CLAIMS

What is claimed is:

1. A system, comprising:

a directional drilling system having a main shaft coupled to a second shaft by a pivot point, the second shaft being coupled to a steering sleeve, and a plurality of actuators mounted at different circumferential positions for engagement with the steering sleeve to selectively pivot the steering sleeve and the second shaft with respect to the main shaft, each actuator comprising a loose element slidably mounted in a piston sleeve oriented to allow the loose element to act against the steering sleeve when sufficient pressure is applied to the loose element within the piston sleeve.

2. The system as recited in claim 1, wherein each actuator comprises a plurality of balls slidably each mounted in a corresponding piston sleeve.

3. The system as recited in claim 2, wherein the plurality of actuators comprises at least three actuators circumferentially spaced around the main shaft and within the steering sleeve.

4. The system as recited in claim 3, further comprising a valve located to control flow of pressurized drilling mud to the plurality of actuators.

5. The system as recited in claim 1, wherein the steering sleeve comprises at least one surface profiled to receive the loose element in a manner that reduces contact stress during pivoting of the steering sleeve.

6. The system as recited in claim 1, wherein the piston sleeve is oriented at a non-perpendicular angle with respect to the steering sleeve.

7. The system as recited in claim 3, wherein the loose elements are substantially spherical balls and the plurality of substantially spherical balls provides rolling contact with an internal surface of the steering sleeve.

8. The system as recited in claim 2, wherein certain balls of the plurality of balls have different diameters with respect to each other.

9. The system as recited in claim 1, wherein the ball sleeve changes in cross-sectional area along its length to vary clearance between the loose element and the piston sleeve.

10. The system as recited in claim 1, further comprising a ball sensor positioned to monitor a position of the ball in the ball sleeve.

11. A method for drilling, comprising:

preparing a directional drilling system with a main shaft pivotably coupled to a second shaft by a pivot point;

coupling a plurality of actuators into the directional drilling system with each actuator comprising a ball slidably mounted in a sleeve; and

orienting each sleeve such that controlled movement of the ball along the sleeve causes the second shaft to pivot about the pivot point with respect to the main shaft.

12. The method as recited in claim 11, further comprising connecting a steering sleeve to the second shaft, wherein coupling comprises mounting the plurality of actuators between the main shaft and the steering sleeve at spaced circumferential positions around the main shaft.

13. The method as recited in claim 12, further comprising forming each actuator with a plurality of balls slidably positioned in a plurality of corresponding ball sleeves.

14. The method as recited in claim 13, further comprising controlling movement of the ball against an interior surface of the steering sleeve by selectively applying pressurized drilling mud to each actuator in a sequential manner to maintain a desired angle of drilling during rotation of the drill bit shaft.

15. The method as recited in claim 11, further comprising providing each actuator with a sensor to monitor ball position.

16. The method as recited in claim 14, further comprising coupling a drill bit to the drill bit shaft and rotating the drill bit to drill a wellbore.

17. The method as recited in claim 13, further comprising forming at least one recess along an internal surface of the steering sleeve to receive at least one ball in a manner that reduces contact stress.

18. The method as recited in claim 11, wherein coupling comprises positioning the plurality of actuators above the universal joint.

19. The method as recited in claim 11, wherein coupling comprises positioning the plurality of actuators below the universal joint.

20. The method as recited in claim 11, wherein orienting comprises orienting each ball sleeve such that movement of each ball along a corresponding ball sleeve enables each ball to act against at least one of the main shaft and the drill bit shaft.

21. The method as recited in claim 11, further comprising moving each ball with a pressurized drilling mud and controlling the flow of drilling mud with a computer-controlled valve of a flow control system.

22. The method as recited in claim 12, further comprising providing each ball with a shape that corresponds with a profile along an interior of the steering sleeve to improve the stability of the rotary steerable system.

23. A method of drilling a wellbore, comprising:

coupling a directional drilling system to a drill string, wherein the directional drilling system comprises a main shaft pivotally coupled to a drill bit shaft;

steering the directional drilling system by selectively directing drilling mud to a plurality of ball actuators positioned within a steering sleeve coupled to the drill bit shaft of the directional drilling system; and

operating the directional drilling system to drill a deviated wellbore.

24. The method as recited in claim 23, wherein steering comprises using a mud valve to selectively direct drilling mud under pressure against a plurality of balls in each actuator such that movement of the balls causes pivoting of the steering sleeve and the drill bit shaft to a desired drilling direction.

25. The method as recited in claim 23, further comprising pivotably coupling the drill bit shaft to the main shaft via a universal joint.

26. A method of facilitating a wellbore operation, comprising:

preparing a downhole tool with a pivotable device;

coupling a plurality of actuators into the downhole tool with each actuator comprising a ball slidably mounted in a ball sleeve; and

orienting each ball sleeve such that controlled movement of the ball along the ball sleeve causes the downhole tool to flex about the pivotable device.

27. The method as recited in claim 26, wherein preparing comprises preparing the downhole tool with the pivotable device in the form of a universal joint.

