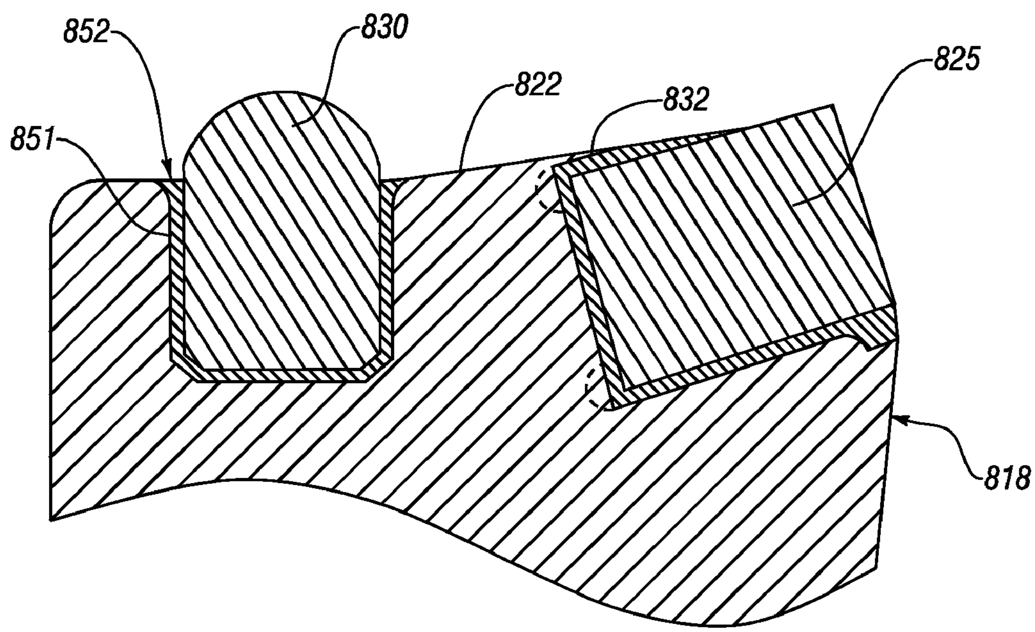
(57) **ABSTRACT**

A bit has a bit body. A pocket is formed in a surface of the bit body. The pocket has an opening at the surface and is defined by a rear wall with a sidewall extending between the rear wall and the surface. The pocket includes a stress relief feature at a front end of the sidewall to reduce stress concentrations in the bit body at or near the pocket, a stress relief feature at a rear end of the sidewall to reduce stress concentrations in the bit body at or near the pocket, or stress relief features at both front and rear ends of the sidewall.



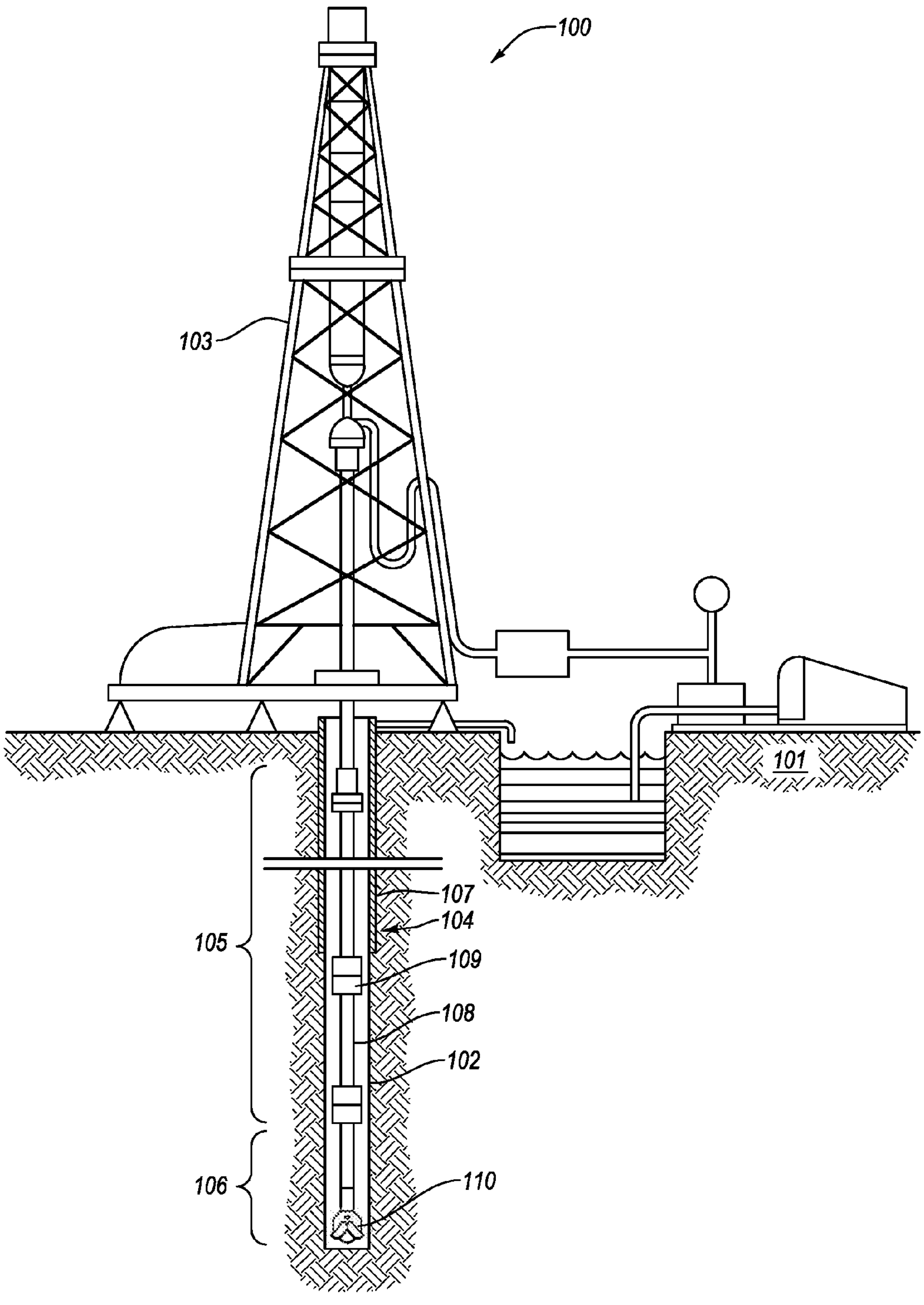


FIG. 1

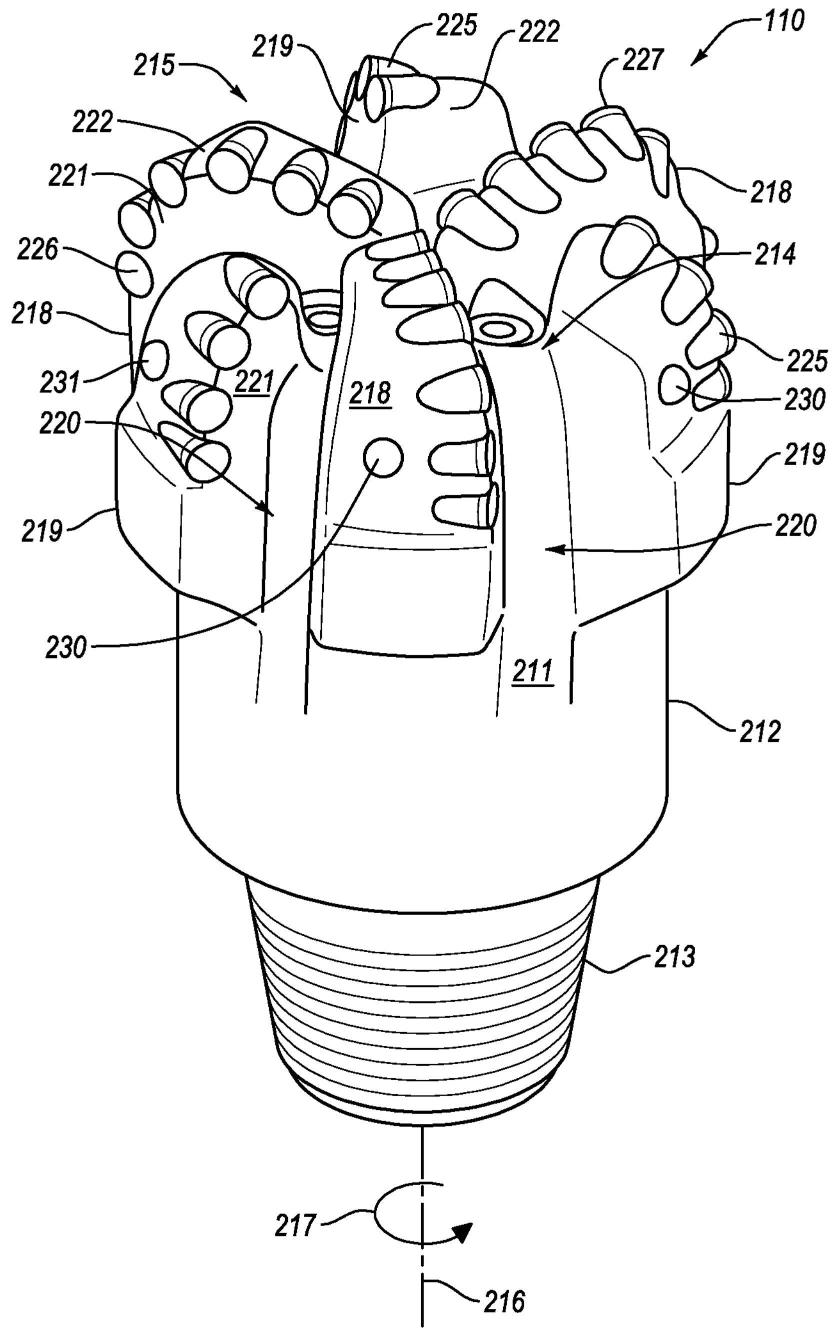

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FIG. 2

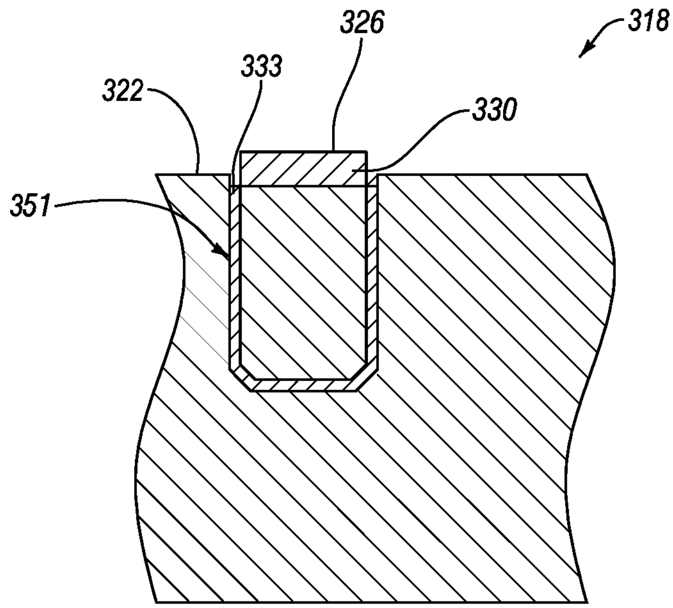
318
326
333
322
330
351

FIG. 3-1

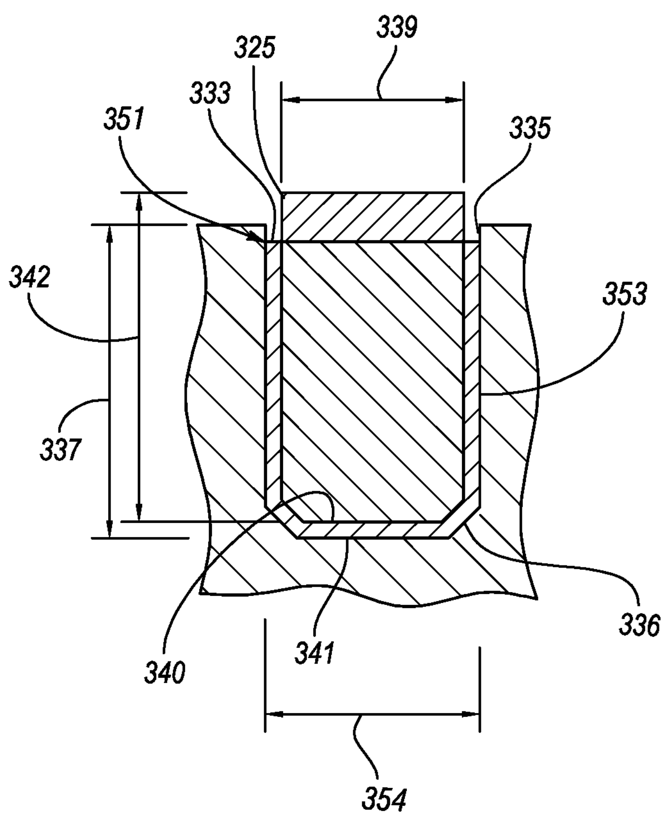
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FIG. 3-2

