A drill bit system for a drilling assembly is disclosed. The drill bit system may include a chassis, a head, and one or more gauge pads. The head may include a first plurality of cutters coupled with an end of the head, and the head may be coupled with the chassis. The one or more gauge pads may include a second plurality of cutters, and the one or more gauge pads may be movably coupled with the chassis.
COMPLIANTLY COUPLED GAUGE PAD SYSTEM WITH MOVABLE GAUGE PADS

[0001] This application is related to U.S. patent application Ser. No. ____ filed on the same date as the present application, entitled “COMPLIANTLY COUPLED CUTTING SYSTEM (temporarily referenced by Attorney Docket No. 57.0865 US NP1)”, which is incorporated by reference in its entirety for all purposes.

[0002] This application is related to U.S. patent application Ser. No. ____ filed on the same date as the present application, entitled “MOTOR BIT SYSTEM” (temporarily referenced by Attorney Docket No. 57.0865 US NP2), which is incorporated by reference in its entirety for all purposes.

BACKGROUND

[0003] Embodiments of this invention relate generally to drilling. More specifically, but not by way of limitation, systems and methods are described for controlling and/or harnessing the vibration of various portions of a drill bit, as well as for directionally drilling cavities drilled in through earth formations.

[0004] Drill bits used for drilling in earthen formations, as well as other mediums, often have cutters on the head of the drill bit and ridges on the sides of the drill bit. The ridges on the sides of the bits are often referred to as gauge pads, and may serve to confine or direct the cutters on the head of the drill bit to a continued path through the medium related to the path already taken by the cutters on the head. In some drill bits, cutters may be placed on all or a portion of the gauge pads.

[0005] Interactions between the gauge pads and the bore wall of the cavity, which are not intended to be as significant as the interaction of the cutters on the head of the drill bit with the cutting face of the borehole, can cause backward whirl. Backward whirl may cause damage to cutters both close to the center of the bit, as well as cutters outward from the center.

[0006] Energy wasted by the reaction of the gauge pads with the bore wall of the cavity is therefore wasteful in two respects. First, any energy wasted by damaging the cutters on the drill bit head is energy which is not being applied to maximize drilling force, and hence speed, through the medium. Second, damage to the cutters on the drill bit head eventually requires the drill bit to be replaced, reducing speed and increasing cost of drilling.

[0007] The prior art is therefore deficient in providing a system for avoiding these harmful forces and/or causing them to only occur in favorably lateral directions when steering a drill bit during directional drilling. Embodiments of the present invention provide solutions to these and other problems.

BRIEF DESCRIPTION OF THE INVENTION

[0008] In one embodiment of the invention, a drill bit system for a drilling assembly is provided. The drill bit system may include a chassis, a head, and one or more gauge pads. The head may include a first plurality of cutters coupled with an end of the head, and the head may be coupled with the chassis. The one or more gauge pads may include a second plurality of cutters, and the one or more gauge pads may be moveably coupled with the chassis.

[0009] In another embodiment of the invention, another drill bit system for a drilling assembly is provided. The drill bit system may include a first means, a second means, a third means, and a fourth means. The first means may be for coupling the drill bit system with the drilling assembly. The second means may be for drilling longitudinally into a medium. The third means may be for controlling lateral movement of the second means in the medium. The fourth means for movably coupling the third means with the second means.

[0010] In another embodiment of the invention, a method of drilling a borehole in a medium is provided. The method may include providing a drill bit, where the drill bit includes a drill head, a compliant coupling, and one or more gauge pads. The drill head may have a first plurality of cutters, the compliant coupling may be coupled with the drill head, and the one or more gauge pads may be coupled with the compliant coupling. The method may also include rotating the drill head against a face of the borehole.

[0011] In another embodiment of the invention, another drill bit system for a drilling assembly is provided. The drill bit system may include a chassis, a head, and one or more gauge pads. The head may include a first plurality of cutters coupled with an end of the head, and the head may be moveably coupled with the chassis. The one or more gauge pads may include a second plurality of cutters, and the one or more gauge pads may be fixedly coupled with the chassis.

[0012] In another embodiment of the invention, another drill bit system for a drilling assembly is provided. The drill bit system may include a chassis, a head, and one or more gauge pads. The head may include a first plurality of cutters coupled with an end of the head, and the head may be moveably coupled with the chassis. The one or more gauge pads may include a second plurality of cutters, and the one or more gauge pads may be movably coupled with the chassis.

[0013] In another embodiment of the invention, another drill bit system for a drilling assembly is provided. The drill bit system may include a first means, a second means, a third means, and a fourth means. The first means may be for coupling the drill bit system with the drilling assembly. The second means may be for drilling longitudinally into a medium. The third means may be for controlling lateral movement of the second means in the medium. The fourth means may be for movably coupling the second means with the first means.

[0014] In another embodiment of the invention, another method of drilling a borehole in a medium is provided. The method may include providing a drill bit, where the drill bit may include a drill head and one or more gauge pads. The method may also include rotating the drill head at a first rotational speed, and rotating the one or more gauge pads at a second rotational speed.

