



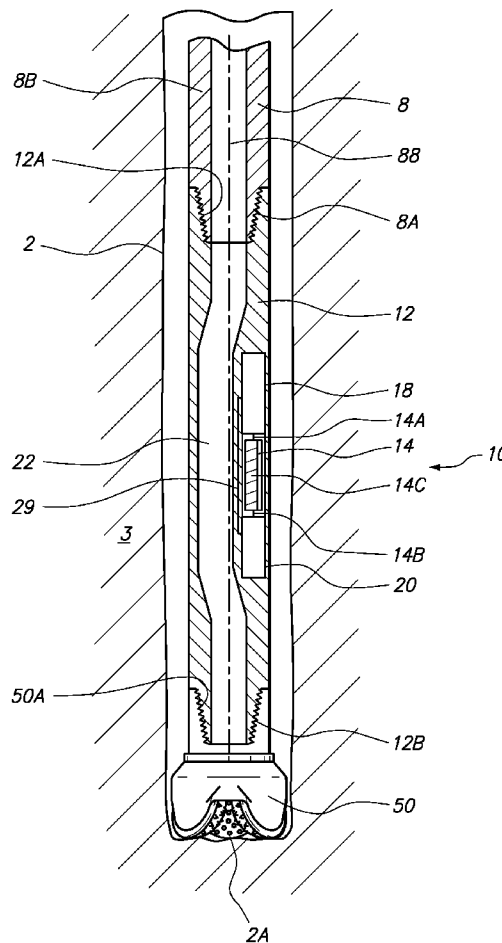
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(19) **United States**(12) **Patent Application Publication**
Buytaert(10) **Pub. No.: US 2010/0212901 A1**(43) **Pub. Date: Aug. 26, 2010**(54) **DOWNHOLE VIBRATION APPARATUS AND METHODS****Publication Classification**(75) Inventor: **Jean Buytaert**, Mineral Wells, TX (US)Correspondence Address:
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E21B 33/14 (2006.01)(52) **U.S. Cl. 166/286; 166/381; 175/61; 166/380; 166/285; 175/57**(73) Assignee: **FRANK'S INTERNATIONAL, INC.**, Houston, TX (US)(21) Appl. No.: **12/714,157**(22) Filed: **Feb. 26, 2010****Related U.S. Application Data**

(60) Provisional application No. 61/155,601, filed on Feb. 26, 2009.

ABSTRACT

A method of extending an earthen bore comprises the steps of rotating a drill bit at the end of a tubular while vibrating the tubular. The method results in reduced friction to tubular advance through the bore and results in stabilized drill bit loading and longer usable drill bit life. A method of conditioning a cement slurry in an annulus between a casing and a bore to improve a resulting cement liner comprises the steps of coupling a vibration generator to the casing, running the casing into the bore, displacing the cement slurry into the annulus and using the vibration generator to vibrate the casing. A vibration generator may comprise a mass, having a mass center, coupled to a frame, a motor and a power source to spin the mass about an axis offset from the mass center.