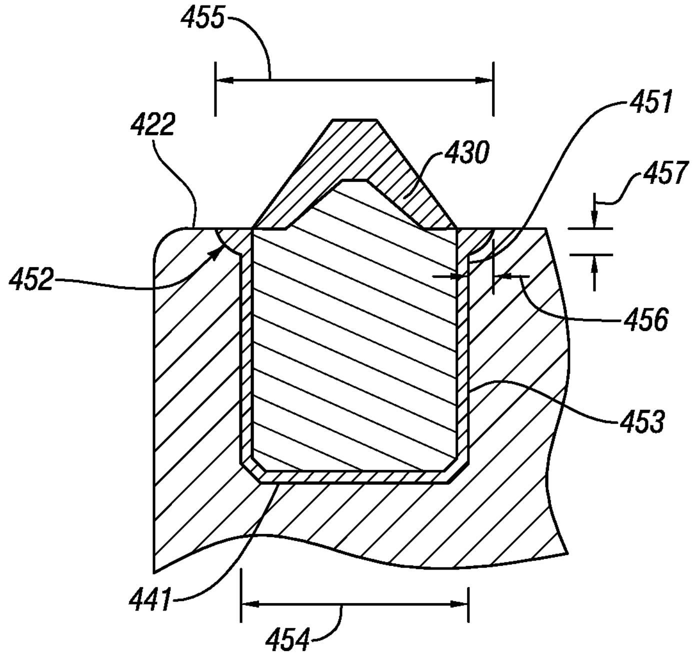
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FIG. 4

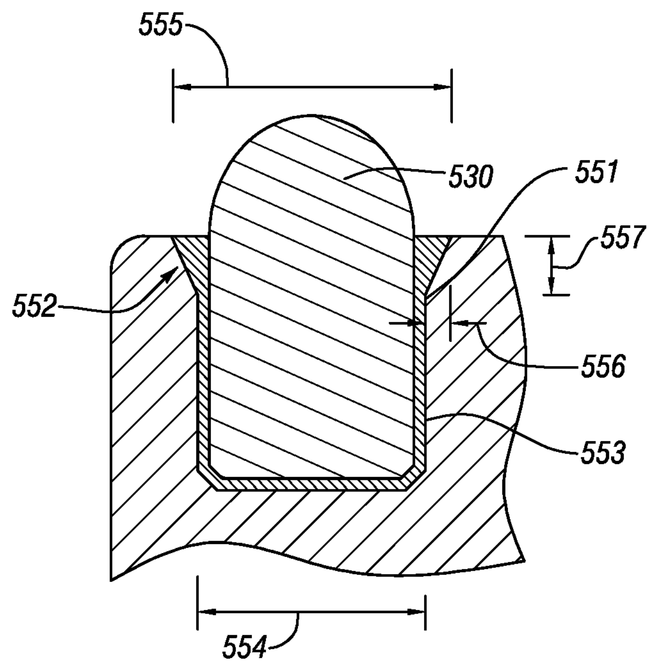
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FIG. 5

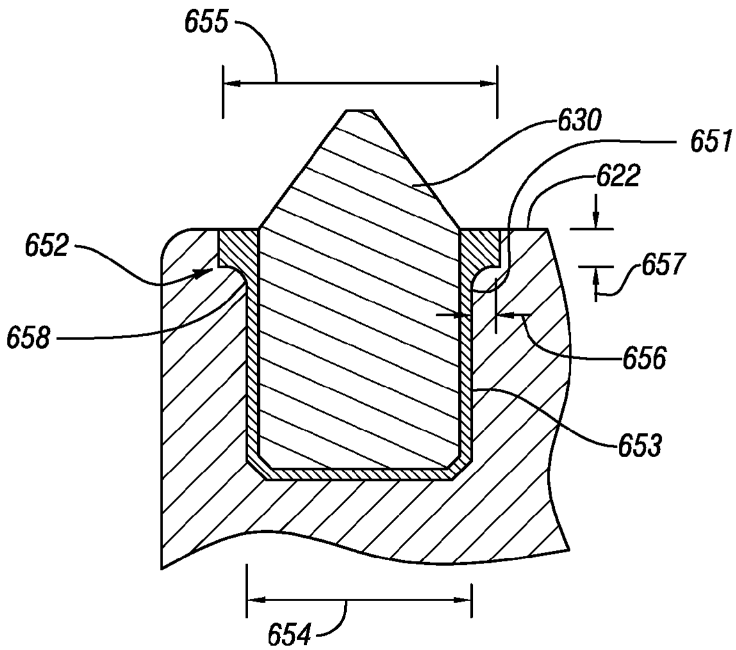
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FIG. 6

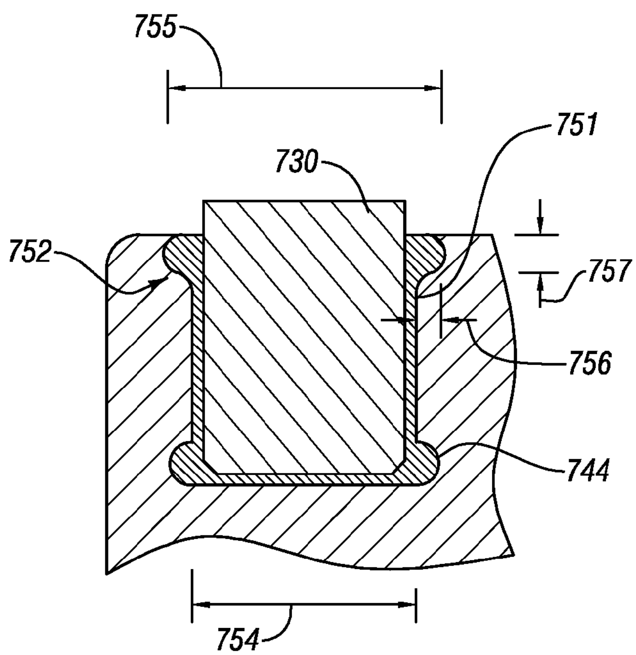
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FIG. 7

