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- (54) Title: SAFETY VALVE WITH ELECTRICAL ACTUATOR AND TUBING PRESSURE BALANCING

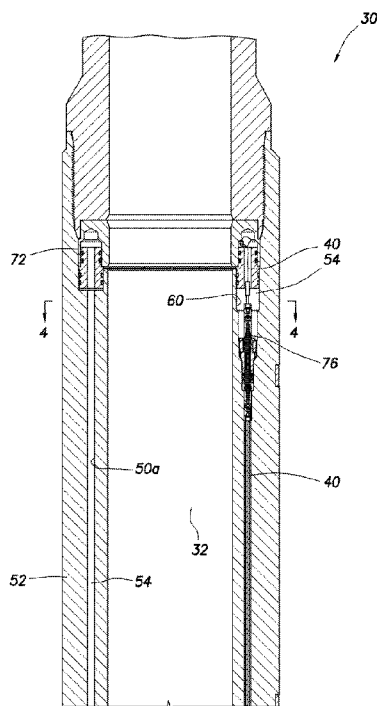


FIG. 2A

(57) Abstract: A well tool for use with a subterranean well can include a flow passage extending longitudinally through the well tool, an internal chamber containing a dielectric fluid, and a flow path which alternates direction, and which provides pressure communication between the internal chamber and the flow passage. A method of controlling operation of a well tool can include actuating an actuator positioned in an internal chamber of the well tool, a dielectric fluid being disposed in the chamber, and the chamber being pressure balanced with a flow passage extending longitudinally through the well tool, and varying the actuating, based on measurements made by at least one sensor of the well tool.



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LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE,
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AMENDED CLAIMS

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1. A well tool for use with a subterranean well, the well tool comprising:

5 a flow passage extending longitudinally through the well tool;

an internal chamber containing a dielectric fluid; and

a flow path which alternates direction, and which provides pressure communication between the internal chamber
10 and the flow passage.

2. The well tool of claim 1, further comprising a floating piston in the flow path, and wherein the floating piston prevents the dielectric fluid from flowing into the
15 flow passage.

3. The well tool of claim 2, wherein the floating piston is positioned in an enlarged section of the flow path.

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4. The well tool of claim 1, further comprising an electrical actuator in the dielectric fluid.

5. The well tool of claim 4, wherein the actuator
25 displaces a pressure transmission device which isolates the chamber from the flow passage.

6. The well tool of claim 5, wherein the pressure transmission device comprises a bellows.

7. The well tool of claim 5, wherein the pressure transmission device comprises a piston.

5 8. The well tool of claim 1, wherein the chamber is in fluid communication with a source of the dielectric fluid via a conduit extending to a remote location, and wherein a line extends through the conduit to an actuator in the chamber.

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9. The well tool of claim 1, wherein the chamber is in fluid communication with a source of chemical treatment fluid via a conduit extending to a remote location, and wherein a line extends through the conduit to an actuator in
15 the chamber.

10. The well tool of claim 1, further comprising a pressure relief device, and wherein the pressure relief device permits the dielectric fluid to flow into the flow
20 passage in response to pressure in the chamber exceeding a predetermined pressure level.

11. The well tool of claim 1, further comprising an actuator in the dielectric fluid, and a force sensor which
25 senses a force applied by the actuator.

12. The well tool of claim 11, wherein the force applied by the actuator is controlled, based on measurements made by the force sensor.

13. The well tool of claim 1, further comprising an actuator in the dielectric fluid, and wherein a force output by the actuator varies, based on a displacement of an operating member of the well tool by the actuator.

14. The well tool of claim 13, further comprising a displacement sensor which senses the displacement of the operating member.

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15. The well tool of claim 13, wherein the displacement of the operating member causes displacement of a closure member which selectively permits and prevents flow through the flow passage.

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16. The well tool of claim 15, wherein the displacement of the operating member actuates an equalizing valve which equalizes pressure across the closure member.

17. The well tool of claim 1, further comprising at least one of the group comprising temperature, force, pressure, position, and vibration sensors in the dielectric fluid.

18. The well tool of claim 17, wherein at least one of the sensors and an electronic circuit are disposed in an enclosure isolated from pressure in the chamber.