28. The method as recited in claim 26, further comprising using the downhole tool in a coil tubing drilling operation.

29. The method as recited in claim 26, wherein preparing comprises preparing a mud motor with the pivotable device.

CLAIMS

What is claimed is:

1. A system, comprising: a directional steerable system having a main shaft coupled to a second shaft by a pivot point, the second shaft being coupled to a steering sleeve, and a plurality of actuators mounted at each circumferential positions of a plurality of different circumferential positions for engagement with the steering device to selectively pivot the steering sleeve and the second shaft with respect to the main shaft, each actuator comprising a loose element slidably mounted in a piston sleeve oriented to allow the loose element to act against the steering sleeve when sufficient pressure is applied to the loose element within the piston sleeve, a subset of the plurality of actuators mounted at a given circumferential position being actuatable while others of the plurality of actuators mounted at the given circumferential position remain un-actuated.

2. The system as recited in claim 1, wherein each actuator comprises a plurality of balls, each of the plurality of balls slidably mounted in a corresponding piston sleeve.

3. The system as recited in claim 2, wherein the plurality of actuators comprises at least three actuators circumferentially spaced around the main shaft and within the steering sleeve.

4. The system as recited in claim 3, further comprising a valve located to control flow of pressurized drilling mud to the plurality of actuators.

5. The system as recited in claim 3, wherein the loose elements are substantially spherical balls and the plurality of substantially spherical balls provides rolling contact with an internal surface of the steering sleeve.

6. The system as recited in claim 2, wherein certain balls of the plurality of balls have different diameters with respect to each other.

7. The system as recited in claim 1, wherein the steering sleeve comprises at least one surface profiled to receive the loose element in a manner that reduces contact stress during pivoting of the steering sleeve.

8. The system as recited in claim 1, wherein the piston sleeve is oriented at a non-perpendicular angle with respect to the steering sleeve.

9. The system as recited in claim 1, wherein the piston sleeve changes in cross-sectional area along its length to vary clearance between the loose element and the piston sleeve.

10. The system as recited in claim 1, further comprising a sensor positioned to monitor a position of the loose element in the piston sleeve.

11. A method for drilling a borehole, comprising: preparing a directional drilling system with a main shaft pivotably coupled to a second shaft by a pivot point; coupling a plurality of actuators into the directional drilling system with each actuator comprising a ball slidably mounted in a sleeve; orienting each sleeve such that controlled movement of the ball along the sleeve causes the second shaft to pivot about the pivot joint with respect to the main shaft; positioning a sensor along each sleeve to directly monitor a position of the ball along the sleeve; connecting a steering sleeve to the second shaft, wherein coupling comprises mounting the plurality of actuators between the main shaft and the steering sleeve at spaced circumferential positions around the main shaft; and forming at least one recess along an internal surface of the steering sleeve to receive at least one ball in a manner that reduces contact stress.

12. The method as recited in claim 11, further comprising forming each actuator with a plurality of balls, each of the plurality of balls slidably positioned in a plurality of corresponding sleeves.

13. The method as recited in claim 12, further comprising controlling movement of the ball against an interior surface of the steering sleeve by selectively applying pressurized drilling mud to each actuator in a sequential manner to maintain a desired angle of drilling during rotation of the drill bit shaft.

14. The method as recited in claim 13, further comprising coupling a drill bit to the second shaft and rotating the drill bit to drill a wellbore.

15. The method as recited in claim 11, wherein coupling comprises positioning the plurality of actuators above the pivot joint.

16. The method as recited in claim 11, wherein coupling comprises positioning the plurality of actuators below the pivot joint.

17. The method as recited in claim 11, wherein orienting comprises orienting each sleeve such that movement of each ball along a corresponding sleeve enables each ball to act against at least one of the main shaft and the second shaft.

18. The method as recited in claim 11, further comprising moving each ball with a pressurized drilling mud and controlling the flow of drilling mud with a computer-controlled valve of a flow control system.

19. The method as recited in claim 11, further comprising providing each ball with a shape that corresponds with a profile along an interior of the steering sleeve.

20. A method of drilling a wellbore, comprising: coupling a directional drilling system to a drill string, wherein the directional drilling system comprises a main shaft pivotally coupled to a drill bit shaft; steering the rotary steerable system by selectively directing drilling mud to a plurality of ball actuators positioned within a steering sleeve coupled to the drill bit shaft of the directional drilling system; each ball actuator comprising a ball moved within a corresponding ball sleeve by an actuating fluid to enable the ball to apply a force; operating the directional drilling system to drill a deviated wellbore; and changing the force which can be applied by the ball as the ball travels along the ball sleeve.

21. The method as recited in claim 20, wherein steering comprises using a mud valve to selectively direct drilling mud under pressure to selected ball actuators and against a plurality of balls such that movement of the balls causing pivoting of the steering sleeve and the drill bit shaft to a desired drilling direction.

22. The method as recited in claim 20, further comprising pivotably coupling the drill bit shaft to the main shaft via a universal joint.