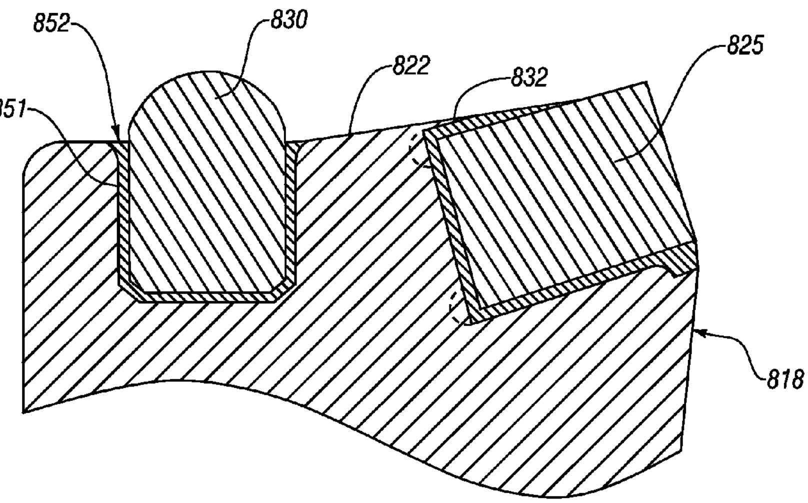

FIG. 8

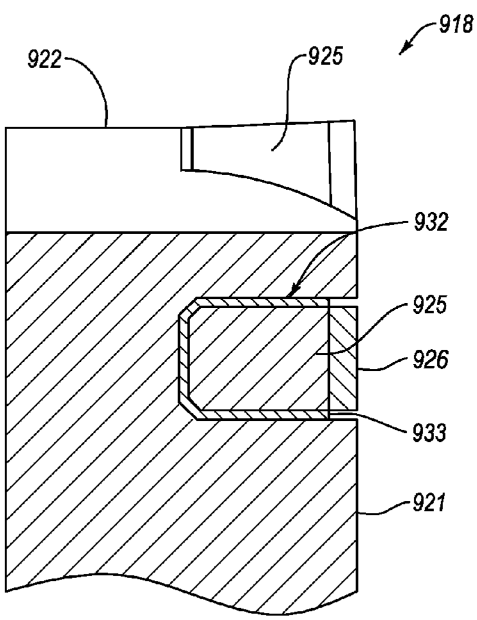

FIG. 9-1

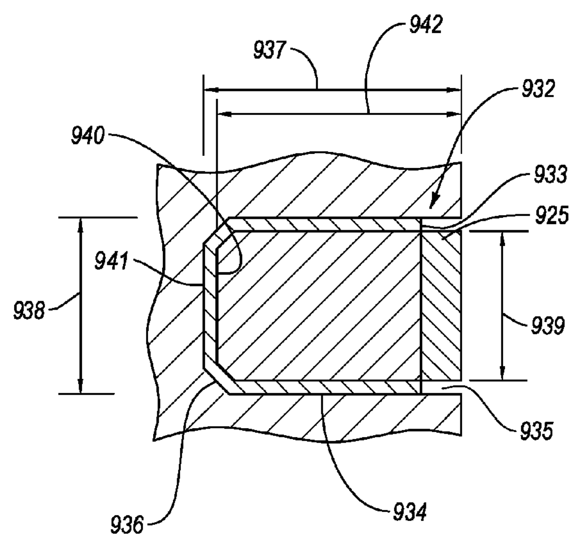

FIG. 9-2

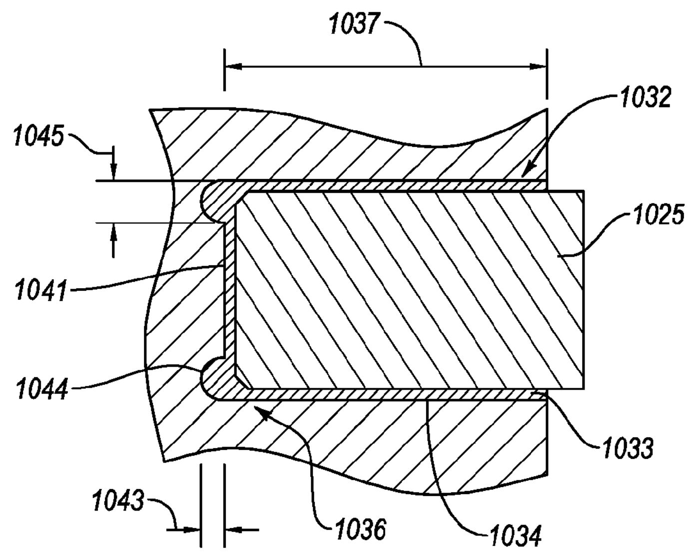

FIG. 10-1

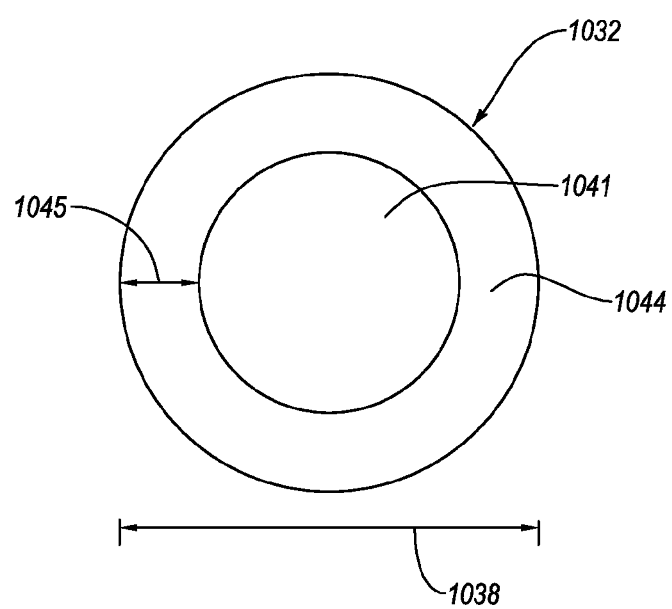

FIG. 10-2

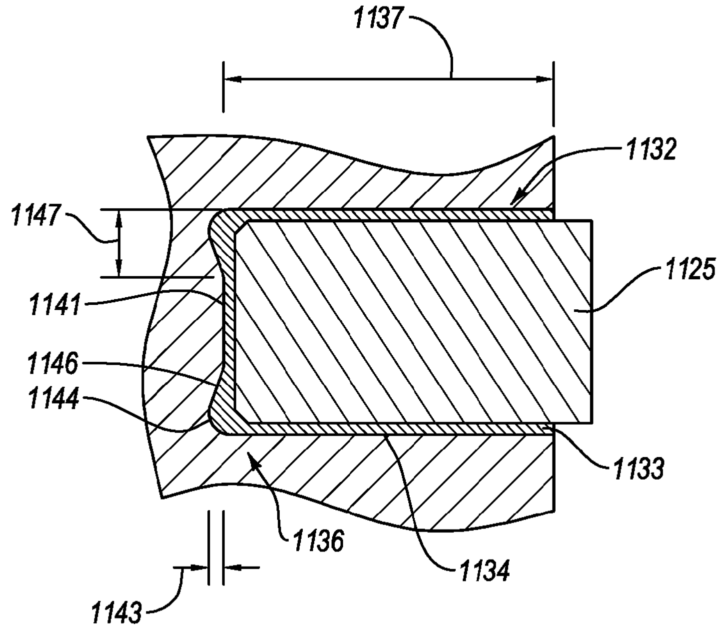

FIG. 11-1

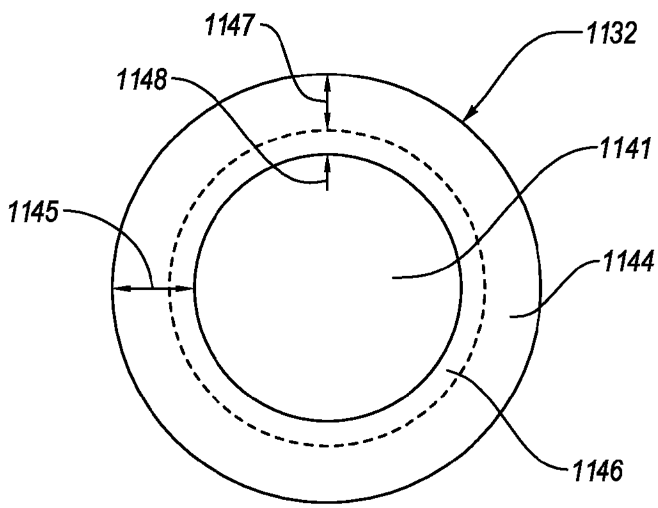

FIG. 11-2

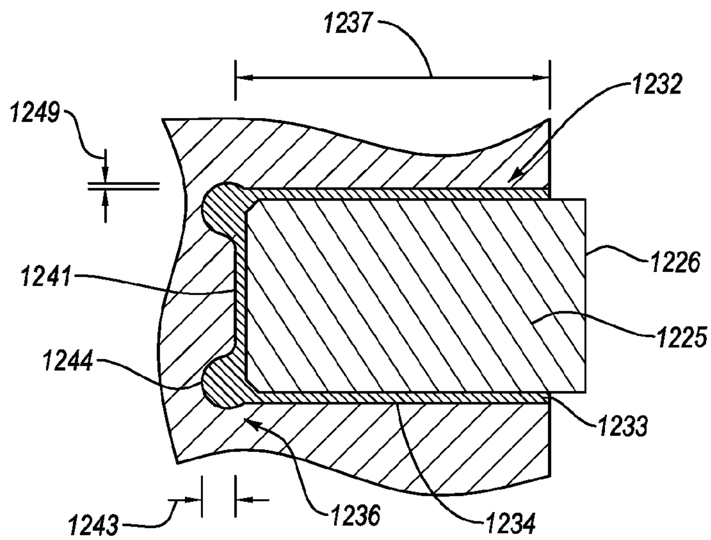

FIG. 12-1

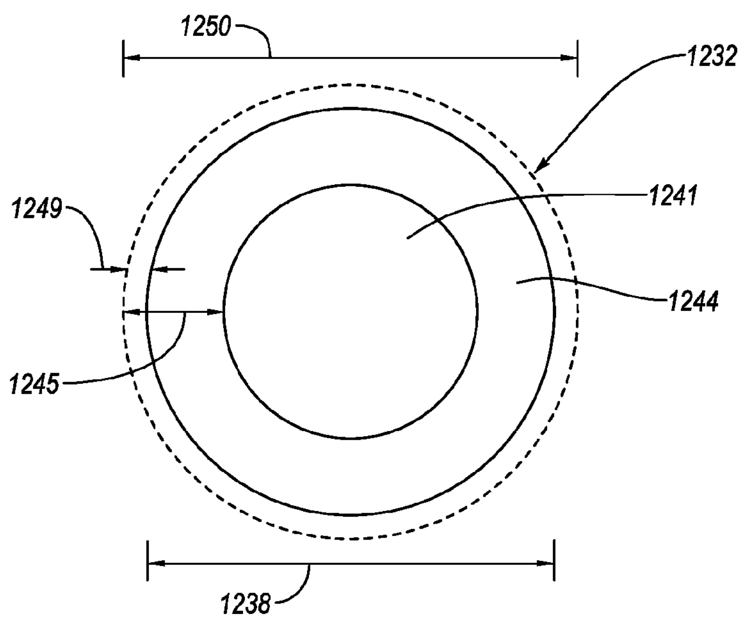

FIG. 12-2

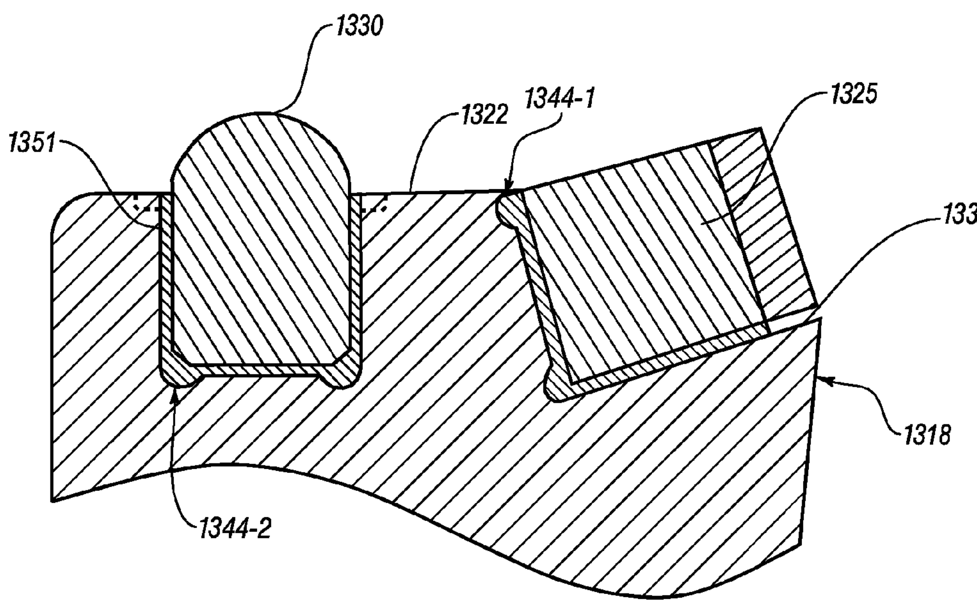

FIG. 13

CUTTING ELEMENT POCKET WITH RELIEF FEATURES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of, and priority to, U.S. Patent Application No. 62/320,045, filed Apr. 8, 2016 and titled "Cutting Element Pocket with Front Relief Groove" and to. U.S. Patent Application No. 62/320,076, filed Apr. 8, 2016 and titled "Cutting Element with Base Relief Groove." Each of the foregoing applications is incorporated herein by this reference in its entirety.

BACKGROUND

[0002] Wellbores may be drilled into a surface location or seabed for a variety of exploratory or extraction purposes. For example, a wellbore may be drilled to access fluids, such as liquid and gaseous hydrocarbons, stored in subterranean formations and to extract the fluids from the formations. Wellbores used to produce or extract fluids may be lined with casing around the walls of the wellbore. A variety of drilling methods and tools may be utilized depending partly on the characteristics of the formation through which the wellbore is drilled.

[0003] A drilling system may use a variety of bits in the creation, maintenance, extension, and abandonment of a wellbore. Bits include drilling bits, mills, reamers, hole openers, and other cutting tools. Some bits employ cutting elements held by a body of the bit. The cutting elements may include materials that are harder or more wear resistant than the body of the bit. A cutting element is secured within a pocket in the body by friction, brazing, welding, or mechanical fasteners.

[0004] During operation of the drilling system, the bit experiences forces and vibration through the body and the cutting elements. The forces and vibration on both the body and the cutting elements can loosen the cutting elements in the pockets, damage the body at or near the pockets, damage the braze or other material in the pocket between the cutting element and the body, or otherwise compromise retention of the cutting element in the bit, or the integrity of the bit itself.

SUMMARY

[0005] In some embodiments, a bit includes a bit body and a cutting face forming part of, or otherwise coupled to, the bit body. The cutting face includes a surface having a pocket. The pocket is fully or partially defined by a rear wall and a sidewall. The pocket includes a relief opening at an interface of the pocket and the surface, and extends around at least 75% of a perimeter of the pocket.

[0006] According to some embodiments, a bit includes a bit body and a blade extending from the bit body. The blade has a formation facing surface with a top pocket therein. An insert is positioned in the top pocket. The top pocket is at least partially defined by a rear wall and a sidewall, and includes a relief opening extending at least partially around a perimeter of the top pocket, at an interface between the formation facing surface and the sidewall.

[0007] In yet further embodiments, a method of manufacturing a bit includes forming a bit body having a cutting face with a formation facing surface. A top pocket is in the formation facing surface and cutting face, and is defined by a rear wall and a sidewall. An insert is placed into the top pocket and brazed in place. A temperature of the bit body and of the insert is lowered, which causes the cutting face to thermally contract at a greater rate than the insert. Stress concentrations in the cutting face are reduced with a stress relief opening around a perimeter of the top pocket, and located at an interface between the formation facing surface and the sidewall.