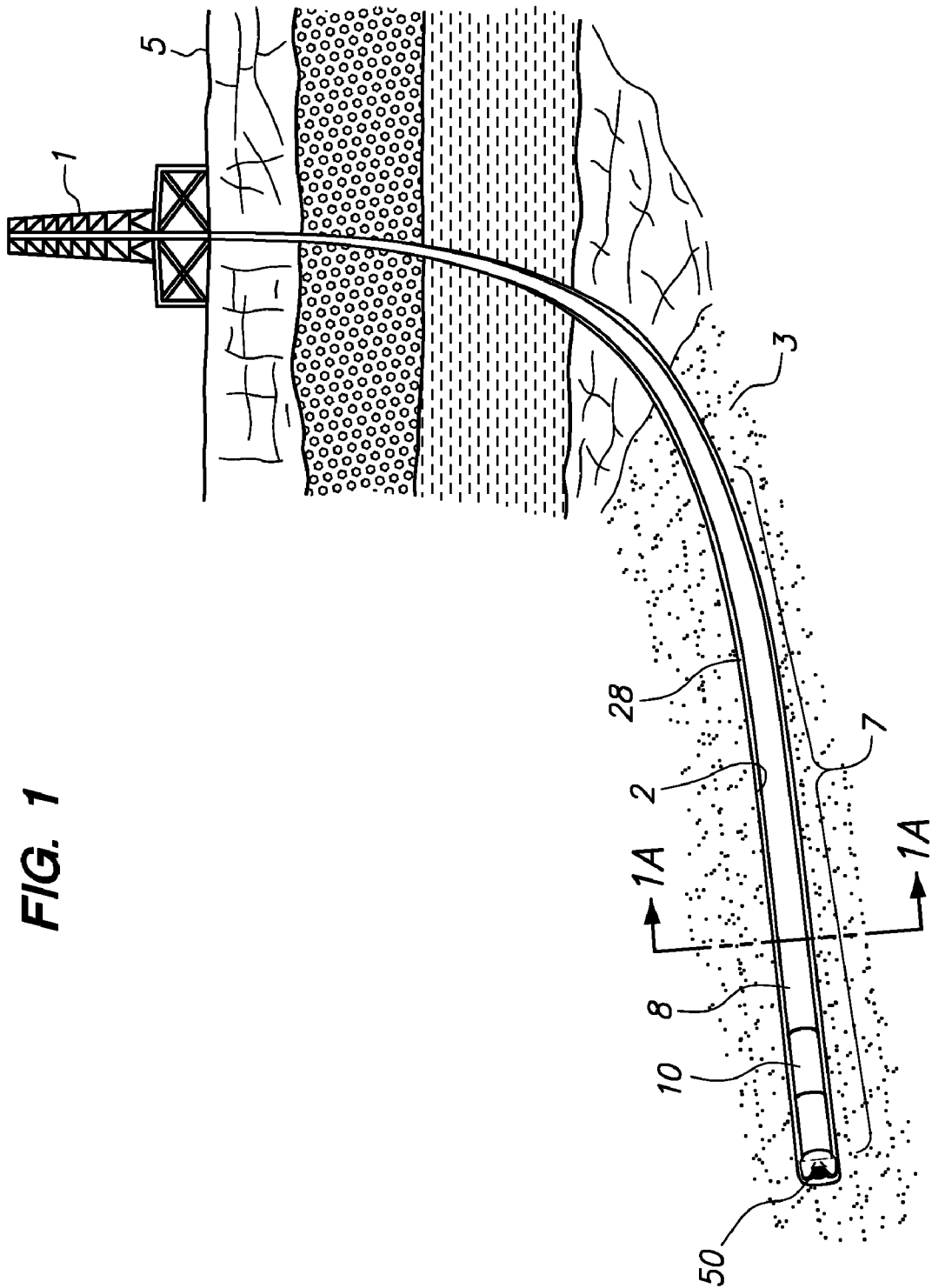


FIG. 1A

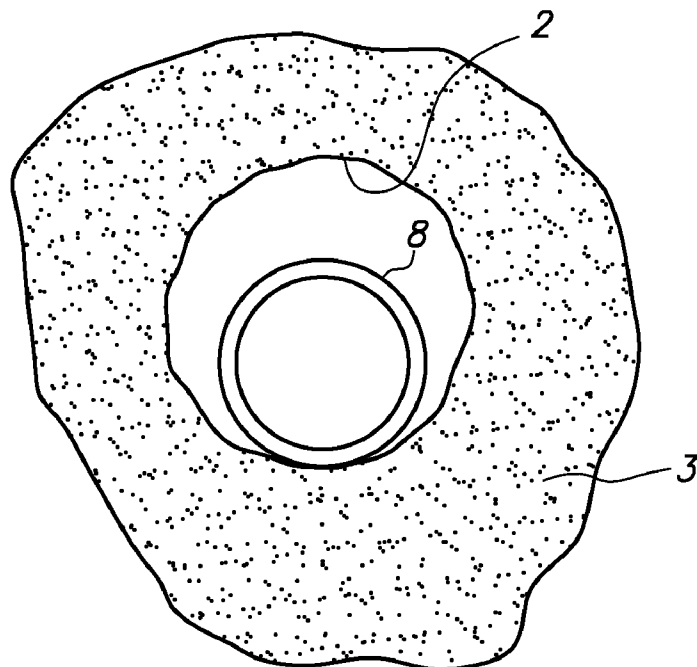
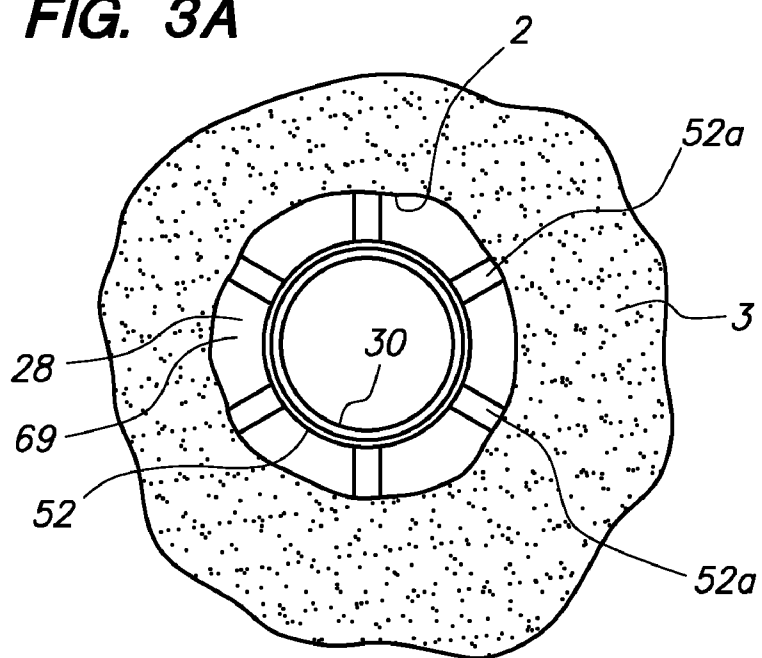