[0015] In another embodiment of the invention, another drill bit system for a drilling assembly is provided. The drill bit system may include a chassis, a head, and one or more gauge pads. The chassis may be configured to be operably coupled with a first rotational motion source. The head may include a first plurality of cutters coupled with an end of the head, and the head may be rotateably coupled with the chassis. The head may be configured to be operably coupled with a second rotational motion source. The one or more gauge pads may include a second plurality of cutters, and the one or more gauge pads may be fixedly coupled with the chassis.

[0016] In another embodiment of the invention, another drill bit system for a drilling assembly is disclosed. The drill bit system may include a chassis, a head, and one or more
gauge pads. The chassis may be configured to be operably coupled with a first rotational motion source. The head may include a first plurality of cutters coupled with an end of the head, and the head may be rotatably coupled with the chassis. The head may be configured to be operably coupled with a second rotational motion source. The one or more gauge pads may include a second plurality of cutters, and the one or more gauge pads may be movably coupled with the chassis.

[0017] In another embodiment of the invention, another drill bit system for a drilling assembly is provided. The drill bit system may include a first means, a second means, a third means, a fourth means, and a fifth means. The first means may be for coupling the drill bit system with the drilling assembly. The second means may be for drilling longitudinally into a medium at a first rotational speed. The third means may be for controlling lateral movement of the second means in the medium. The fourth means may be for rotatably coupling the second means with the first means. The fifth means may be for rotating the third means at a second rotational speed.

[0018] In another embodiment of the invention, another method of drilling a borehole in a medium is provided. The method may include providing a drill bit. The drill bit may include a drill head having a first plurality of cutters. The drill bit may also include a chassis movably coupled with the drill head, and one or more gauge pads coupled with the chassis. The method may also include rotating the drill head against a face of the borehole.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The present invention is described in conjunction with the appended figures:

[0020] FIG. 1 is a schematic representation of one embodiment of the invention having a drill bit which includes a chassis, a head, and one or more gauge pads coupled with a first sub-chassis having a compliant sub-section;

[0021] FIG. 2 is a schematic representation of another drill bit embodiment of the invention, similar to that shown in FIG. 1, except that the first sub-chassis does not have a compliant sub-section, but instead is movably coupled with the chassis;

[0022] FIG. 3 is a schematic representation of another drill bit embodiment of the invention, similar to that shown in FIG. 1, except that the drill bit includes a second plurality of gauge pads coupled with a second sub-chassis fixedly coupled with the chassis, and the second sub-chassis is detachably coupled with the chassis;

[0023] FIG. 4 is a schematic representation of another drill bit embodiment of the invention, similar to that shown in FIG. 3, except that the sub-chassis which includes the compliant sub-section has changed;

[0024] FIG. 5 is a schematic representation of another drill bit embodiment of the invention, similar to that shown in FIG. 3, except that both sub-chassis include a compliant sub-section;

[0025] FIG. 6 is a schematic representation of another embodiment of the invention having a drill bit which includes a chassis, a head, and one or more gauge pads movably coupled with the chassis;

[0026] FIG. 7 is a schematic representation of another embodiment of the invention having a drill bit which includes a chassis, a head, and one or more gauge pads movably coupled with a first sub-chassis fixedly coupled with the chassis;

[0027] FIG. 8 is a schematic representation of another embodiment of the invention, similar to that shown in FIG. 7, except that the drill bit includes a second plurality of gauge pads coupled with a second sub-chassis fixedly coupled with the chassis;

[0028] FIG. 9 is a schematic representation of another embodiment of the invention, similar to that shown in FIG. 7, except that the drill bit includes a second plurality of gauge pads fixedly coupled with the chassis;

[0029] FIG. 10 is a schematic representation of another embodiment of the invention having a drill bit which includes a chassis, a head, and one or more gauge pads fixedly coupled with the chassis, and an off-set mechanism, where the head is movably coupled with the chassis, and is movable via actuation of the off-set mechanism;

[0030] FIG. 11 is a schematic representation of another drill bit embodiment of the invention, similar to that shown in FIG. 10, except that the one or more gauge pads are movably coupled with the chassis;

[0031] FIG. 12 is a schematic representation of another embodiment of the invention, similar to that shown in FIG. 11, except that the drill bit includes a second plurality of gauge pads fixedly coupled with the chassis;

[0032] FIG. 13 is a schematic representation of another embodiment of the invention, similar to that shown in FIG. 10, except that the drill bit includes a joint for pivotally coupling the head with the chassis;

[0033] FIG. 14 is a schematic representation of another drill bit embodiment of the invention, similar to that shown in FIG. 13, except that the one or more gauge pads are movably coupled with the chassis;

[0034] FIG. 15 is a schematic representation of another embodiment of the invention, similar to that shown in FIG. 14, except that the drill bit includes a second plurality of gauge pads fixedly coupled with the chassis;

[0035] FIG. 16 is a schematic representation of another embodiment of the invention having a drill bit which includes a chassis, a head, a bearing, and one or more gauge pads fixedly coupled with the chassis, where the chassis is configured to be coupled with a first rotational motion source, and the head is configured to be coupled with a second rotational motion source;

[0036] FIG. 17 is a schematic representation of another embodiment of the invention, similar to that shown in FIG. 16, except that the drill bit includes a bias system; and

[0037] FIG. 18 is a schematic representation of another drill bit embodiment of the invention, similar to that shown in FIG. 16, except that the bearing includes a bias system.