[0008] In some embodiments, a bit includes a bit body and blades extending from the bit body. The blades have pockets at least partially defined by a rear wall and a side wall. One or more of the pockets includes an annular stress relief element in the sidewall or rear wall. An insert is brazed into the pocket with the annular stress relief element.

[0009] Yet additional embodiments include a bit with a bit body having a surface, and a pocket in the surface. The pocket is at least partially defined by a sidewall and rear wall, and has a pocket depth and a pocket width. The bit body also includes a relief recess at an interface of the rear wall and the sidewall. The relief recess has a recess depth and a recess width. The bit body further includes a relief opening at an interface of the sidewall and the surface. The relief opening extends at least partially around a perimeter of the pocket and has an opening depth and an opening lateral extension.

[0010] In some embodiments, a bit includes a bit body and a blade extending from the bit body. The blade includes a surface with a pocket. The pocket is defined by a sidewall and rear wall, and a relief recess is formed between the sidewall and rear wall. The relief recess has a depth extending beyond a pocket depth of the pocket.

[0011] In some embodiments, a bit includes a bit body, a blade extending from the bit body, and a cutting element. The cutting element is positioned in a face pocket in the blade. The face pocket is in a forward facing surface of the blade, and is defined by a sidewall and a rear wall. The pocket includes a relief recess between the rear wall and the sidewall. A relief recess is positioned between the rear wall and the side wall, and the relief recess has a depth extending beyond a pocket depth of the face pocket.

[0012] In further embodiments, a method of manufacturing a bit includes forming a bit body with a blade extending therefrom. The blade includes a forward facing surface with a face pocket therein. A cutting element is placed in the face pocket and brazed therein. The temperatures of the blade and cutting element are lowered, which causes the blade to thermally contract at a greater rate than the cutting element. Stress concentrations are reduced in the blade using a stress relief recess at the base of the face pocket.

[0013] This summary is provided to introduce a selection of concepts that are further described in the detailed description, and is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter. Additional features and aspects of embodiments of the disclosure will be set forth in the description that follows. These and other features will become more fully apparent from the following description and appended claims, or may be learned by the practice of such embodiments as set forth herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] In order to describe the manner in which the above-recited and other features of the disclosure can be obtained, a more particular description will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. For better understanding, the like elements have been designated by like reference numbers throughout the various accompanying figures. While some of the drawings may be schematic or exaggerated representations of concepts, at least some of the drawings may be drawn to scale. Understanding that the drawings depict some example embodiments, the embodiments will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

[0015] FIG. **1** is a side cross-sectional schematic representation of an embodiment of a drilling system, according to the present disclosure;

[0016] FIG. **2** is a perspective view of an embodiment of a bit having a plurality of cutting elements, according to the present disclosure;

[0017] FIG. **3-1** is a side partial cross-sectional view of an embodiment of a blade, according to the present disclosure;

[0018] FIG. **3-2** is a detail view of the embodiment of a top pocket of FIG. **3-1**, according to the present disclosure;

[0019] FIG. **4** is a detail view of an embodiment of a stress relief opening in a top pocket, according to the present disclosure;

[0020] FIG. **5** is a detail view of another embodiment of a stress relief opening in a top pocket, according to the present disclosure;

[0021] FIG. **6** is a detail view of yet another embodiment of a stress relief opening in a top pocket, according to the present disclosure;

[0022] FIG. **7** is a detail view of a further embodiment of a stress relief opening and a stress relief recess in a top pocket, according to the present disclosure;

[0023] FIG. **8** is side cross-sectional view of an embodiment of a blade with a top pocket and a face pocket, according to the present disclosure.

[0024] FIG. **9-1** is a side partial cross-sectional view of an embodiment of a blade, according to the present disclosure;

[0025] FIG. **9-2** is a detail view of the embodiment of a face pocket of FIG. **3-1**, according to the present disclosure;

[0026] FIG. **10-1** is a detail view of an embodiment of a stress relief recess in a face pocket, according to the present disclosure;

[0027] FIG. **10-2** is an end view of the embodiment of a stress relief recess of FIG. **4-1**, according to the present disclosure;

[0028] FIG. **11-1** is a detail view of another embodiment of a stress relief recess in a face pocket, according to the present disclosure;

[0029] FIG. **11-2** is an end view of the embodiment of a stress relief recess of FIG. **5-1**, according to the present disclosure;

[0030] FIG. **12-1** is a detail view of yet another embodiment of a stress relief recess in a face pocket, according to the present disclosure;

[0031] FIG. **12-2** is an end view of the embodiment of a stress relief recess of FIG. **6-1**, according to the present disclosure; and

[0032] FIG. **13** is side cross-sectional view of an embodiment of a blade having top and face pockets, according to the present disclosure.

DETAILED DESCRIPTION

[0033] This disclosure generally relates to devices, systems, and methods for positioning one or more cutting elements in a bit body. More particularly, the present disclosure relates to embodiments of bits having cutting element pockets with one or more stress relief portions that may increase operational lifetime, improve connection strength between the cutting element and the bit body, reduce the likelihood of cutting element or bit body failure, or combinations thereof. While a drill bit for cutting through an earth formation is described herein, it should be understood that the present disclosure may be applicable to other bits such as mills, reamers, hole openers, and other bits used in downhole or other applications.

[0034] FIG. **1** shows one example of a drilling system **100** for drilling an earth formation **101** to form a wellbore **102**. The drilling system **100** includes a drill rig **103** used to turn a drilling tool assembly **104** which extends downward into the wellbore **102**. The drilling tool assembly **104** may include a drill string **105**, a bottomhole assembly ("BHA") **106** attached to a downhole end portion of drill string **105**. The BHA **106** may include a bit **110** for drilling, milling, reaming, or performing other cutting operations within the wellbore.

[0035] The drill string **105** may include several joints of drill pipe **108** a connected end-to-end through tool joints **109**. The drill string **105** transmits drilling fluid through a central bore and optionally transmits rotational power from the drill rig **103** to the BHA **106**. In some embodiments, the drill string **105** may further include additional components such as subs, pup joints, etc. The drill string **105** may include slim drill pipe, coiled tubing, or other materials that transmit drilling fluid through a central bore, which may not transmit rotational power. Where rotational power is used, a downhole motor (e.g., a positive displacement motor, turbine-driven motors, electric motor, etc.) may be included in the BHA. The drill string **105** provides a hydraulic passage through which drilling fluid is pumped from the surface. The drilling fluid discharges through selected-size nozzles, jets, or other orifices in the bit **110** (or other components of the drill string **105** of BHA **106**) for the purposes of cooling the bit **110** and cutting structures thereon, for lifting cuttings out of the wellbore **102** as downhole operations are performed, or for other purposes (e.g., cleaning, powering a motor, etc.).

[0036] The BHA **106** may include the bit **110** or other components. An example BHA **106** may include additional or other components (e.g., coupled between to the drill string **105** and the bit **110**). Examples of additional BHA components include drill collars, stabilizers, measurement-while-drilling ("MWD") tools, logging-while-drilling ("LWD") tools, downhole motors, underreamers, section mills, hydraulic disconnects, jars, vibration or dampening tools, other components, or combinations of the foregoing.

[0037] In general, the drilling system **100** may include other drilling components and accessories, such as special valves (e.g., kelly cocks, blowout preventers, and safety valves). Additional components included in the drilling system **100** may be considered a part of the drilling tool assembly **104**, the drill string **105**, or a part of the BHA **106** depending on their locations or functions in the drilling system **100**.

[0038] The bit **110** in the BHA **106** may be any type of bit suitable for degrading downhole materials. For instance, the bit **110** may be a drill bit suitable for drilling the earth formation **101**. Example types of drill bits used for drilling earth formations are fixed-cutter or drag bits (see FIG. **2**), roller cone bits, impregnated bits, or coring bits. In other embodiments, the bit **110** may be a mill used for removing metal, composite, elastomer, or other materials downhole. For instance, the bit **110** may be used with a whipstock (not shown) to mill a window into a casing **107** lining at least a portion of the wellbore **102**. The bit **110** may also be a section mill used to mill away an entire section of the casing **107**, or a junk mill used to mill away tools, plugs, cement, or other materials within the wellbore **102**. Swarf or other cuttings formed by use of a mill may be lifted to surface, or may be allowed to fall downhole.

[0039] Referring to FIG. **2**, an example fixed cutter or drag bit **210** adapted for drilling through formations of rock to form a wellbore is shown. The bit **210** generally includes a bit body **211**, a shank **212**, and a threaded connection or pin **213** for connecting the bit **210** to a drill string (e.g., drill string **105** of FIG. **1**), drive shaft, or other component that is employed to rotate the bit **210** in order to drill the wellbore. A bit face **214** supports a cutting structure **215** and is formed on, or coupled to, a cutting end portion of the bit **210** that is opposite the pin **213**. The bit **210** further includes a central axis **216** about which bit **210** rotates in a cutting direction represented by arrow **217**.

[0040] The cutting structure **215** is provided on the face **214** of the bit **210**. The cutting structure **215** may include a plurality of angularly spaced-apart primary blades **218** and secondary blades **219**, each of which may extend from the bit face **214**. The primary blades **218** and the secondary blades **219** may extend generally radially along the bit face **214** and then axially along a portion of the periphery of the bit **210**; however, the secondary blades **219** are shown as extending radially along the bit face **214** from a position that is offset from the central axis **216** toward the periphery of the bit **210**. Thus, a secondary blade may refer to a blade that begins at some distance from the bit axis and extends generally radially along the bit face to the periphery of the bit. The primary blades **218** and the secondary blades **219** are circumferentially separated by drilling fluid flow courses or junk slots **220**.

[0041] Referring still to FIG. **2**, each primary and secondary blade **218**, **219** may include a forward facing surface **221** that faces the cutting direction **217**, and a top or formation facing surface **222** that faces radially outward toward a bottom or end of a wellbore, and toward the sides of the wellbore. A plurality of cutting elements **225** may be mounted in or otherwise coupled to the primary and secondary blades **218**, **219**. In particular, cutting elements **225**, each having a cutting face **226**, may be face or front loaded into pockets formed in the blades **218**, **219**. For instance, the pockets may be formed in one or both of the forward facing surface **221** or the formation facing surface **222**, and may extend generally along the periphery of the primary and secondary blades **218**, **219**. The cutting elements **225** may be arranged adjacent one another in a radially extending row proximal the leading edge at the interface of the forward facing and formation facing surfaces **221**, **222**. Each cutting face **226** may have an outermost cutting tip **227** farthest from a portion of the formation facing surface **222** to which the corresponding cutting element **225** is mounted. While the cutting face **226** is shown as being generally planar such that the cutting element **225** can act as a shear cutting element, in other embodiments the cutting face **226** may have non-planar shapes (e.g., ridged, domed, conical, frustoconical, bullet-shaped, etc.).

[0042] One or more additional elements **230** may also be coupled to the blades **218**, **219** or the bit body **211**. In FIG. **2**, for instance, the elements **230** may be coupled to the formation facing surfaces **222** of the primary and secondary blades **218**, **219**. The elements **230** may be behind or trail the cutting elements **225** when the bit **210** rotates in the cutting direction **217**. The elements **230** may be top loaded into blind or top pockets formed in the blades **218**, **219**. For instance, pockets may be formed in the formation facing surface **222** and may extend radially inward within the primary and secondary blades **218**, **219**, rather than circumferentially along the formation facing surface **222**. In other embodiments, the elements **230** may be loaded into pockets that extend along the formation facing surface **222**.