FIG. 3A



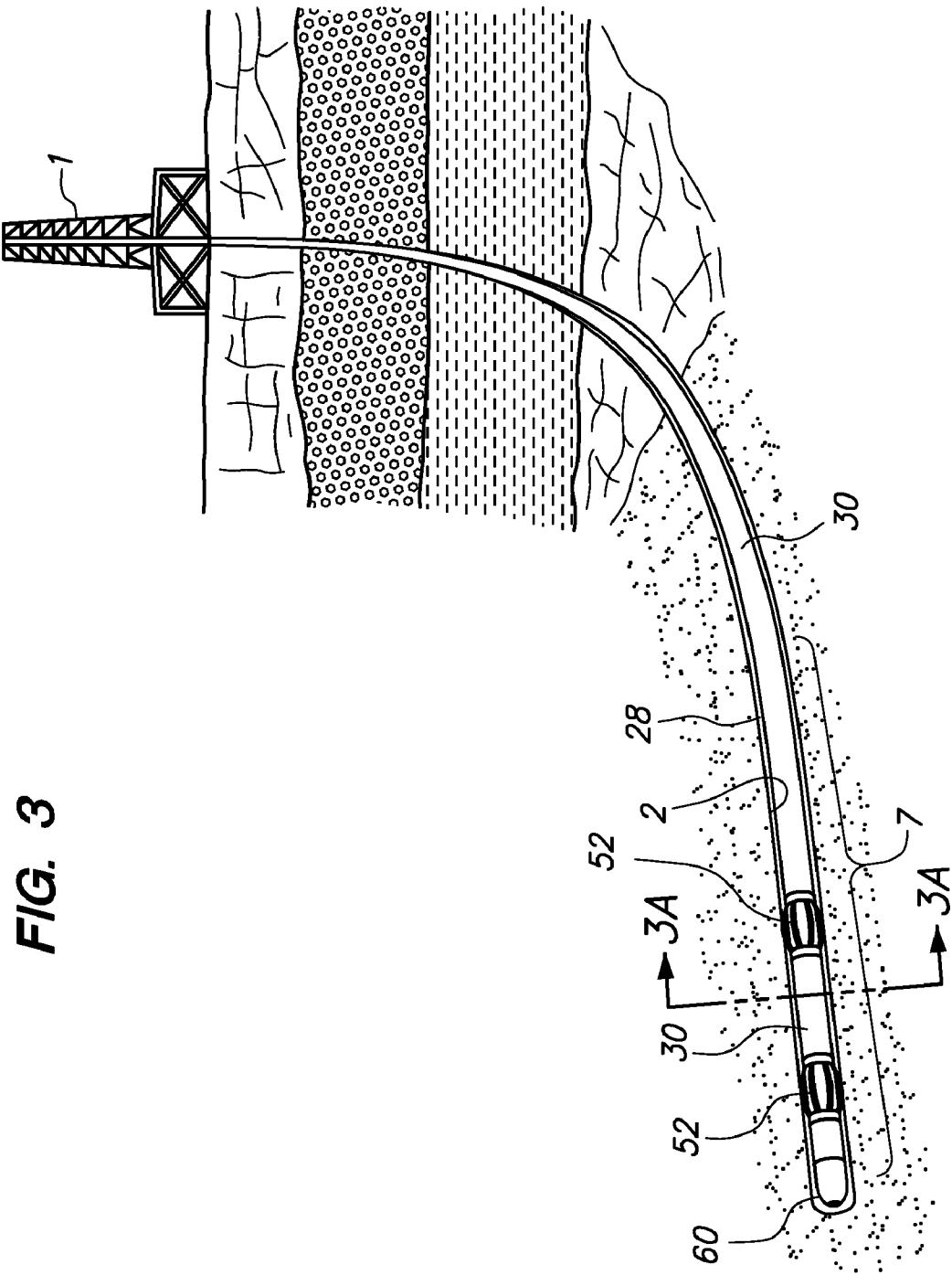


FIG. 4

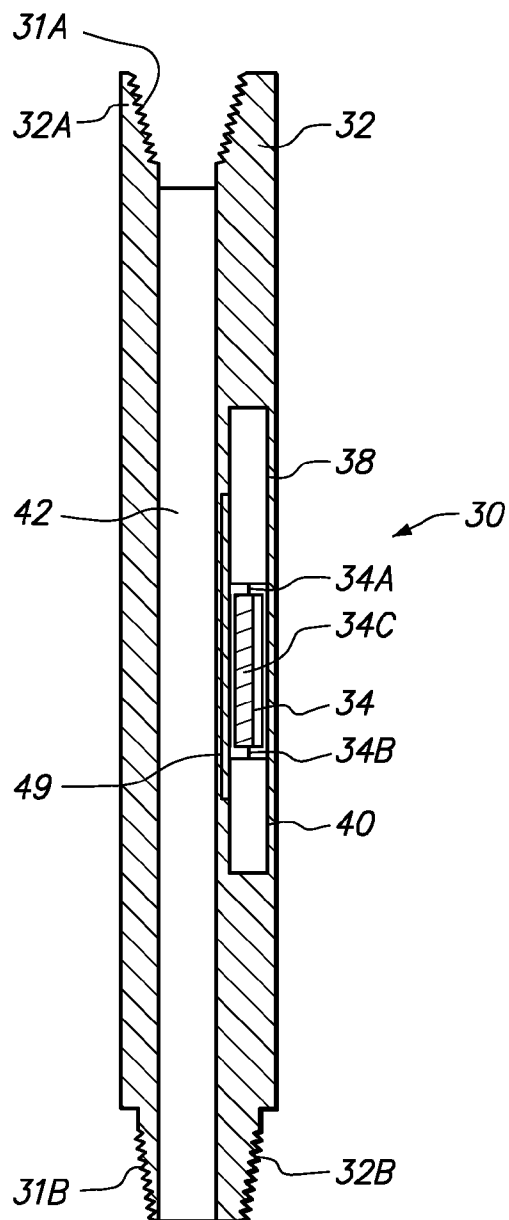
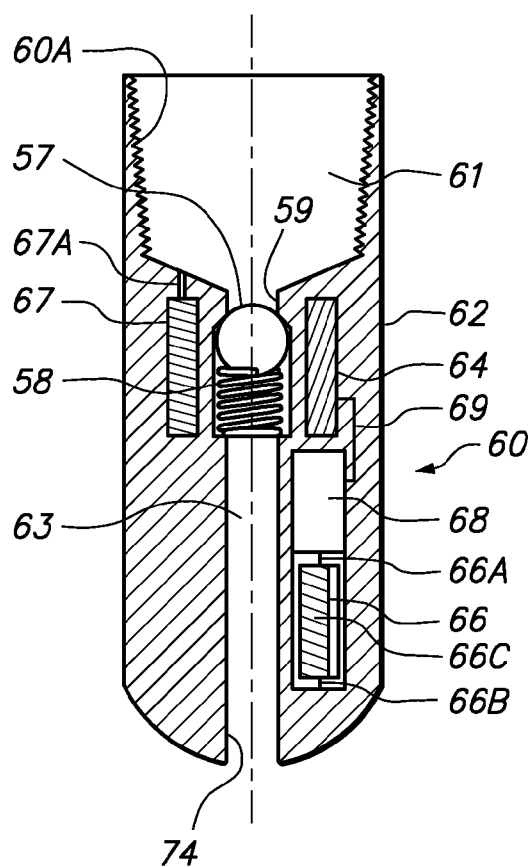


FIG. 5



DOWNHOLE VIBRATION APPARATUS AND METHODS

STATEMENT OF RELATED APPLICATIONS

[0001] This application depends from and claims the benefit of U.S. Provisional Patent Application No. 61/155,601 filed on Feb. 26, 2009.

FIELD OF THE INVENTION

[0002] This application relates to the drilling of an earthen bore, cementing of a casing in an earthen bore, improving drill bit service life and improving bonding between a cement liner installed around a casing in an earthen bore.

BACKGROUND

[0003] It is conventional practice to couple a drill bit to a tubular, for example, a drill string, and to rotate the drill bit against an end of an earthen bore to extend the bore into the earth's crust. A drill string may comprise slick (i.e., constant diameter) drill collars or enlarged (relative to the mid-section of the joints) drill collars. In casing while drilling applications, the drill bit is coupled to a casing. Drill cuttings are removed from the bore by circulating drilling fluid through a fluid passage in the drill string (which, in drilling applications, may be a drill string or a casing) to the drill bit, and back to the surface through an annulus between the drill string and the earthen bore. As the drill bit penetrates the earth's crust, the drill string advances through the bore at a rate of penetration of the drill bit. In conventional drilling operations, the drill string may rotate along with the drill bit. In some drilling operations, such as casing while drilling, the drill bit may rotate independently of the drill string using a bottom hole assembly (BHA) that includes a mud motor powered by pressurized drilling fluid to rotate the drill bit. The weight or load imparted to the drill bit by the drill string is a factor that determines the rate of penetration.