[0038] In the appended figures, similar components and/or features may have the same numerical reference label. Further, various components of the same type may be distinguished by following the reference label by a letter that distinguishes among the similar components and/or features. If only the first numerical reference label is used in the specification, the description is applicable to any one of the similar components and/or features having the same first numerical reference label irrespective of the letter suffix.

DETAILED DESCRIPTION OF THE INVENTION

[0039] The ensuing description provides exemplary embodiments only, and is not intended to limit the scope, applicability or configuration of the disclosure. Rather, the ensuing description of the exemplary embodiments will provide those skilled in the art with an enabling description for implementing one or more exemplary embodiments. It being understood that various changes may be made in the function
and arrangement of elements without departing from the scope of the invention as set forth in the appended claims. [0040] Specific details are given in the following description to provide a thorough understanding of the embodiments. However, it will be understood by one of ordinary skill in the art that the embodiments may be practiced without these specific details. For example, circuits, systems, networks, processes, and other elements in the invention may be shown as components in block diagram form in order not to obscure the embodiments in unnecessary detail. In other instances, well-known circuits, processes, algorithms, structures, and techniques may be shown without unnecessary detail in order to avoid obscuring the embodiments.

[0041] Also, it is noted that individual embodiments may be described as a process which is depicted as a flowchart, a flow diagram, a data flow diagram, a structure diagram, or a block diagram. Although a flowchart may describe the operations as a sequential process, many of the operations can be performed in parallel or concurrently.

[0042] In addition, the order of the operations may be rearranged. A process may be terminated when its operations are completed, but could have additional steps not discussed or included in a figure. Furthermore, not all operations in any particularly described process may occur in all embodiments. A process may correspond to a method, a function, a procedure, a subroutine, a subprogram, etc. When a process corresponds to a function, its termination corresponds to a return of the function to the calling function or the main function.

[0043] The term “machine-readable medium” includes, but is not limited to portable or fixed storage devices, optical storage devices, wireless channels and various other mediums capable of storing, containing or carrying instruction(s) and/or data. A code segment or machine-executable instructions may represent a procedure, a function, a subprogram, a program, a routine, a subroutine, a module, a software package, a class, or any combination of instructions, data structures, or program statements. A code segment may be coupled to another code segment or a hardware circuit by passing and/or receiving information, data, arguments, parameters, or memory contents. Information, arguments, parameters, data, etc. may be passed, forwarded, or transmitted via any suitable means including memory sharing, message passing, token passing, network transmission, etc.

[0044] Furthermore, embodiments of the invention may be implemented, at least in part, either manually or automatically. Manual or automatic implementations may be executed, or at least assisted, through the use of machines, hardware, software, firmware, middleware, microcode, hardware description languages, or any combination thereof. When implemented in software, firmware, middleware or microcode, the program code or code segments to perform the necessary tasks may be stored in a machine readable medium. A processor(s) may perform the necessary tasks.

[0045] In one embodiment of the invention, a drill bit system for a drilling assembly is provided. The drill bit system may include a chassis, a head, and one or more gauge pads. The head may include a first plurality of cutters coupled with an end of the head, and the head may be coupled with the chassis. The one or more gauge pads may include a second plurality of cutters, and the one or more gauge pads may be movably coupled with the chassis.

[0046] In some embodiments, the chassis may be constructed from a metallic compound. In these and other embodiments, any one or more of the first plurality of cutters may be a polycrystalline diamond compact (“PDC”) cutter. In some embodiments, any one or more of the second plurality of cutters may also be a PDC cutter. Additionally, in any of the embodiments discussed herein, any plurality of gauge pads and/or cutters may also be presumed to also include a single gauge pad and/or cutter, but pluralities will be referred to as occurring in many of the embodiments. Furthermore, any of the embodiments discussed herein may have any of the features discussed above.

[0047] In some embodiments, the drill bit system may include a first sub-chassis. In these embodiments, the one or more gauge pads being movably coupled with the chassis may include the one or more gauge pads being fixedly coupled with the first sub-chassis, and the first sub-chassis being movably coupled with the chassis. In other embodiments, a first sub-chassis, the one or more gauge pads being movably coupled with the chassis may include the one or more gauge pads being fixedly coupled with the first sub-chassis, with the first sub-chassis including a compliant sub-section. Furthermore, any of the embodiments discussed herein may have any of the features discussed above.

[0048] In other embodiments with a first sub-chassis, the one or more gauge pads being movably coupled with the chassis may include the one or more gauge pads being movably coupled with the first sub-chassis, and the first sub-chassis being movably coupled with the chassis. In some of these embodiments, the one or more gauge pads being movably coupled with the first sub-chassis may include the one or more gauge pads having a first rate of lateral compliance with the chassis, and the first sub-chassis being movably coupled with the chassis may include the first sub-chassis having a second rate of lateral compliance with the chassis. Furthermore, any of the embodiments discussed herein may have any of the features discussed above.