[0043] The elements **230** may include cutting elements having a cutting face similar to the cutting face **226** described above, and may thus be planar or non-planar. In other embodiments, the elements **230** may be used for other purposes, such as limiting the depth of cut of the cutting elements **225**. In such an embodiment, the elements may have a domed, curved, or other contact surface **231**. In other embodiments, however, the contact surface **231** may have other configurations (e.g., planar, ridged, conical, frustoconical, bullet-shaped, etc.). The cutting elements **225** and the elements **230** may have any suitable exposure relative to the formation facing surface **222**, and may be oriented at any suitable angle (e.g., side rake angle, back rake angle, etc.).

[0044] FIG. **3-1** illustrates an embodiment of a blade **318** (e.g. a primary or secondary blade), according to some embodiments of the present disclosure. The blade **318** may have one or more cutting elements **330** top, face, or front mounted thereto, with a cutting face **326** of the cutting element **330** extending from a formation facing surface **322** (or potentially recessed within or about flush with the formation facing surface **322**) of the blade **318**. In other embodiments, however, the cutting element **330** may be about flush with, recessed in, or extending from a forward facing surface. The illustrated cutting element **330** (and the insert **430** of FIG. **4**) is shown as including multiple portions (e.g., a diamond table coupled to a substrate), although the cutting element **330** may include more than two portions, or may include a single portion.

[0045] The cutting elements **330** may be secured to the blade **318** within corresponding top pockets **351**. In some embodiments, the cutting element **330** may be secured in the top pocket **351** by a friction fit, a snap fit, a compression fit, one of more mechanical fasteners (e.g., pin, screw, set screw, clip, clamp, retention ring, sleeve, etc.), one or more adhesives, braze materials, welds, or combinations thereof. For example, a braze material **333** may be positioned around the cutting element **330**, between the cutting element **330** and the inner wall defining the top pocket **351** of the blade **318**.

[0046] A brazing process for brazing the cutting element **330** into the top pocket **351** of the blade **318** may include heating the blade **318** around the top pocket **351**, heating the cutting element **330**, or both, by a direct or indirect heating method (e.g., using a furnace, using a torch, application of braze material **333** at an elevated temperature). The heating of the blade **318** and cutting element **330** during brazing may cause expansion of the blade **318** (and top pocket **351**) and of the cutting element **330**.

[0047] In some embodiments, the blade **318** may include a body material (e.g., steel, matrix material with tungsten carbide particles bonded together by a metallic binder, etc.) and the cutting element **330** may include one or more cutting materials (e.g., tungsten carbide, polycrystalline diamond, boron cubic nitride, etc.). The body material may have a coefficient of thermal expansion that is different than (e.g., greater than) that of the cutting material. During the cooling of the cutting material of the cutting element **330**, the body material of the blade **318** around the top pocket **351**, and the braze material **333** therebetween, the dimensions of the top pocket **351** may change more or at a different or greater rate than the dimensions of the cutting element **330**. The disproportionate rates of change in volume of the top pocket **351**, the cutting element **330**, and the braze material **333** may lead to stress concentrations in the blade **318** around the top pocket **351**.

[0048] FIG. **3-2** illustrates a detail view of the top pocket **351** in FIG. **3-1**. The top pocket **351** may have sidewall **353** with a front end portion **335** at or near the opening of the top pocket **351** in the formation facing surface **322** (see FIG. **3-1**) and a rear end portion **336** inside the top pocket **351**. The sidewall **353** may extend around a full or partial circumference of the cutting element **330**. The pocket depth **337** may be a distance into the blade **318** extending from the front end portion **335** to the rear end portion **336** of the sidewall **353**. The cutting element **330** may have a cutting element length **342**. The top pocket **351** and cutting element **330** may have a pocket width **354** and a cutting element width **339**, respectively. The pocket width **354** may be larger than the cutting element width **339** when the cutting element **3515** and braze material **333** are positioned at least partially within the top pocket **351**. A rear surface **340** of the cutting element **330** may abut a base wall **341** of the top pocket **351**, although as shown in FIG. **3-2**, the braze material **333** may also be positioned between the rear surface **340** and the base wall **341**. The cutting element length **342** may be greater than the pocket depth **337**, although in other embodiments the cutting element length **342** may be less than or about equal to the pocket depth **337**. In some embodiments, the pocket depth **337** may be about equal to the combination of the cutting element length **342** and the thickness of the braze material **333** along the rear surface **340**, such that the cutting face **326** is about flush with the formation facing surface **322** of the blade **318**.

[0049] During cooling after brazing of the cutting element **330** within the top pocket **351**, the different coefficients of thermal expansion and, therefore, expansion/contraction rates of the body material and the cutting material, may cause residual stresses near the top pocket **351**. The residual stresses may concentrate or be multiplied near at the front end portion **335** of the sidewall **344**, the rear end portion **336** of the sidewall **353**, in other locations, or in combinations of the foregoing. In particular, a junction where the front end portion **335** of the sidewall **353** meets with the formation facing surface **322** may concentrate residual stress as the top pocket **351** contracts around the cutting element **330** during cooling. For example, in some embodiments, the pocket width **354** may be less than the combined width of the cutting element **330** and the braze material **333** below 100° F. (37.8° C.). In such embodiments, the contraction force of the sidewall **353** against the cutting element **330** may concentrate at the front end portion **335** of the sidewall **353**.

[0050] Referring now to FIG. **4**, another embodiment of a top pocket **451** is depicted in cross-section with a top-mounted insert **430** positioned therein. In the illustrative embodiment shown in FIG. **4**, the insert **430** includes a frustoconical face surface, but the insert **430** may include any suitable surface shape, such as planar, ridged, conical, domed, bullet-shaped, other shapes, or combinations of the foregoing. The face of the insert **430** may be used for cutting formation, casing, or other materials, although in other embodiments the face of the insert **430** may be used as a depth of cut limiter, to reduce wear of the formation-facing surface **422**, or for other purposes.

[0051] In some embodiments, the top pocket **451** has a relief opening **452** that includes a curved profile. For example, at least a portion of the profile of the relief opening **452** in a plane parallel to a central axis of the insert **430** or top pocket **451** may be circular (i.e., having a constant radius of curvature) or elliptical, parabolic, hyperbolic, or combinations thereof (i.e., have a radius of curvature that varies). The top pocket sidewall **453** may define a pocket width **454**. The relief opening **452** may define an opening width **455**. The opening width **455** may be the greatest lateral dimension of the relief opening **452**. The opening width **455** and the pocket width **454** may define an opening ratio that, in some embodiments, may be in a range having a lower value, an upper value, or both lower and upper values including any of 1.5:1, 1.25:1, 1.20:1, 1.15:1, 1.12:1, 1.10:1, 1.08:1, 1.06:1, 1.04:1, 1.02:1, 1.01:1, or any values therebetween. For example, the opening ratio may be between 1.25:1 and 1.01:1. In other examples, the opening ratio may be between 1.20:1 and 1.02:1. In yet other examples, the opening ratio may be between 1.18:1 and 1.01:1. In some examples, the opening ratio may be 1.05:1, 1.14:1, or 1.16:1. In still other embodiments, the opening ratio may be greater than 1.5:1 or less than 1.01:1.

[0052] The sidewall **453** may define a pocket depth extending to a rear wall **441**. The relief opening **452** may extend laterally beyond the sidewall **453** in an amount shown as the opening lateral extension **456**. The opening lateral extension **456** may be at least partially related to the pocket width **454**. For instance, the opening lateral extension **456** and the pocket width **454** may be related by an opening extension ratio of the opening lateral extension **456** to the pocket width **454**. The opening extension ratio may be in a range having a lower value, an upper value, or lower and upper values including any of 0.12:1, 0.10:1, 0.08:1, 0.06:1, 0.04:1, 0.02:1, 0.01:1, or any values therebetween. For example, the opening extension ratio may be between 0.12:1 and 0.01:1. In other examples, the opening extension ratio may be between 0.10:1 and 0.02:1. In yet other examples, the opening extension ratio may be between 0.08:1 and 0.05:1. In some examples, the opening extension ratio may be 0.07:1 or 0.08:1. In still other embodiments, the opening extension ratio may be greater than 0.12:1 or less than 0.01:1.

[0053] The relief opening **452** may further include an opening depth **457** that is at least partially related to the opening lateral extension **456**. In some embodiments, an opening aspect ratio (i.e., opening depth **457** to opening lateral extension **456**) may be in a range having a lower value, an upper value, or lower and upper values including any of 15:1, 10:1, 8:1, 6:1, 4:1, 2:1, 1:1, 1:2, 1:4, 1:6, 1:8, 1:10, 1:15, or any values therebetween. For example, the opening aspect ratio may be between 10:1 and 1:10. In other examples, the opening aspect ratio may be between 8:1 and 1:8. In yet other examples, the opening aspect ratio may be between 6:1 and 1:6. In at least one example, the opening aspect ratio may be between 9:1 and 4:1. In another example, the opening aspect ratio may be about 1:1. In further examples, the opening aspect ratio may be greater than 15:1 or less than 1:15.

[0054] FIG. **5** illustrates yet another embodiment of a top pocket **551** having a relief opening **552** therearound. A top-mounted insert **530** having an elliptical face profile may be positioned in the top pocket **551**. In some embodiments, the top pocket **551** has a relief opening **552** that includes an at least partially linear profile. The top pocket sidewall **553** may define a pocket width **554**. The relief opening **552** may define an opening width **555** defining an opening ratio within a range as described herein with respect to FIG. **4**.

[0055] The relief opening **552** may extend laterally beyond the sidewall **553** by an amount defined by an opening lateral extension **556**. The opening lateral extension **556** may be at least partially related to the pocket width **554**, as described herein. For instance, the opening lateral extension **556** and the pocket width **554** may be related by an opening extension ratio within a range as described herein with respect to FIG. **4**. The relief opening **552** may further include an opening depth **557** that is at least partially related to the opening lateral extension **556**, and may have an opening aspect ratio (i.e., opening depth **557** to opening lateral extension **556**) within a range as discussed herein with respect to FIG. **4**.

[0056] FIG. **6** illustrates a further embodiment of a top pocket **651** having a relief opening **652** therein. A top-mounted insert **630** having a substantially conical profile may be positioned in the top pocket **651**. In some embodiments, the top pocket **651** has a relief opening **652** that includes a profile that is at least partially linear and at least partially curved. For example, the relief opening **652** may have a curved portion **658** with a curvature that curves away from the top pocket **651** when moving toward the formation facing surface **622**. In other examples (see FIG. **7**) the relief opening may have a curved portion with a curvature oriented toward the top pocket **651** when moving in a direction toward the formation facing surface **622**. In at least some embodiments, a portion of the relief opening **652** may be parallel to a sidewall **653** of the top pocket **651**.

[0057] The top pocket sidewall **653** may define a pocket width **654**. The relief opening **652** may define an opening width **655**, and an opening lateral extension **656**. The opening width **655** may be related to the pocket width **654** by an opening ratio, and the lateral extension **656** may be related to the pocket width **654** by an opening extension ratio. The opening ratio and the opening extension ratio may be within ranges as described herein, including as discussed with respect to FIG. **4**. The relief opening **652** may further include an opening depth **657** that is at least partially related to the opening lateral extension **656** by an opening aspect ratio (i.e., opening depth **657** to opening lateral extension **656**). The opening aspect ratio may be in a range as discussed with respect to FIG. **4**.

[0058] FIG. **7** illustrates a further embodiment of a top pocket **751** having a relief opening **752** therein. A top-mounted insert **730** having a substantially planar face surface may be positioned in the top pocket **751**. In some embodiments, the top pocket **751** has a relief opening **752** that includes a curved profile. At least a portion of the profile may have a curvature oriented away from the top pocket **751** and at least a portion of the profile may have a curvature oriented toward the top pocket **751** (e.g., when moving in a direction toward the face surface of the insert **730**).