[0004] In drilling operations, it is advantageous to stabilize the rate of advance of the drill string through the borehole to prevent unwanted spikes in the load imparted to the drill bit. Intermittent or sporadic advances of the drill string within the bore may cause drill bit damage due to excessive loading. This problem may be greater in bores having a highly deviated section due to substantially greater frictional resistance between the bore and the drill string. In highly deviated sections of a bore, the weight of the drill string (and contents) bear on the floor, or downwardly disposed side, of the bore to cause substantially greater frictional resistance to advance of the drill string through the bore. The result may be intermittent and erratic advances of the drill string and related peak loads imparted to the drill bit.

[0005] An attempt to stabilize the rate of advance of a drill string through a bore having a highly deviated section uses an oscillating valve disposed within a BHA coupled to the drill string. Pressurized drilling fluid may be pumped through the fluid passage in the drill string to drive the oscillating valve to vibrate the BHA and reduce frictional resistance to advance of the drill string through the bore.

[0006] An oscillating valve powered by pressurized drilling fluid may consume a substantial portion of the mechanical energy provided to the BHA, leaving less mechanical energy to drive the mud motor and/or to circulate and remove drill cuttings.

[0007] After an earthen bore is drilled to a targeted depth, it is conventional practice to cement a casing in the bore to prevent collapse and stabilize the bore. A float device, such as a float shoe or a float collar, may be coupled to the casing, and the casing may be run into the bore and positioned within a targeted interval. The casing may also be radially positioned (or "centered") within the bore using casing centralizers, such as bow spring centralizers, coupled at intervals along the casing to provide an annulus between the casing and the bore. Cement slurry is pumped through the casing with cementing plugs to facilitate displacement of the slurry through the float device and into the annulus. The cement slurry solidifies to provide a protective cement liner around the casing. Alternatively, an inner cementing string may be run through the casing and stung into a mandrel, for example, a mandrel in a float device, and cement slurry may be delivered through the inner cementing string and the float device to the annulus.

[0008] The quality of the cement liner may be improved by conditioning the cement slurry within the annulus while and/or after the cement slurry is displaced into the annulus. The cement slurry may be conditioned by agitation to induce turbulent fluid flow, disrupt fluid channeling and promote bonding of the cement liner to the bore.

[0009] Reciprocation and/or rotation of the casing using the drilling rig are conventional methods of agitating a cement slurry. In substantially vertical bores, where casing hangs primarily in tension, casing is more easily reciprocated and/or rotated within the bore. In bores having highly deviated sections, reciprocating or rotating the casing may be difficult because the weight of the casing (and contents) bears heavily on the floor, or downwardly disposed side, of the bore. As a result, casing rotation and/or reciprocation within a highly deviated section of a bore causes unwanted wear and stress on the casing, on the casing centralizers and on rig equipment used to move the casing within the bore.

[0010] What is needed is a method to stabilize the advance of a tubular, such as a drill string, through an earthen bore to prevent excessive drill bit loading. What is needed is a method to condition a cement slurry displaced into an annulus between a tubular, such as a casing, and a bore. What is needed is a method to condition an annular flow or volume of cement slurry around a casing without imparting unwanted stress and wear on the casing, casing centralizers and rig equipment.

SUMMARY

[0011] One embodiment of the invention is a method of stabilizing drill bit loading to extend the usable life of a drill bit comprising the steps of coupling a drill bit to a drill string (which may be a casing used in a casing while drilling application), coupling a vibration generator to the drill string, coupling a power source, such as a battery, to the vibration generator, running the drill string into a bore to engage the drill bit with an end of the bore, rotating the drill bit to extend the bore, and activating the vibration generator to vibrate a portion of the drill string within a highly deviated section of the bore to reduce frictional resistance to advance of the drill string and thereby stabilize drill bit loading.

[0012] Another embodiment of the invention is a method of reducing frictional resistance to advance of a tubular through a highly deviated section of a drilled earthen bore comprising the steps of coupling a vibration generator to the tubular, e.g., a casing, coupling a power source, such as a battery, to the vibration generator, running the tubular into a bore, and acti-

vating the vibration generator to vibrate a portion of the tubular within a highly deviated section of the bore to reduce frictional resistance to advance of the casing and thereby stabilize advance of the casing through the bore towards the targeted interval.

[0013] Another embodiment of the invention is a method of conditioning a cement slurry to promote improved bonding between a cement liner and a bore comprises the steps of coupling a float device (such as a float shoe or a float collar) to a casing, coupling a vibration generator to the casing, coupling a power source (such as a battery) to the vibration generator, running the casing into a bore, displacing a volume of cement slurry through the casing and the float device and into an annulus between the casing and the bore, and activating the vibration generator to vibrate a portion of the casing to condition a portion of the volume of cement slurry adjacent the vibration generator.