[0049] In some embodiments, the drill bit system may include a first sub-chassis and a second sub-chassis. One or more gauge pads may be coupled with the first sub-chassis, and a second plurality of gauge pads, which may comprise a third plurality of cutters, may be coupled with the second sub-chassis. In various embodiments, each of the one or more gauge pads and the second plurality of gauge pads may be fixedly or movably coupled with the corresponding sub-chassis. Additionally, each of the first sub-chassis and the second sub-chassis may be fixedly or movably coupled with the chassis.

[0050] Furthermore, any of the embodiments discussed herein may have any of the features discussed above.

[0051] In some embodiments, any sub-chassis referred to herein may be detachably coupleable with the chassis, and may include multiple sub-components. In this manner, sub-chassis may be replaced on a drill bit system, possibly when the performance of gauge pads thereon has degraded due to wear. Though such sub-chassis may be “detachably coupleable” with the chassis, the sub-chassis may be “fixedly” coupled with the chassis once so coupled, or “movably” coupled with the chassis once so coupled, depending on the particular configuration. Furthermore, any of the embodiments discussed herein may have any of the features discussed above.

[0052] In some embodiments, any plurality of gauge pads or other element herein being “movably coupled” may refer to the particular gauge pads or other element having a measure of lateral compliance with the chassis or other portion of the drill bit system. In other words, upon a force acting upon
the gauge pads, the gauge pads may move, at least partially laterally, rather than rigidly transferring the force to another coupled-with portion of the drill bit system or drilling assembly. “Lateral” may refer to a direction substantially orthogonal to and/or in any direction that is away from and not parallel with a longitudinal direction that is substantially co-linear with the axis of the drill bit system. Furthermore, any of the embodiments discussed herein may have any of the features discussed above.

In some embodiments, a lateral compliance for any movable element discussed herein may be between about 1 kilo-Newton per millimeter and about 16 kilo-Newton per millimeter. In other embodiments, a lateral compliance for any movable element discussed herein may be between about 2 kilo-Newton per millimeter and about 8 kilo-Newton per millimeter. In an exemplary embodiment, a lateral compliance for any movable element discussed herein may be between 4 and 6 kilo-Newton per millimeter. In yet other embodiments, a lateral compliance for any movable element discussed herein may be about 4 kilo-Newton per millimeter. In some embodiments, a lateral compliance for any movable element discussed herein may be less than about 16 kilo-Newton per millimeter. In other embodiments, a lateral compliance for any movable element discussed herein may be less than about 8 kilo-Newton per millimeter. In an exemplary embodiment, a lateral compliance for any movable element discussed herein may be less than about 6 kilo-Newton per millimeter. In yet other embodiments, a lateral compliance for any movable element discussed herein may be less than about 2 kilo-Newton per millimeter.

Merely by way of example, the first means may be for coupling the drill bit system with the drilling assembly. Merely by way of example, the second means may include a head or any other component discussed herein, or otherwise known in the art, now or in the future, for coupling the third means with the second means.

In some embodiments, the fourth means for movable coupling the third means with the second means. Merely by way of example, the fourth means may include a compliant coupling between the third means and the second means or any other component discussed herein, or otherwise known in the art, now or in the future, for coupling the third means with the second means.

In some embodiment the drill bit system may further include a fifth means for controlling lateral movement of the second means in the medium. Merely by way of example, the fifth means may include a steerable bit system coupled with the second means or any other component discussed herein, or otherwise known in the art, now or in the future, for controlling lateral movement of the second means in the medium.

In another embodiment of the invention, another drill bit system for a drilling assembly is provided. The drill bit system includes a first means, a second means, a third means, and a fourth means.
gauge pads. The head may include a first plurality of cutters coupled with an end of the head, and the head may be movably coupled with chassis. The one or more gauge pads may include a second plurality of cutters, and the one or more gauge pads may be movably coupled with the chassis.

In some embodiments, the drill bit system may also include an off-set mechanism configured to move the head relative to the chassis. In some of these embodiments, the off-set mechanism may be configured to move the head relative to the chassis in a substantially constant lateral direction while the drill bit system rotates about its axis. In some embodiments, the off-set mechanism may include, merely by way of example, a cam system, a hydraulic actuator system, a drilling fluid (mud) powered actuator system, a piezo-electric actuator system, an electro rheological actuator system, a magneto rheological actuator system, and electro active polymer actuator system, and/or a ball screw actuator system. In some embodiments, the off-set mechanism may be configured to provide a displacement of up to about 0.1 millimeters. In other embodiments, the off-set mechanism may be configured to provide a displacement of up to about 0.2 millimeters. Furthermore, any of the embodiments discussed herein may have any of the features discussed above.

In some embodiments, the drill bit system may also include a flexible coupling. In some of these embodiments, the head may be movably coupled with the chassis. The flexible coupling may be directly connected to the head, and the flexible coupling being coupled with the chassis. Furthermore, any of the embodiments discussed herein may have any of the features discussed above.