[0059] The top pocket sidewall **753** may define a pocket width **754**, and the relief opening **752** may define an opening width **755**, an opening lateral extension **756**, and an opening depth **757**. An opening ratio (i.e., the opening width **755** to the pocket width **754**), an opening extension ratio (i.e., the opening lateral extension **756** to the pocket width **754**), and an opening aspect ratio (i.e., the opening depth **757** to the opening lateral extension **756**) may be defined for the top pocket **751**, and may be within ranges as discussed with respect to FIG. **4**.

[0060] While embodiments of the present disclosure include relief openings at the interface between a top pocket and a formation facing surface, in some embodiments a relief opening or recess may be formed at an interface with a face pocket, or at a different location within the pocket. For instance, a top pocket **751** may include a relief groove/recess **744** at the base of the pocket, as shown in FIG. **7**. Such a relief recess **744** may extend laterally beyond the pocket width **754** as shown, or beyond a depth of the pocket (see dashed lines in FIG. **8**).

[0061] FIG. **8** illustrates another embodiment of a blade having a pocket with a stress relief element. The stress relief element may be positioned at or near the opening of the pocket to reduce stress concentrations at the surface of the blade **818** (or other portion of a bit). In FIG. **8**, a top-mounted insert **830** and the blade **818** may experience residual stresses, as described herein. A face-mounted cutting element **825** may also experience residual stresses as described herein. For example, a portion of the blade **818** may contract during cooling around the top-mounted insert **830**, the cutting insert **825**, or both, and residual stress may concentrate along a formation facing surface **822** around a top pocket **851**, a forward facing surface and the face pocket holding the cutting insert **825**, at the rear or base of the front and top pockets, at other locations, or at combinations of the foregoing. The top-mounted insert **830** may be a cutting element; however, the insert **830** may be used for functions other than, or in addition to, cutting. For instance, the insert **830** may be a tungsten carbide or grit-hot pressed insert used for limiting depth of cut of the cutting element **825**. Similarly, the cutting insert **825** may or may not be used to cut formation or another workpiece. For instance, the insert **825** may be a gauge protector.

[0062] The top pocket **851** may be positioned in a formation facing surface **822**. The top-mounted insert **830** may be loaded and secured in the top pocket **851** (e.g., by brazing, press-fitting, mechanical attachment, etc.). In some embodiments, the top pocket **851** may have a relief opening **852** for reducing reduce residual stress concentrations after brazing or otherwise securing of the insert **830** in the top pocket **851**. The relief opening **852** may have any of various shapes, profiles, or other configurations. The relief opening **852** may extend around at least a portion of the top pocket **851**, and in some embodiments, the relief opening **852** may extend around an entirety of the circumference or perimeter of the top pocket **851**. For example, the relief opening **852** may extend around a portion within a range having a lower value, an upper value, or both lower and upper values including any of 20%, 30%, 40%, 50%, 60%, 75%, 90%, or 100% of the circumference/perimeter of the top pocket **851**, or values therebetween. For instance, the relief opening **852** may extend around at least 50% or at least 75% of the circumference of the top pocket **851**. In yet other examples, the relief opening **852** may extend around at least 90% of the circumference of the top pocket **851**, or between 50% and 100% of the perimeter of the top pocket **851**. In yet other embodiments, the relief opening **852** may extend around less than 20% of the perimeter of the circumference of the top pocket **851**. Any relief opening or recess in the face pocket **832** around the cutting insert **825** may be similarly configured to extend around full or partial portion of the circumference or perimeter of the face pocket. Additionally, in some embodiments, a relief recess may be positioned around a full or partial portion of the rear wall of the corresponding pocket (e.g., face pocket **832**) with a recess depth extending beyond the rear wall, as shown in the dashed lines in FIG. **8**.

[0063] An example set of top pockets in accordance with embodiments of the present disclosure was tested to evaluate the stress concentrations at locations in the bit body adjacent the top pockets, where cracks are known to occur. A baseline sample was produced without a relief opening for comparative purposes. In the relief opening samples, the top pockets included a curved portion extending away from the pocket, and a linear portion, similar to FIG. **6**, with the opening extending fully around a circumference of a top pocket, at the interface between the top pocket and the formation-facing surface of a blade. The top pockets had opening ratios between 1.14:1 and 1.16:1 and opening extension ratios between 0.07:1 and 0.08:1. The braze thickness was the same as the baseline sample, except within the relief opening, which had an increased braze thickness. A finite element analysis showed that each pocket had a reduced stress concentration, and the amount of reduction varied from 22.3% to 25.0%, with an average stress concentration reduction of 23.6%.

[0064] FIG. **9-1** illustrates an embodiment of a blade **918** (e.g. a primary or secondary blade), according to some embodiments of the present disclosure. The blade **918** may have one or more cutting elements **925** face or front mounted thereto, with a cutting face **926** of the cutting element **925** about flush with a forward facing surface **921**, and optionally extending from a formation facing surface **922** of the blade **918**. In other embodiments, however, the cutting element **925** may be about flush with or even inset within the formation facing surface **922**, or may extend from or be inset within the formation facing surface **922**. The illustrated cutting element **925** is shown as including multiple portions (e.g., a diamond table coupled to a substrate), although the cutting element **925** may include more than two portions, or may include a single portion.

[0065] The cutting elements **925** may be secured to the blade **918** within corresponding face pockets **932**. In some embodiments, the cutting element **925** may be secured in the face pocket **932** by a friction fit, a snap fit, a compression fit, one of more mechanical fasteners (e.g., pin, screw, set screw, clip, clamp, retention ring, sleeve, etc.), one or more adhesives, braze materials, welds, or combinations thereof. For example, a braze material **933** may be positioned around the cutting element **925**, between the cutting element **925** and the inner wall defining the face pocket **932** of the blade **918**.

[0066] A brazing process for brazing the cutting element **925** into the face pocket **932** of the blade **918** may include heating the blade **918** around the face pocket **932**, heating the cutting element **925**, or both, by a direct or indirect heating method (e.g., using a furnace, using a torch, application of braze material **933** at an elevated temperature). The heating of the blade **918** and cutting element **925** during brazing may cause expansion of the blade **918** (and face pocket **932**) and of the cutting element **925**.

[0067] In some embodiments, the blade **918** may include a body material (e.g., steel, matrix material with tungsten carbide particles bonded together by a metallic binder, etc.) and the cutting element **925** may include one or more cutting materials (e.g., tungsten carbide, polycrystalline diamond, boron cubic nitride, etc.). The body material may have a coefficient of thermal expansion that is different than (e.g., greater than) that of the cutting material. During the cooling of the cutting material of the cutting element **925**, the body material of the blade **918** around the face pocket **932**, and the braze material **933** therebetween, the dimensions of the face pocket **932** may change more or at a different or greater rate than the dimensions of the cutting element **925**. The disproportionate rates of change in volume of the face pocket **932**, the cutting element **925**, and the braze material **933** may lead to stress concentrations in the blade **918** around the face pocket **932**.

[0068] FIG. **9-2** illustrates a detail view of the face pocket **932** in FIG. **9-1**. The face pocket **932** may have sidewall **934** with a front end portion **935** at or near the opening of the face pocket **932** and a rear end portion **936** inside the face pocket **932**. The sidewall **934** may extend around a full or partial circumference of the cutting element **925**. The pocket depth **937** may be a distance through the thickness of the blade **918** extending from the front end portion **935** to the rear end portion **936** of the sidewall **934**. The cutting element **925** may have a cutting element length **942**. The face pocket **932** and cutting element **925** may have a pocket width **938** and a cutting element width **939**, respectively. The pocket width **938** may be larger than the cutting element width **939** when the cutting element **9325** and braze material **933** are positioned at least partially within the face pocket **932**. A rear surface **940** of the cutting element **925** may abut a base wall **941** of the face pocket **932**, although as shown in FIG. **9-2**, the braze material **933** may also be positioned between the rear surface **940** and the base wall **941**. The cutting element length **942** may be less than the pocket depth **937**, although in other embodiments the cutting element length **942** may be greater than or about equal to the pocket depth **937**. In some embodiments, such as that shown in FIG. **9-1**, the pocket depth **937** may be about equal to the combination of the cutting element length **942** and the thickness of the braze material **933** along the rear surface **940**, such that the cutting face **926** is about flush with the forward facing surface **921** of the blade **918**.

[0069] During cooling after brazing of the cutting element **925** within the face pocket **932**, the different coefficients of thermal expansion and, therefore, expansion/contraction rates of the body material and the cutting material, may cause residual stresses near the face pocket **932**. The residual stresses may concentrate or be multiplied near at the front end portion **935** and the rear end portion **936** of the sidewall **934**. In particular, a junction where the rear end portion **936** of the sidewall **934** meets with the base wall **941** may concentrate residual stress as the face pocket **932** contracts around the cutting element **925** during cooling. For example, in some embodiments, the pocket width **938** may be less than the combined width of the cutting element **925** and the braze material **933** below 100° F. (37.8° C.). In such embodiments, the contraction force of the sidewall **934** against the cutting element **925** may concentrate at the rear end portion **936** of the sidewall **934**.

[0070] FIG. **10-1** is a side cross-sectional view of an embodiment of a face pocket **1032** that reduces stress concentrations around the face pocket **1032** in some embodiments of the present disclosure. A cutting element **1025** may be secured in the face pocket **1032** (e.g., by brazing the cutting element **1025** to the sidewall **1034**, the rear wall **1041**, or both using a braze material **1033**). In some embodiments, a relief recess **1044** may be located at the rear end portion **1036** of the sidewall **1034**. At least a portion of the relief recess **1044** may be curved and recessed away from the face pocket **1032** (i.e., away from the cutting element **1025**).

[0071] In some embodiments, at least a portion of the relief recess **1044** may be circular (i.e., have a constant radius of curvature) in profile in a plane parallel to a central axis of the face pocket **1032** or insert **1025**. In other embodiments, at least a portion of the relief recess **1044** may be elliptical, parabolic, hyperbolic, or combinations thereof (i.e., have a radius curvature that varies) in the profile. In other embodiments, at least a portion of the relief recess **1044** may be linear in profile.

[0072] In some embodiments, the relief recess **1044** may have a recess depth **1043**. The recess depth **1043** may be the depth of the relief recess **1044** from the rear wall **1041** away from the face pocket **1032**. The recess depth **1043** may be related to the pocket depth **1037** (as measured to the rear wall **1041**). A recess depth ratio may be the ratio of the recess depth **1043** to the pocket depth **1037**. In some embodiments, the recess depth ratio may be in a range having a lower value, an upper value, or both lower and upper values including any of 1:100, 1:50, 1:25, 1:20, 1:15, 1:10, 1:8, 1:4, 1:2, or any values therebetween. For example, the recess depth ratio may be between 1:20 and 1:2. In other examples, the recess depth ratio may be between 1:18 and 1:4. In yet other embodiments, the recess depth ratio may be between 1:16 and 1:6. In other embodiments, the recess depth ratio may be less than 1:100 or greater than 1:2.

[0073] According to at least some embodiments, the relief recess **1044** may not extend laterally beyond the sidewall **1034** of the face pocket **1032**. For instance, where the face pocket **1032** is circular and the relief recess **1044** extends a full or partial circumference thereof (e.g., where the face pocket **1032** is configured to receive a cylindrical cutting element **1025**), the outer diameter of the relief recess **1044** may be about equal to, or less than, the outer diameter of the face pocket **1032**. In still other embodiments, as described in more detail herein, the outer diameter of the relief recess **1044** may be greater than the outer diameter of the face pocket **1032**, such that there is a lateral offset. The reference to diameters of components is merely illustrative, and in other embodiments the face pocket **1032** may have a width rather than a diameter, such as where the cutting element **1025** has a square, rectangular, or other non-circular cross-sectional shape for receiving a non-cylindrical cutting element.