[0014] In the methods described above, the vibration generator may be activatable using a pressure sensor disposed in communication with the power source to detect an activating condition. For example, in one embodiment, a pressure sensor may be disposed to detect the pressure in a fluid passage in the drill string, the casing, in a sub or in the float device. The pressure sensor may be coupled to a microprocessor programmed to monitor readings of the pressure sensor and to recognize an activating condition or sequence. For example, but not in the way of limitation, the pressure sensor may detect a first predetermined pressure threshold, followed by a pressure trough lasting for a predetermined interval of time, followed by a second predetermined pressure threshold, altogether comprising a sequence of events recognizable by the microprocessor. In response, the microprocessor may close an electrical circuit to provide current from the a power source to a motor to activate the vibration generator. A subsequent predetermined event or sequence may be used to deactivate the vibration generator.

[0015] One embodiment of the method of conditioning a cement slurry may comprise coupling the vibration generator to a float device, such as a float shoe or float collar. Another embodiment of the method of conditioning a cement slurry may comprise coupling the vibration generator to one or more drillable components, such as a float device, so that the vibration generator and the float device may be drilled or destroyed to provide an unrestricted passage through the casing to facilitate further extension of the bore after the cementing step.

[0016] An embodiment of an apparatus that may be used to implement a method described above comprises a mass rotatably coupled within a frame and having a mass center, a motor coupled to the mass, and a power source coupled to the motor to provide energy for spinning the mass on an axis offset from the mass center to produce reactive vibrations in the frame.

[0017] A power source for providing energy to a motor may, in one embodiment, comprise a battery having a high power-density including, but not limited to, a nickel-cadmium battery, a nickel-metal-hydride battery or a lithium-ion battery. While high power-density batteries may provide for optimal performance of the vibration generator, a conventional lead acid battery may also be used.

[0018] A mass to be spun to produce vibrations may, in one embodiment, comprise an elongate member of a high density material, such as lead, or it may comprise a substrate to which weighted attachments are secured to provide a mass center offset from an axis about which the mass is spun. It will be understood that factors affecting the frequency and magni-

tude of vibrations includes the weight of the mass, the offset between the axis of rotation and the mass center, the angular velocity of spinning of the mass and the relative size of the sub, float device or other frame to which the mass is secured.

[0019] The foregoing, as well as other, objects, features, and advantages of the invention will be more fully appreciated and understood by reference to the drawings, described below, and to the claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] FIG. 1 is an illustration of a drilling rig on the earth's surface and a drill string extending from the rig into an earthen bore.

[0021] FIG. 1A is a section view taken at position 1A-1A along the drill string of FIG. 1.

[0022] FIG. 2 is a section view of one embodiment of a vibrating sub having a vibration generator and coupled within a drill string adjacent a drill bit.

[0023] FIG. 3 is an illustration of a drilling rig on the earth's surface and a casing being installed in a targeted interval in a highly deviated section of the bore.

[0024] FIG. 3A is a section view taken at position 3A-3A along the casing of FIG. 3.

[0025] FIG. 4 is a section view of an alternate embodiment of a drill sub having a vibration generator.

[0026] FIG. 5 is a section view of an embodiment of a float device having a vibration generator.

DETAILED DESCRIPTION

[0027] FIG. 1 is an illustration of a drilling rig 1 on the earth's surface 5 and a tubular 8 extending from the rig 1 into an earthen bore 2 drilled into the earth's crust 3. A drill bit 50 and a vibration generator 10 are coupled to the tubular 8. The vibration generator 10 is illustrated in FIG. 1 as being disposed within a highly deviated section 7 of the bore 2. A highly deviated section 7 is a section of the bore 2 disposed at a substantial angle from vertical. The highly deviated section may be horizontal. The tubular 8 in FIG. 1 may comprise a drill string or a casing, the latter being likely in casing while drilling applications.

[0028] FIG. 1A is a section view taken at position 1A-1A on FIG. 1. FIG. 1A illustrates the nature of the frictional resistance to advance of the tubular 8 and a bore 2 in a highly deviated section (see reference number 7 of FIG. 1A) of the bore 2. FIG. 1A illustrates how the weight of the tubular 8 (and contents) bears downwardly on the supporting floor, or downwardly disposed side, of the bore 2. The large reaction force applied by the bore 2 to support the tubular 8 substantially increases frictional resistance to advance of the tubular 8 through the bore 2.