In some embodiments, the drill bit system may also include a joint for pivotally coupling the head with the chassis. Merely by way of example, the joint may be a universal joint configured to allow for a wide degree of freedom of movement for the head. Furthermore, any of the embodiments discussed herein may have any of the features discussed above.

In another embodiment of the invention, another drill bit system for a drilling assembly is provided. The drill bit system may include a chassis, a head, and one or more gauge pads. The head may include a first plurality of cutters coupled with an end of the head, and the head may be movably coupled with the chassis. The one or more gauge pads may include a second plurality of cutters, and the one or more gauge pads may be movably coupled with the chassis.

In these embodiments, features discussed above related to sub-chassis, movably and fixedly coupled, and/or pluralities of gauge pads, movably and/or fixedly coupled, may be included, either in-whole or in-part. These embodiments may also include off-set mechanisms, flexible couplings, and/or joints as discussed above.

In another embodiment of the invention, another drill bit system for a drilling assembly is provided. The drill bit system may include a first means, a second means, a third means, and a fourth means.

In some embodiments, the first means may be for coupling the drill bit system with the drilling assembly. Merely by way of example, the first means may include a chassis or any other component discussed herein, or otherwise known in the art, now or in the future, for coupling the drill bit system with the drilling assembly.

In some embodiments, the second means may be for drilling longitudinally into a medium. Merely by way of example, the second means may include a head or any other component discussed herein, or otherwise known in the art, now or in the future, for drilling longitudinally into a medium.

In some embodiments, the third means may be for controlling lateral movement of the second means in the medium. Merely by way of example, the third means may include one or more gauge pads or any other component discussed herein, or otherwise known in the art, now or in the future, for controlling lateral movement of the second means in the medium. Further by way of example, the third means may include one or more gauge pads movably or fixedly coupled with the second means.

In some embodiments, the fourth means may be for movably coupling the second means with the first means. Merely by way of example, the fourth means may include a compliant coupling between the second means and the first means or any other component discussed herein, or otherwise known in the art, now or in the future, for movably coupling the second means with the first means.

In some embodiments, the drill bit system may also include a fifth means for controlling lateral movement of the second means in the medium. Merely by way of example, the fifth means may include an off-set mechanism configured to move the second means relative to the first means or any other component discussed herein, or otherwise known in the art, now or in the future, for controlling lateral movement of the second means in the medium.

In another embodiment of the invention, another drill bit system for a drilling assembly is disclosed. The drill bit system may include a chassis, a head, and one or more gauge pads. The chassis may be configured to be operably coupled with a first rotational motion source. The head may include a first plurality of cutters coupled with an end of the head, and the head may be rotatably coupled with the chassis. The head may be configured to be operably coupled with a second rotational motion source. The one or more gauge pads may include a second plurality of cutters, and the one or more gauge pads may be movably coupled with the chassis.

In some embodiments, the first rotational motion source may include an above-ground rotational motion source such as a topdrive system or a rotary table system. In these and other embodiments, the second rotational motion source may include a mud motor located in a bottom hole assembly. Furthermore, any of the embodiments discussed herein may have any of the features discussed above.

In some embodiments, the first rotational motion source may have a first rotational speed, and the second rotational motion source may have a second rotational speed. In other embodiments, the first rotational motion source and the second rotational motion source may have the same speed. In some embodiments, each of the first rotational speed and the second rotational speed may be either fixed or variable, discretely variable, and/or continuously variable. Furthermore, any of the embodiments discussed herein may have any of the features discussed above.

In some embodiments, the drill bit system may also include a bias system configured to transfer a vibration of the head to the chassis in substantially one direction. In some of these embodiments, the bias system may also be configured to transfer the vibration of the head in a substantially constant lateral direction while the head rotates about its axis. In some embodiments, merely by way of example, the bias system may include a cam system, a hydraulic actuator system, a drilling fluid (mud) powered actuator system, a piezo-electric actuator system, an electro rheological actuator system, a
magneto rheological actuator system, and electro active poly-
mer actuator system, and/or a ball screw actuator system. In
some embodiments, the bias system may be configured to
provide a displacement of up to about 0.1 millimeters. In
other embodiments, the bias system may be configured to
provide a displacement of up to about 0.2 millimeters. Fur-
thermore, any of the embodiments discussed herein may have
any of the features discussed above.

[0081] In some embodiments, the drill bit system may also
include a bearing. In some of these embodiments, the head
being rotatably coupled with the chassis may include the h
head being operably coupled with the bearing, and the bear-
ing being operably coupled with the chassis. Bearing is
understood, as is known in the art, to include bushings and
other means for rotatably coupling two components and
allowing for smooth rotational motion between the two com-
ponents. Furthermore, any of the embodiments discussed
herein may have any of the features discussed above.

[0082] In some of the embodiments which include a bear-
ing, the bearing may include a bias system configured to
transfer a vibration of the head to the chassis in substantially
one direction. In these embodiments, the bias system may be
configured to transfer the vibration of the head in a substan-
tially constant lateral direction while the head rotates about its
axis. Furthermore, any of the embodiments discussed herein
may have any of the features discussed above.