[0074] FIG. **10-2** illustrates the face pocket **1032** of FIG. **10-1** viewed in an end view without the cutting element positioned therein. In some embodiments, the relief recess **1044** may be extend around at a portion of the perimeter rear wall **1041**. In other embodiments, the relief recess **1044** may be positioned around the full perimeter of the rear wall **1041**. Where the relief recess **1044** extends around a portion of the perimeter of the rear wall **1041**, the relief recess **1044** may extend along a portion within a range having a lower value, an upper value, or both lower and upper values including any of 20%, 30%, 40%, 50%, 60%, 75%, 90%, or 100% of the perimeter of the rear wall **1041**, or values therebetween. For instance, the relief recess **1044** may extend around at least 50%, at least 75%, or at least 90% of the perimeter of the rear wall **1041**. In still other embodiments, the relief recess **1044** may extend around 20% to 100%, or around 60% to 100% of the rear wall **1041**. In yet other embodiments, the relief recess **1044** may extend around less than 20% of the perimeter of the rear wall **1041**. In some embodiments, the relief recess **1044** may be an annular recess.

[0075] At least a portion of the relief recess **1044** may have a recess width **1045** measured between an inner and outer surfaces of the relief recess **1044**. The recess width **1045** may be related to the pocket width **1038**. A recess width ratio may be the ratio of the recess width **1045** to the pocket width **1038**. In some embodiments, the recess width ratio may be in a range having upper and lower values including any of 1:20, 1:15, 1:10, 1:8, 1:4, 1:2, or any values therebetween. For example, the recess width ratio may be between 1:20 and 1:2. In other examples, the recess width ratio may be between 1:18 and 1:4. In yet other embodiments, the recess width ratio may be between 1:16 and 1:6. In still other embodiments, the recess width ratio may be less than 1:20.

[0076] FIGS. **11-1** and **11-2** illustrate another embodiment of a face pocket **1132** configured to reduce stress concentrations in a blade around the face pocket **1132**. A braze material **1133** may secure the cutting element **1125** in the face pocket **1132** and against a sidewall **1134** and a rear wall **1141**. In some embodiments, the rear wall **1141** may not intersect the sidewall **1134**, but may be spaced apart from the sidewall **1134** by a relief recess **1144** at the rear end portion **1136** of the sidewall **1134**. In some embodiments, and as shown in FIG. **11-1**, at least part of the relief recess **1144** may be curved in the transverse profile and at least part of the relief recess **1144** may be linear. At least part of the stress relief curve may be recessed away from the face pocket **1132** (i.e., extend away from the cutting element **1125**).

[0077] In some embodiments, at least a portion of the relief recess **1144** may have a circular curvature in the illustrated transverse profile (i.e., have a radius of curvature that is constant). In other embodiments, at least a portion of the relief recess **1144** may be elliptical, parabolic, hyperbolic, or combinations thereof (i.e., have a radius curvature that varies). In other embodiments, at least a portion of the relief recess **1144** may be linear in profile. In some embodiments, a linear portion **1146** may be located radially adjacent the rear wall **1141**. In the same or other embodiments, a linear portion **1146** may be located radially adjacent the sidewall **1134** of the face pocket **1132**.

[0078] In some embodiments, the relief recess **1144** may have a recess depth **1143**. The recess depth **1143** may be the depth of the relief recess **1144** from the rear wall **1141** away from the face pocket **1132**. The recess depth **1143** may be related to the pocket depth **1137**, and the recess depth ratio may be the ratio of the recess depth **1143** to the pocket depth

1137. In some embodiments, the recess depth ratio may be in a range described herein with respect to the embodiment of FIGS. 10-1 and 10-2.

[0079] FIG. 11-2 illustrates the face pocket 1132 of FIG. 11-1 viewed in an end view without the cutting element positioned therein. In some embodiments, the relief recess 1144 may be positioned around at least a portion of the perimeter of the rear wall 1141, as described with respect to FIGS. 10-1 and 10-2. In some embodiments, the relief recess 1144 may be an annular recess such that the rear surface 1141 forms a shelf on or against which the cutting element can be positioned and brazed within the face pocket 1132.

[0080] At least a portion of the relief recess 1144 may have a recess width 1145 between the inner and outer surfaces of the relief recess, and which may be measured perpendicularly to a line tangent to the exterior of the relief recess 1144. The recess width 1145 may be related to the pocket width 1138 in a manner such as that described for the recess 1032 of FIGS. 10-1 and 10-2.

[0081] The linear portion 1146 may make up any number of different percentages of the relief recess 1144. In some embodiments, the curved portion width 1147 and the linear portion width 1148 may sum to the recess width 1145. The curved portion width 1147 and the linear portion width 1148 may be related to one another by a curved-linear ratio. In some embodiments, the curved-linear ratio may be a range having a lower value, an upper value, or both lower and upper values including any of 50:1, 25:1, 15:1, 10:1, 5:1, 3:1, 2:1, 1:1, 1:2, 1:3, 1:5, 1:10, 1:15, 1:25, 1:50, or any values therebetween. For example, the curved-linear ratio may be between 50:1 and 1:50. In other examples, the curved-linear ratio may be between 25:1 and 1:25. In yet other examples, the curved-linear ratio may be between 5:1 and 1:5. In at least one example, the curved-linear ratio may be between 2:1 and 1:2, or about 1:1. In other embodiments, the curved-linear ratio may be greater than 50:1 or less than 1:50. In further embodiments, there may be multiple curved portions (see FIG. 12-1) and the curved-linear ratio may be the combined width of the curved portions relative to the combined width of the one or more linear portions.

[0082] FIGS. 12-1 and 12-2 illustrate yet another embodiment of a face pocket 1232 configured to reduce stress concentrations in the primary, secondary, or other blades around the face pocket 1232. A braze material 1233 may be used to secure a cutting element 1225 in the face pocket 1232 against a sidewall 1234 and a rear wall 1241. In some embodiments, the rear wall 1241 may be spaced apart from the sidewall 1234 by a relief recess 1244 at the rear end portion 1236 of the sidewall 1234. In some embodiments, at least part of the relief recess 1244 may be curved in the transverse profile shown in FIG. 12-1. Optionally, one or more portions of the of the relief recess 1244 may be linear. In some embodiments, there may be multiple curved portions (e.g., a first curved portion at the interface with the sidewall 1234, and a radiused or second curved portion at the interface with the rear surface 1241). At least part of the stress relief recess may be recessed away from the face pocket 1232 (i.e., from the rear surface 1241 in a direction opposite the cutting portion 1226 of the cutting element 1225).

[0083] In some embodiments, at least a portion of the relief recess 1244 may be circular in the profile shown in FIG. 12-1 (i.e., have a radius of curvature that is constant). In other embodiments, at least a portion of the relief recess 1244 may be elliptical, parabolic, hyperbolic, or combinations thereof in profile (i.e., have a radius of curvature that varies). In other embodiments, at least a portion of the relief recess 1244 may be linear in longitudinal profile.

[0084] In some embodiments, the relief recess 1244 may have a recess depth 1243. The recess depth 1243 may be the depth of the relief recess 1244 from the rear wall 1241 away from the face pocket 1232. The recess depth 1243 may be related to the pocket depth 1237 as described for the recess depth 1043 of the embodiment in FIGS. 10-1 and 10-2.

[0085] Still referring to FIG. 12-1, the relief recess 1244 may extend laterally away from the rear wall 1241 of the face pocket 1232 and beyond the sidewall 1234 (i.e., outside the diameter/width of the sidewall 1234). The relief recess 1244 may have a lateral extension 1249. The lateral extension 1249 may be positive or negative. As shown, for instance, the lateral extension 1249 may extend beyond the sidewall 1234 and may be positive as the diameter/width of the face pocket 1232 is greater at the relief recess 1244 than at the sidewall 1234. In contrast, if the diameter/width of the face pocket 1232 is less at the relief recess 1244 than at the sidewall 1234, the lateral extension 1249 may be considered to be negative. The lateral extension 1249 of the relief recess 1244 may be at least part of a recess width 1245 and be at least partially related to a pocket width 1238, as shown in FIG. 12-2.

[0086] FIG. 12-2 illustrates the face pocket 1232 of FIG. 12-1 viewed in an end view without the cutting element positioned therein. In some embodiments, the relief recess 1244 may be positioned around at least a portion of the rear wall 1241, and potentially around the full circumference of the rear wall 1241, in a manner similar to the relief recess 1044 of FIGS. 10-1 and 10-2, as described herein.

[0087] At least a portion of the relief recess 1244 may have a recess width 1245 measured perpendicularly to a line tangent to the exterior of the relief recess 1244. The recess width 1245 may be related to the pocket width 1238. A recess width ratio may be the ratio of the recess width 1245 to the pocket width 1238, and may be within a range similar to that of the relief recess 1044 of FIGS. 10-1 and 10-2, as described herein.

[0088] The lateral extension 1249 of the relief recess 1244 may extend outside of the pocket width 1238 when positive, or inside the pocket width 1238 when negative. In some embodiments, the lateral extension 1249 may be related to the recess width 1245 by an extension-recess ratio. The extension-recess ratio may be the ratio of the absolute value of the lateral extension 1249 to the recess width 1245. In some embodiments, the extension-recess ratio may be in a range having a lower value, an upper value, or lower and upper values including any of 1:100, 1:50, 1:20, 1:10, 1:8, 1:4, 1:3, 1:2, or any values therebetween. For example, the extension-recess ratio may be between 1:100 and 1:2. In other examples, the extension-recess ratio may be between 1:50 and 1:3. In yet other example, the extension-recess ratio may be between 1:20 and 1:4. In still other example embodiments, the extension-recess ratio may be less than 1:100 or greater than 1:2.

[0089] In embodiments of a face pocket 1232 having a relief recess 1244 at least partially radially outside the face pocket 1232, the relief recess 1244 may define a total recess width 1250 that is greater than the pocket width 1238. A total recess ratio may be the ratio of the total recess width 1250 to the pocket width 1238. In some embodiments, the total recess ratio may be in a range having a lower value, an upper value, or both lower and upper values including any of 1.25:1, 1.20:1, 1.15:1, 1.10:1, 1.08:1, 1.04:1, 1.02:1, 1.01:1, or any values therebetween. For example, the total recess ratio may be between 1.25:1 and 1.01:1. In other examples, the total recess ratio may be between 1.20:1 and 1.02:1. In yet other examples, the total recess ratio may be between 1.15:1 and 1.04:1. In at least one example, the total recess ratio may be about 1.05:1. In still other embodiments, the total recess ratio may be greater than 1.25:1 or less than 1.01:1. For instance, where the relief recess **1244** is radially within the face pocket **1232** and there is a negative lateral extension **1249**, the total recess ratio may be less than 1:1.

[0090] An example set of face pockets in accordance with embodiments of the present disclosure was tested to evaluate the strength of the braze joint when a relief recess is added. The face pockets were also analyzed to evaluate the stress concentrations at locations in the bit body adjacent the face pockets, where cracks are known to occur. A baseline sample was produced without a relief recess for comparative purposes.

[0091] In the relief recess samples, the face pockets included a circular relief recess similar to FIG. **10-1**, with the circular profile extending fully around a circumference of a circular rear wall. The face pockets had recess depth ratios between 1:5 and 1:15, recess width ratios between 1:3 and 1:10, and total recess ratios of 1:1. The braze thickness was the same as the baseline sample, except within the relief recess, which had an increased braze thickness. The resulting pull-out test showed the relief recess provided an average increase of 11.5% in braze joint strength relative to the baseline braze joint without a corresponding relief recess. A finite element analysis was also performed on the same joints to compare the stress concentrations. The analysis showed that each pocket had a reduced stress concentration, and the amount of reduction varied from 6.8% to 33.2%, with an average stress concentration reduction of 20.4%.