19. A method of controlling operation of a well tool,
the method comprising:

actuating an actuator positioned in an internal chamber
of the well tool, a dielectric fluid being disposed in the
5 chamber, and the chamber being pressure balanced with a flow
passage extending longitudinally through the well tool; and

varying the actuating, based on measurements made by at
least one sensor of the well tool.

10 20. The method of claim 19, wherein the actuating
further comprises the actuator displacing an operating
member, and wherein the sensor senses displacement of the
operating member.

15 21. The method of claim 20, wherein the varying
comprises changing a speed of the displacement, based on the
sensed displacement of the operating member.

22. The method of claim 20, wherein the varying
20 comprises changing a force output by the actuator, based on
the sensed displacement of the operating member.

23. The method of claim 20, wherein the varying
comprises changing a torque output by the actuator, based on
25 the sensed displacement of the operating member.

24. The method of claim 19, wherein the varying
comprises varying a frequency of electrical pulses
transmitted to the actuator.

25. The method of claim 19, wherein the varying comprises closing a closure member, in response to the sensor sensing that a force output by the actuator exceeds a predetermined maximum force level.

26. The method of claim 19, wherein the varying comprises ceasing displacement of an operating member, and then resuming displacement of the operating member.

27. The method of claim 26, wherein the ceasing displacement is performed when the actuator has displaced the operating member to an equalizing position, in which pressure is equalized across a closure member.

28. The method of claim 27, wherein the resuming displacement is performed when the pressure has equalized across the closure member.

29. The method of claim 27, wherein the resuming is performed in response to a predetermined period of time elapsing from the operating member being displaced to the equalizing position.

30. The method of claim 19, wherein the well tool comprises a safety valve, and wherein the actuator causes a closure member to be alternately opened and closed to thereby respectively permit and prevent flow through the flow passage.

31. A safety valve for use in a subterranean well, the safety valve comprising:

a flow passage extending longitudinally through the safety valve;

5 an internal chamber containing a dielectric fluid;

a flow path which alternates direction, and which provides pressure communication between the internal chamber and the flow passage;

an actuator exposed to the dielectric fluid;

10 an operating member; and

a closure member having open and closed positions, in which the closure member respectively permits and prevents flow through the flow passage,

wherein the actuator displaces the operating member,
15 which causes displacement of the closure member between its open and closed positions.

32. The safety valve of claim 31, further comprising a floating piston in the flow path, and wherein the floating
20 piston prevents the dielectric fluid from flowing into the flow passage.

33. The safety valve of claim 32, wherein the floating piston is positioned in an enlarged section of the flow
25 path.

34. The safety valve of claim 31, wherein the actuator comprises an electrical actuator.

35. The safety valve of claim 31, wherein the actuator displaces a pressure transmission device which isolates the chamber from the flow passage.

5 36. The safety valve of claim 35, wherein the pressure transmission device comprises a bellows.

37. The safety valve of claim 35, wherein the pressure transmission device comprises a piston.

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38. The safety valve of claim 31, wherein the chamber is in fluid communication with a source of the dielectric fluid via a conduit extending to a remote location, and wherein a line extends through the conduit to the actuator.

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39. The safety valve of claim 31, wherein the chamber is in fluid communication with a source of chemical treatment fluid via a conduit extending to a remote location, and wherein a line extends through the conduit to
20 the actuator.

40. The safety valve of claim 31, further comprising a pressure relief device, and wherein the pressure relief device permits the dielectric fluid to flow into the flow
25 passage in response to pressure in the chamber exceeding a predetermined pressure level.

41. The safety valve of claim 31, further comprising a force sensor which senses a force applied by the actuator.

42. The safety valve of claim 41, wherein the force applied by the actuator is controlled, based on measurements made by the force sensor.

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43. The safety valve of claim 31, wherein a force output by the actuator varies, based on a displacement of the operating member by the actuator.

10 44. The safety valve of claim 43, further comprising a displacement sensor which senses the displacement of the operating member.

15 45. The safety valve of claim 43, wherein the displacement of the operating member actuates an equalizing valve which equalizes pressure across the closure member.

20 46. The safety valve of claim 31, further comprising at least one of the group comprising temperature, force, pressure, position, and vibration sensors in the dielectric fluid.

25 47. The safety valve of claim 46, wherein at least one of the sensors and an electronic circuit are disposed in an enclosure isolated from pressure in the chamber.