[0083] In another embodiment of the invention, another
drill bit system for a drilling assembly is disclosed. The drill
bit system may include a chassis, a head, and one or more
gauge pads. The chassis may be configured to be operably
coupled with a first rotational motion source. The head may
include a first plurality of cutters coupled with an end of the
head, and the head may be rotatably coupled with the chassis. The
head may be configured to be operably coupled with a second
rotational motion source. The one or more gauge pads may
include a second plurality of cutters, and the one or more
gauge pads may be movably coupled with the chassis.

[0084] In these embodiments, features discussed above
related to sub-chassis, movably and fixedly coupled, and/or
pluralities of gauge pads, movably and/or fixedly coupled,
may be included, either in-whole or in-part. These embodi-
ments may also include bias systems and/or bearings as dis-
cussed above.

[0085] In another embodiment of the invention, another
drill bit system for a drilling assembly is provided. The drill
bit system may include a first means, a second means, a third
means, a fourth means, and a fifth means.

[0086] In some embodiments, the first means may be for
coupling the drill bit system with the drilling assembly.
Merely by way of example, the first means may include a
chassis or any other component discussed herein, or other-
wise known in the art, now or in the future, for coupling the
drill bit system with the drilling assembly.

[0087] In some embodiments, the second means may be for
drilling longitudinally into a medium at a first rotational
speed. Merely by way of example, the second means may
include a head or any other component discussed herein, or
otherwise known in the art, now or in the future, for drilling
longitudinally into a medium at a first rotational speed.

[0088] In some embodiments, the third means may be for
controlling lateral movement of the second means in the
medium. Merely by way of example, the third means may
include one or more gauge pads or any other component
discussed herein, or otherwise known in the art, now or in the
future, for controlling lateral movement of the second means
in the medium.

[0089] In some embodiments, the fourth means may be for
rotatably coupling the second means with the first means.
Merely by way of example, the fourth means may include a
bearing or any other component discussed herein, or other-
wise known in the art, now or in the future, for rotatably
coupling the second means with the first means.

[0090] In some embodiments, the fifth means may be for
rotating the third means at a second rotational speed. Merely
by way of example, the fifth means may include the first
means, and the first means may include a rotatable chassis.
Additionally, the fifth means may include any other compo-
nent discussed herein, or otherwise known in the art, now or in the future, for rotating the third means at a second rotational
speed.

[0091] In some embodiments, the drill bit system may also
include a sixth means for transferring lateral vibration of the
second means to the third means. Merely by way of example,
the sixth means may include a bias system or any other
component discussed herein, or otherwise known in the art,
now or in the future, for transferring lateral vibration of the
second means to the third means.

[0092] Turning now to FIG. 1, a schematic representation
of one embodiment of the invention having a drill bit 100
which includes a chassis 105, a head 110, and one or more
gauge pads 115 coupled with a first sub-chassis 120 having a
compliant subsection 125 is shown.

[0093] Chassis 105 includes a threaded pin 130 for cou-
pling drill bit 100 with a bottom hole assembly or other
drilling assembly. Chassis 105 and head 110 also have drilling
fluid passages 135 defined therein. Head 110 includes a first
plurality of cutters 140. First plurality of gauge pads 115 may
include a second plurality of cutters 145.

[0094] In the embodiment shown in FIG. 1, first sub-chas-
sis 120 has a compliant subsection 125, and is fixedly coupled
with chassis 105. Compliant subsection 125 allows first plu-
arity of gauge pads 115 to have a certain amount of compli-
ance relative to chassis 105 and head 110. Thus, as drill bit
100 rotates through a medium, a force acting on first plurality
of gauge pads 115 may cause at least a portion first plurality
of gauge pads 115 to deflect inward toward the chassis. This
will cause more force from the interaction of drill bit 100 and
the medium to be applied to first plurality of cutters 140 on
head 110, rather than on first plurality of gauge pads 115.

[0095] In FIG. 1, the one or more gauge pads 115 are
depicted as hemispherical shapes, however, in some embodi-
ments of the present invention, the gauge pads may comprise
any shape, including a single solid ridge, a protrusion, a cylin-
der, a disc and/or the like—as depicted by an extending
gauge pad 115A in FIG. 1—that may extend outward from the
sub-chassis 120. Where the one or more gauge pads 115 com-
pare a single gauge pad the gauge pad may comprise a
ridge, a protrusion, a lateral extension of the sub-chassis 120,
a shaped portion of the sub-chassis 120, a cylinder, a disc
and/or the like extending laterally from the sub-chassis 120.
In some embodiments, the first sub-chassis 120 may comprise
a plurality of sub-chasses coupled with the chassis 105 with
each of the plurality of sub-chasses in turn being coupled with
one or more gauge pads. In such embodiments, there may be
a plurality of compliant elements or the like coupled with the
plurality of the sub-chasses. In some embodiments of the
present invention, one or more of the one or more gauge pads
115 may be configured to engage a sidewall of a borehole being drilled by the drilling system of FIG. 1 during a drilling process.