[0029] FIG. 2 is an enlarged section view of the embodiment of the vibration generator 10 of FIG. 1 comprising a sub 12 having a first threaded connection 12A, a second threaded connection 12B, and a fluid passage 22 therebetween. The fluid passage 22 illustrated in FIG. 2 deviates from an axis 88 of the tubular 8. The first threaded connection 12A of the sub 12 is coupled to a mating connection 8A of an adjacent tubular segment 8B of the tubular 8, and the second threaded connection 12B of the sub 12 is coupled to a mating connection 50A of the drill bit 50 (not shown in section) disposed against the end 2A of the bore 2. The vibration generator 10 of FIG. 2 comprises a mass 14 rotatably coupled to the sub 12, a motor 18 coupled to the mass 14 and a power source 20

coupled to the motor 18 through electrical conduit 29. Activation of the motor 18 using the power source 20 spins the mass 14 on an axis including the axle first portion 14A and axle second portion 14B, but offset from a mass center 14C.

[0030] FIG. 3 is an illustration of a drilling rig 1 on the earth's surface 5 and a casing 30 disposed in a targeted interval in a highly deviated section 7 of the bore 2. A plurality of centralizers 52 are received on the casing 30 at intervals along the casing 30 to provide an annulus 28 between the casing 30 and the bore 2. A float device 60 is coupled to the casing 30 to facilitate displacement of cement slurry from a fluid passage (not shown) within the casing 30 and into the annulus 28.

[0031] FIG. 3A is a section view taken at position 3A-3A along the casing of FIG. 3 and illustrates the stand-off between the casing 30 and the bore 2 provided by the bow springs 52a of the centralizer 52. The resulting annulus 28 receives a cement slurry 69 therein to form a cement liner upon curing of the cement slurry. As can be seen in FIG. 3A, vibration of the casing 30, especially vibration having a radial displacement as will be generated by the apparatus illustrated in FIGS. 3, 4 and 5, will condition the cement slurry 69 within the annulus 28 and promote improved cement liner bonding to the bore 2.

[0032] FIG. 4 is a section view of an alternate embodiment of a vibration generator 30 comprising a sub 32 having a first connection 30A with threads 31A, a second connection 30B with threads 31B, a fluid passage 42 therebetween, and a vibration generator 30 comprising a mass 34, a motor 38 coupled to the mass 34, and a power source 40 coupled to the motor 38 through an electrical conduit 49. Activation of the motor 38 using the power source 40 spins the mass 34 on an axis including axle first portion 34A and axle second portion 34B but offset from a mass center 34C to vibrate the sub 32 and a tubular (not shown in FIG. 4—see FIG. 3).

[0033] FIG. 5 is an enlarged section view of the float device 62 of FIG. 3. The float device 62 comprises a threaded connection 60A at which it may be coupled to a casing (see FIG. 3—float device is illustrated in FIG. 5 decoupled from the casing). The float device 62 further comprises a vibration generator comprising a mass 66 rotatably coupled to the float device 62, a motor 68 coupled to the mass 66, and a power source 64 coupled to the motor 68. Activation of the motor 68 using the power source 64 spins the mass 66 about an axis including axle first portion 66A and axle second portion 66B but offset from a mass center 66C. The float device 62 of FIG. 5 further comprises a module 67 comprising a pressure sensor and a microprocessor. The module 67 is in fluid communication with a fluid passage inlet 61 within the threaded connection 60A through a channel 67A in the float device 62. The fluid passage inlet 61 is separated from a fluid passage outlet 63 by a check valve comprising a ball 57 movably captured between a restriction 59 and a spring 58. It will be understood that the ball 57 is disposed by the spring 58 against the restriction 59 to prevent flow through the restriction 59 until the pressure in the fluid passage inlet 61 exceeds the pressure in the fluid passage outlet 63 by a differential that is sufficient to overcome the force of the spring 58 against the ball 57, at which time fluid (not shown) will flow from the fluid passage inlet 61, past the ball 57, through the fluid passage outlet 63 and through the exit port 74. Operating in this manner, the float device 62 prevents fluid within the bore 2 (see FIG. 3) from flowing into the fluid passage inlet 61 and entering the casing 30 (see FIG. 3).

[0034] The terms “comprising,” “including,” and “having,” as used in the claims and specification herein, shall be considered as indicating an open group that may include other elements not specified. The terms “a,” “an,” and the singular forms of words shall be taken to include the plural form of the same words, such that the terms mean that one or more of something is provided. The term “one” or “single” may be used to indicate that one and only one of something is intended. Similarly, other specific integer values, such as “two,” may be used when a specific number of things is intended. The terms “preferably,” “preferred,” “prefer,” “optionally,” “may,” and similar terms are used to indicate that an item, condition or step being referred to is an optional (not required) feature of the invention.