[0092] While relief recesses are discussed herein with respect to face pockets, in other embodiments, a relief recess may be used in connection with other features, such as top pockets, back-up pockets, or the like. FIG. **13** illustrates another embodiment of a blade **1318** having face pocket **1332** and a top pocket **1351** with corresponding stress relief elements **1344-1**, **1344-2**. The stress relief elements **1344-1**, **1344-2** may be positioned at or near the rear or base of a pocket to reduce stress concentrations at a position within the blade **1318** (or other portion of a bit) that is offset from the face of the blade **1318**, gauge pad, or other feature. In FIG. **13**, a top-mounted insert **1330** and the blade **1318** may experience residual stresses, as described herein with reference to front-mounted or face-mounted cutting elements (e.g., cutting element **1325**). For example, a portion of the blade **1318** may contract during cooling around the top-mounted insert **1330** and residual stress may concentrate at or near the base of the top pocket **1351**, at or along a formation facing surface **1322** around a top pocket **1351**, or at any of various other locations. The top-mounted insert **1330** may be referred to herein as a cutting element; however, the insert **1330** may be used for functions other than, or in addition to, cutting. For instance, the insert **1330** may be a tungsten carbide or grit-hot pressed insert used for limiting depth of cut of the cutting element **1325**.

[0093] A top pocket **1351** may be positioned in the formation facing surface **1322**. The top-mounted insert **1330** may be loaded and secured in the top pocket **1351** (e.g., by brazing, press-fitting, mechanical attachment, etc.). In some embodiments, the top pocket **1351** may have a relief recess **1344-2** for reducing reduce residual stress concentrations after brazing or otherwise securing of the insert **1330** in the top pocket **1351**. The relief recess **1344-1** may have any of various shapes, profiles, or other configurations, such as those disclosed herein. The relief recess **1344-2** may extend around at least a portion of the top pocket **1351**, and in some embodiments, the relief recess **1344-2** may have an annular shape extending extend around an entirety of the circumference or perimeter of the rear wall of the top pocket **1351**. For example, the relief recess **1344-2** may extend around a portion within a range having a lower value, an upper value, or both lower and upper values including any of 20%, 30%, 40%, 50%, 60%, 75%, 90%, or 100% of the circumference/perimeter of the top pocket **1351**, or values therebetween. For instance, the relief recess **1344-2** may extend around at least 50% or at least 135% of the circumference/perimeter of the top pocket **1351**. In yet other examples, the relief recess **1344-2** may extend around at least 90% of the circumference/perimeter of the rear wall of the top pocket **1351**, or between 50% and 100% or between 60% and 100% of the circumference/perimeter of the top pocket **1351**. In yet other embodiments, the relief recess **1344-2** may extend around less than 20% of the circumference/perimeter of the rear wall **1341**.

[0094] Any elements described in relation to any embodiments depicted herein may be combined with any other elements described in relation to any other embodiments depicted herein. For example, the relief recesses **1344-1**, **1344-2** may have the shape of any of the relief recesses shown or described with respect to FIGS. **10-1**- to **12-2**. Additionally, while embodiments of relief recesses are described and depicted herein in relation to rear or base walls and surfaces of face and top pockets (e.g., to act as stress relief pockets for stresses at or near the rear or base wall), in some embodiments a face, top, or other pocket may include a relief recess or opening at another location. For instance, a relief recess or opening may be formed around the pocket adjacent the formation facing surface (see dashed lines around pocket **1351** in FIG. **13**), or at any location along the pocket sidewall, where stress relief may be desired.

[0095] Any elements described in relation to any embodiments depicted herein may be combined with any other elements described in relation to any other embodiments depicted herein. For example, the relief recesses or openings of FIGS. **4** to **7** and **9-1** to **12** may be used in the blade of FIG. **2**, **8**, or **13**.

[0096] Bits and cutting tools of the present disclosure may be formed in any number of manners. For instance, a bit body may be cast (e.g., sand cast, investment casting, die casting, etc.), machined, or formed using additive manufacturing (e.g., 3D printing). The bit body may be formed of any number of materials, including steel, composites, matrix material with tungsten carbide particles bonded together by a metallic binder, etc. Forming the bit body may include forming a blade extending from the body (or a cutting face thereof). The blade may be configured as described herein, and in some embodiments may include one or more pockets in forward facing or formation facing surfaces. In some embodiments, the pockets may be formed by machining or by use of sand displacements. For instance, a sand displacement having a circumferential or annular ridge may be positioned in a mold and used to form a cutter pocket having a circumferential or annular recess. Cutting elements may be positioned in pockets and brazed into the pockets by, for instance, heating the bit body, cutting element, and a braze material. Upon completing the brazing, the temperature of the blade and cutting element may be lowered (e.g., but stopping the application of heat). Due to thermal expansion coefficients, the blade and cutting element may thermally contract at different rates. For instance, the blade may contract at a rate greater than or less than the rate of the cutting element. In some embodiments, the different thermal expansion rates can generate stress concentrations. The stress concentrations may be reduced by using a stress relief recess or opening at a base, face, or other location within a pocket. The stress relief recess may be formed by machining the pocket, through the original casting, machining, or additive manufacturing process used to form the bit body, or in other manners.

[0097] Although the embodiments of bits and pockets have been primarily described with reference to wellbore drilling operations, the bits and pockets described herein may be used in applications other than the drilling of a wellbore. In other embodiments, bits or pockets according to the present disclosure may be used outside a wellbore or other downhole environment used for the exploration or production of natural resources. For instance, bits and pockets of the present disclosure may be used in a borehole used for placement of utility lines, or in a bit used for a machining or manufacturing process. Accordingly, the terms "wellbore," "borehole" and the like should not be interpreted to limit tools, systems, assemblies, or methods of the present disclosure to any particular industry, field, or environment.

[0098] The articles "a," "an," and "the" are intended to mean that there are one or more of the elements in the preceding descriptions. The terms "comprising," "including," and "having" are intended to be inclusive and mean that there may be additional elements other than the listed elements. Additionally, it should be understood that references to "one embodiment" or "an embodiment" of the present disclosure are not intended to be interpreted as excluding the existence of additional embodiments that also incorporate the recited features. For example, any element described in relation to an embodiment herein is combinable with any element of any other embodiment described herein, unless such features are described as, or by their nature are, mutually exclusive. Numbers, percentages, ratios, or other values stated herein are intended to include that value, and also other values that are "about" or "approximately" the stated value, as would be appreciated by one of ordinary skill in the art encompassed by embodiments of the present disclosure. A stated value should therefore be interpreted broadly enough to encompass values that are at least close enough to the stated value to perform a desired function or achieve a desired result. The stated values include at least the variation to be expected in a suitable manufacturing or production process, and may include values that are within 5%, within 1%, within 0.1%, or within 0.01% of a stated value. Where ranges are described in combination with a set of potential lower or upper values, each value may be used in an open-ended range (e.g., at least 50% or up to 50%), as a single value, or two values may be combined to define a range (e.g., between 50% and 75%).

[0099] A person having ordinary skill in the art should realize in view of the present disclosure that equivalent constructions do not depart from the spirit and scope of the present disclosure, and that various changes, substitutions, and alterations may be made to embodiments disclosed herein without departing from the spirit and scope of the present disclosure. Equivalent constructions, including functional "means-plus-function" clauses are intended to cover the structures described herein as performing the recited function, including both structural equivalents that operate in the same manner, and equivalent structures that provide the same function. It is the express intention of the applicant not to invoke means-plus-function or other functional claiming for any claim except for those in which the words 'means for' appear together with an associated function. Each addition, deletion, and modification to the embodiments that falls within the meaning and scope of the claims is to be embraced by the claims.

[0100] The terms "approximately," "about," and "substantially" as used herein represent an amount close to the stated amount that still performs a desired function or achieves a desired result. For example, the terms "approximately," "about," and "substantially" may refer to an amount that is within less than 5% of, within less than 1% of, within less than 0.1% of, and within less than 0.01% of a stated amount. Further, it should be understood that any directions or reference frames in the preceding description are merely relative directions or movements. For example, any references to "up" and "down" or "above" or "below" are merely descriptive of the relative position or movement of the related elements.

[0101] The present disclosure may be embodied in other specific forms without departing from its spirit or characteristics. The described embodiments are to be considered as illustrative and not restrictive. The scope of the disclosure is, therefore, indicated by the appended claims rather than by the foregoing description. Changes that come within the meaning and range of equivalency of the claims are to be embraced within their scope.

What is claimed is:

1. A bit, comprising:

a bit body;

a plurality of blades extending from the bit body, the plurality of blades having a plurality of pockets each at least partially defined by a rear wall and a sidewall, at least one of the plurality of pockets including an annular stress relief element in the sidewall or rear wall thereof; and

an insert brazed into the at least one of the plurality of pockets.

2. The bit of claim **1**, the annular stress relief element being a recess around a full circumference of the rear wall of the pocket.

3. The bit of claim **1**, the insert being a cutting element or depth of cut limiter.

4. The bit of claim **1**, the insert having a lower coefficient of thermal expansion than the bit body.

5. The bit of claim **1**, the annular stress relief element being a relief opening in the sidewall and extending around a full circumference of the pocket adjacent front portion of the pocket that is opposite the rear wall.

6. A bit, comprising:

a bit body; and

a cutting face coupled to the bit body, the cutting face including a surface having at least one pocket therein, the at least one pocket being at least partially defined by a rear wall and a sidewall, the at least one pocket including a relief opening at an interface of the at least one pocket and the surface, and extending around at least 75% of a perimeter of the at least one pocket.

7. The bit of claim **6**, the relief opening extending around an entirety of the perimeter of the at least one pocket.

8. The bit of claim **6**, the relief opening having an opening depth and the at least one top pocket having a pocket depth, an opening depth ratio of the opening depth to the pocket depth being between 1:20 and 1:2.

9. The bit of claim **6**, the relief opening including an opening lateral extension extending laterally beyond a width of the pocket, the relief opening having an opening extension ratio of the opening lateral extension to a pocket width that is between 0.10:1 and 0.04:1.

10. The bit of claim **6**, the relief opening having an opening lateral extension extending laterally beyond a width of the pocket and an opening depth, the opening depth and opening lateral extension defining an opening aspect ratio between 15:1 and 1:15.

11. The bit of claim **6**, the relief opening having a profile that is at least partially curved or at least partially linear.

12. The bit of claim **6**, further comprising an insert brazed in the at least one pocket with braze material, the insert having a different coefficient of thermal expansion than the bit body.

13. The bit of claim **12**, the at least one pocket having a pocket width less than a combined width of the insert and the braze material below 100° F. (37.8° C.).

14. The bit of claim **6**, the at least one pocket including a top pocket and the bit further comprising an insert in the top pocket, the sidewall of the top pocket applying a compression force to the insert.

15. A bit, comprising:

a bit body; and

a blade extending from the bit body, the blade including a surface having at least one pocket therein, the at least pocket being defined by a sidewall and rear wall, the at least one pocket including a relief recess between the rear wall and the sidewall, the relief recess having a recess depth beyond a pocket depth of the at least one pocket.

16. The bit of claim **15**, the relief recess being an annular recess surrounding the rear wall of the pocket.

17. The bit of claim **15**, a recess depth ratio of the recess depth to the pocket depth being between 1:15 and 1:5.

18. The bit of claim **15**, the relief recess having a recess width and the at least one pocket having a pocket width, a recess width ratio of the recess width to the pocket width being between 1:10 and 1:3.

19. The bit of claim **15**, the relief recess having a lateral extension beyond at least a portion of the sidewall and an extension-recess ratio of the lateral extension to a recess width being between 1:100 and 1:2.

20. The bit of claim **15**, the relief recess having a profile that is at least partially curved and at least partially linear, with a curve-linear ratio of a curved portion width to a linear portion width between 50:1 and 1:50.

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