[0096] In some aspects of the present invention, one or more of the one or more gauge pads 115 may extend laterally to the gauge of the drill bit 100. In some aspects, one or more of the one or more gauge pads 115 may extend from the first sub-chassis 120 to less than the gauge of the drill bit 100. In some of the previous aspects of the present invention, one or more of the one or more gauge pads 115 may extend to a range of less than 1 to 10 millimeters of the gauge of the drill bit 100. In some aspects, one or more of the one or more gauge pads 115 may extend beyond the gauge of the drill bit 100. In some of the previous aspects of the present invention, one or more of the one or more gauge pads may extend beyond the gauge of the drill bit by between 1 to 10 millimeters and in other aspects by more than 10 millimeters.

[0097] In this and all other embodiments discussed herein, the physical characteristics of the material employed for a given sub-chassis (for example, Young's modulus of elasticity), as well as the cantilever construction/coupling of the sub-chassis' may also provide a certain amount of compliance for one or more gauge pads. However, in other embodiments, fixedly coupled sub-chassis may also be rigid and non-compliant.

[0098] FIG. 2 shows a schematic representation of another drill bit 200 embodiment of the invention, similar to that shown in FIG. 1, except that first sub-chassis 205 does not have a compliant subsection, but instead is movably coupled with chassis 105 via compliant coupling 210. Compliant coupling 210 may provide at least a similar amount of compliant relative to chassis 105 and head 110 for first plurality of gauge pads 115 as in FIG. 1.

[0099] FIG. 3 shows a schematic representation of another drill bit 300 embodiment of the invention, similar to that shown in FIG. 1, except that drill bit 300 includes a second plurality of gauge pads 305 coupled with a second sub-chassis 310 fixedly coupled with chassis 105, and second sub-chassis 310 is detachably coupled with chassis 105.

[0100] The one or more gauge pads 315 may still include a second plurality of cutters 320. Meanwhile, second plurality of gauge pads 305 may include a third plurality of cutters 325. First plurality of gauge pads 315 are still coupled with a first sub-chassis 310, and second sub-chassis 310 is detachably coupled with chassis 105.

[0101] Second sub-chassis 310 is coupled with chassis 105 via detachable coupling mechanism 335, exemplarily shown here as a countersunk screw coupling. The embodiment shown in FIG. 3 is an example of how a sub-chassis may be fixedly coupled with chassis 105, but may also be "detachably coupled." Second sub-chassis 310 may be comprised of multiple subcomponents to allow for second sub-chassis to be detachably coupled with chassis 105.

[0102] FIG. 4 shows a schematic representation of another drill bit 400 embodiment of the invention, similar to that shown in FIG. 3, except that the sub-chassis which includes compliant subsection 125 has changed. In this embodiment, first sub-chassis 405 is fixedly and undetachably coupled with chassis 105, while second sub-chassis 410 is fixedly and detachably coupled with chassis 105 via detachable coupling mechanism 335.

[0103] FIG. 5 shows a schematic representation of another drill bit 500 embodiment of the invention, similar to that shown in FIG. 3, except that both sub-chassis include a compliant subsection 125. Both first sub-chassis 330 and second sub-chassis 505 include a compliant subsection 125. Likewise second sub-chassis remains detachably coupled with chassis 105 via detachable coupling mechanism 335.

[0104] FIG. 6 shows a schematic representation of another embodiment of the invention having a drill bit 600 which includes a chassis 105, a head 110, and one or more gauge pads 115 movably coupled with chassis 105. In this embodiment, a compliant medium 605 provides the lateral compliance for first plurality of gauge pads 115.

[0105] FIG. 7 shows a schematic representation of another embodiment of the invention having a drill bit 700 which includes a chassis 105, a head 110, and one or more gauge pads 115 movably coupled with a first sub-chassis 705 which is fixedly coupled with chassis 105. In this embodiment, compliant medium 605, as well as possibly the physical properties and cantilever nature of first sub-chassis 705 may provide the lateral compliance for first plurality of gauge pads 115.

[0106] FIG. 8 shows a schematic representation of another embodiment of the invention, similar to that shown in FIG. 7, except that the drill bit 800 includes a second plurality of gauge pads 805 coupled with a second sub-chassis 810 fixedly coupled with the chassis 105. Second plurality of gauge pads 805 may include a third plurality of cutters 815, while first plurality of gauge pads 820 may include a second plurality of cutters 825.

[0107] First plurality of gauge pads 820 are coupled with chassis 105 via fixedly coupled first sub-chassis 830 and compliant medium 835. In this embodiment, compliant medium 835, as well as possibly the physical properties and cantilever nature of first sub-chassis 830 may provide the lateral compliance for first plurality of gauge pads 820.

[0108] FIG. 9 shows a schematic representation of another embodiment of the invention, similar to that shown in FIG. 7, except that the drill bit 900 has second plurality of gauge pads 805 fixedly coupled with chassis 105. In this embodiment, any lateral compliance provided by second sub-chassis 810 in the embodiment shown in FIG. 8 may be reduced and/or eliminated.