[0035] From the foregoing detailed description of specific embodiments of the invention, it should be apparent that an apparatus and a method for stabilizing the advance of a tubular through a bore that is novel has been disclosed, and that an apparatus and a method for conditioning a cement slurry in an annulus has been disclosed. Although specific embodiments of the apparatuses and methods are disclosed herein, this is done solely for the purpose of describing various features and aspects of the invention, and is not intended to be limiting with respect to the scope of the invention. It is contemplated that various substitutions, alterations, and/or modifications, including but not limited to those implementation variations which may have been suggested herein, may be made to the disclosed embodiments without departing from the spirit and scope of the invention as defined by the appended claims which follow.

[0036] While embodiments of the invention have been described herein, various modifications of the apparatus and method of the invention may be made without departing from the spirit and scope of the invention, which is more fully defined in the following claims.

We claim:

1. A method of advancing a tubular through a highly deviated portion of an earthen bore comprising the steps of:
 - coupling a vibration generator to a tubular;
 - running the tubular into the bore to dispose the vibration generator within the highly deviated section; and
 - activating the vibration generator to vibrate a portion of the tubular within the highly deviated section of the bore.
2. The method of claim 1 further comprising the steps of:
 - coupling a drill bit to the tubular; and
 - rotating the drill bit against an end of the bore.
3. The method of claim 2 wherein the tubular is a drill string.
4. The method of claim 2 wherein the step of rotating the drill bit against the end of the bore comprises the steps of:
 - coupling a mud motor to the drill bit; and
 - providing a flow of pressurized fluid to the mud motor to rotate the drill bit.
5. The method of claim 1 wherein the step of coupling a vibration generator to a tubular comprises the steps of:
 - coupling a mass having a mass center to the tubular;
 - coupling a motor to the mass;
 - coupling a power source to the motor; and
 - activating the motor to spin the mass on an axis offset from the mass center.

6. The method of claim 1 further comprising the steps of: coupling a float device to the tubular; displacing a volume of cement slurry through the tubular and the float device and into an annulus between the tubular and the bore; and conditioning a portion of the volume of cement slurry within the highly deviated section.
7. The method of claim 1 further comprising the steps of: coupling a second vibration generator to the tubular; disposing the second vibration generator within the highly deviated section; and activating the second vibration generator to vibrate a second portion of the tubular within the highly deviated section of the bore.
8. The method of advancing a tubular through a highly deviated section of an earthen bore comprising the steps of: coupling a mass having a mass center to a tubular; coupling a motor to the mass; coupling a power source to the motor; running the tubular into the earthen bore to position the mass within the highly deviated section of the bore; and spinning the mass on an axis offset from the mass center to vibrate a portion of the tubular adjacent the mass.
9. The method of claim 8 wherein the power source is a battery and the motor is an electrically-driven motor.
10. A method of extending an earthen bore comprising the steps of:
coupling a drill bit and a vibration generator to a tubular;
running the tubular into the bore;
rotating the drill bit against an end of the bore; and
vibrating the tubular using the vibration generator.
11. The method of claim 10 further wherein the step of vibrating the tubular using the vibration generator comprising the steps of:
coupling a mass having a mass center to a tubular sub;
coupling a motor to the mass;
coupling a power source to the motor; and
activating the motor to spin the mass about an axis offset from the mass center.
12. The method of claim 10 wherein the step of rotating the drill bit against the end of the bore comprises the step of:

fluidically driving a mud motor to rotate the drill bit relative to the tubular.

13. The method of claim 10 further comprising the step of: coupling a second vibration tool to the tubular; and vibrating the tubular using the second vibration tool.

14. A method of conditioning a volume of cement slurry disposed within an annulus between a tubular and an earthen bore into which the tubular is run, comprising the steps of:
coupling a vibration generator to the tubular;
displacing the volume of cement slurry through the bore of the tubular and into the annulus; and
activating the vibration generator to vibrate the volume of cement slurry.

15. The method of claim 14 wherein the step of coupling a vibration generator to the tubular comprises the steps of:
rotatably coupling a mass having a mass center to the tubular; and
coupling a motor to the mass;
coupling a power source to the motor; and
activating the motor to spin the mass on an axis offset from the mass center.

16. The method of claim 15 further comprising the step of coupling a float device to the tubular.

17. The method of claim 16 wherein the float device is at least one of a float collar and a float shoe.

18. The method of claim 17 wherein the float device comprises a check valve.

19. The method of claim 14 wherein the step of coupling a vibration generator to the tubular comprises the steps of:
providing a sub having a first threaded connection at a first end coupled to the tubular, a second threaded connection at a second end, and a fluid passage therebetween in fluid communication with the bore of the tubular.

20. The vibration tool of claim 14 wherein the sub further comprises a second threaded connection at a second end of the fluid passage.

21. The vibration tool of claim 14 wherein the sub further comprises a float shoe having a valve.

* * * * *