[0109] FIG. 10 shows a schematic representation of another embodiment of the invention having a drill bit 1000 which includes a chassis 105, a head 110, and one or more gauge pads 115 fixedly coupled with chassis 105, and an off-set mechanism 1005, where both compliant subsection 125.

[0110] FIG. 11 shows a schematic representation of another drill bit 1100 embodiment of the invention, similar to that shown in FIG. 10, except that first plurality of gauge pads 115 are movable coupled with chassis 105 via compliant medium 605.

[0111] FIG. 12 shows a schematic representation of another embodiment of the invention, similar to that shown in FIG. 11, except that the drill bit 1200 includes a second plurality of gauge pads 805 fixedly coupled with chassis 105.

[0112] FIG. 13 shows a schematic representation of another embodiment of the invention, similar to that shown in FIG. 10, except that the drill bit 1300 includes a joint 1305 for pivotally coupling head 110 with chassis 105 to account for actuation of off-set mechanism 1305. Embodiments such as
those shown in FIG. 13 allow for angular rotation of head 110 instead of parallel offsetting the axis of head 110 as would occur in the embodiment shown in FIG. 10.

[0113] FIG. 14 shows a schematic representation of another drill bit 1400 embodiment of the invention, similar to that shown in FIG. 13, except that first plurality of gauge pads 115 are movably coupled with chassis 105 via compliant medium 605.

[0114] FIG. 15 shows a schematic representation of another embodiment of the invention, similar to that shown in FIG. 14, except that the drill bit 1500 includes a second plurality of gauge pads 805 fixedly coupled with chassis 105.

[0115] FIG. 16 shows a schematic representation of another embodiment of the invention having a drill bit 1600 which includes a chassis 105, a head 110, a bearing 1605, and one or more gauge pads fixedly coupled with the chassis 115, where chassis 105 is configured to be coupled with a first rotational motion source, and head 110 is configured to be coupled with a second rotational motion source via coupling point 1610. Coupling point 1610 allows a fluidic connection to be maintained to drilling fluid passages 135. Embodiments having the features shown in FIG. 16 may allow for selectively different and/or similar rotational speeds to be applied to first plurality of gauge pads 115 and head 110.

[0116] FIG. 17 shows a schematic representation of another embodiment of the invention, similar to that shown in FIG. 16, except that the drill bit 1700 includes a bias system 1705. Bias system may allow vibration and/or other forces to be transferred, selectively, from head 110 to chassis and hence first plurality of gauge pads 115. Selective and/or progressive activation of bias system 1705 during specific discrete points or ranges of rotation of head 110 and chassis 105 may allow drill bit 1700 to be steered through the medium and create curved direction cavities.

[0117] FIG. 18 shows a schematic representation of another drill bit 1800 embodiment of the invention, similar to that shown in FIG. 16, except that the bearing 1805 includes a bias system 1810 internal to its operation. Bias system 1810 may still be controllable as in FIG. 17.

[0118] The invention has now been described in detail for the purposes of clarity and understanding. However, it will be appreciated that certain changes and modifications may be practiced within the scope of the appended claims.

1. A drill bit system for a drilling assembly, wherein the drill bit system comprises:
   a. a chassis;
   b. a head, wherein:
      the head comprises a first plurality of cutters coupled with an end of the head; and
      the head is coupled with chassis; and
   a first set of gauge pads, wherein the first set of gauge pads comprises one or more gauge pads movably coupled with the chassis.
2. The drill bit system for a drilling assembly of claim 1, further comprising:
   a second plurality of cutters coupled with the one or more gauge pads.
3. The drill bit system for a drilling assembly of claim 1, wherein the head being movably coupled with the chassis comprises a selection from a group consisting of:
   the head having a lateral compliance with the chassis of between about 12 and about 16 kilo-Newton per millimeter;
   the head having a lateral compliance with the chassis of between about 8 and about 12 kilo-Newton per millimeter;
   the head having a lateral compliance with the chassis of between about 6 and about 8 kilo-Newton per millimeter;
   the head having a lateral compliance with the chassis of between about 4 and about 6 kilo-Newton per millimeter; and
   the head having a lateral compliance with the chassis of less than about 4 kilo-Newton per millimeter.
4. (canceled)
5. (canceled)
6. The drill bit system for a drilling assembly of claim 1, wherein the drill bit system further comprises a second set of gauge pads, wherein the second set of gauge pads comprises one or more gauge pads fixedly coupled with the chassis.
7. The drill bit system for a drilling assembly of claim 1, wherein the drill bit system further comprises a second set of gauge pads, wherein the second set of gauge pads comprises one or more gauge pads and includes a third plurality of cutters.
8. The drill bit system for a drilling assembly of claim 1, wherein the drill bit system further comprises a second set of gauge pads, wherein the second set of gauge pads comprises one or more gauge pads that are movably coupled with the chassis.
9. The drill bit system for a drilling assembly of claim 8, wherein:
   the first set of gauge pads being movably coupled with the chassis comprises the first set of gauge pads having a first rate of lateral compliance with the chassis; and
   the second set of gauge pads being movably coupled with the chassis comprises the second set of gauge pads having a second rate of lateral compliance with the chassis.

10-25. (canceled)