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(54) **REMOTELY CONTROLLABLE WELLBORE VALVE SYSTEM**

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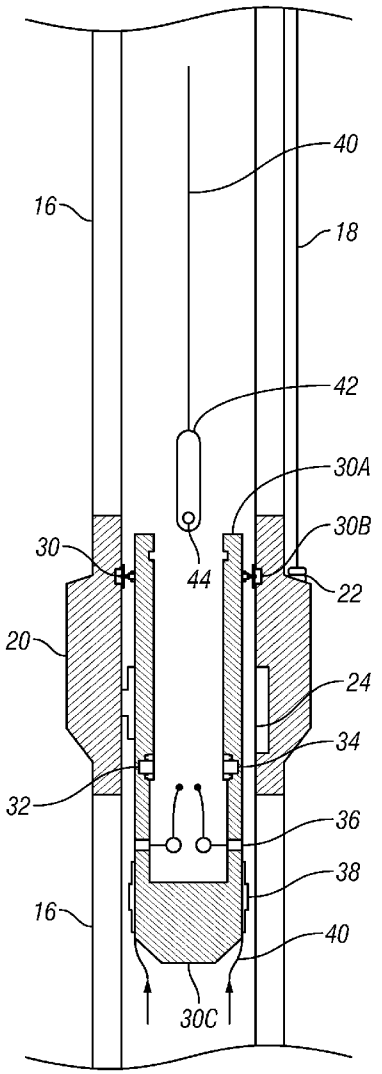
(57) **ABSTRACT**

A remotely operable wellbore valve system includes a valve configured to be coupled to a wellbore conduit and to selectively close the conduit. The valve is disposed in a valve body configured to open an existing wellbore valve by longitudinal motion therethrough and to sealingly engage an interior of the existing wellbore valve. The system includes a valve actuator and a signal receiver in communication with the valve actuator. The signal receiver is configured to detect command signals transmitted from the Earth's surface and to cause the actuator to operate the valve in response to the detected command signals.



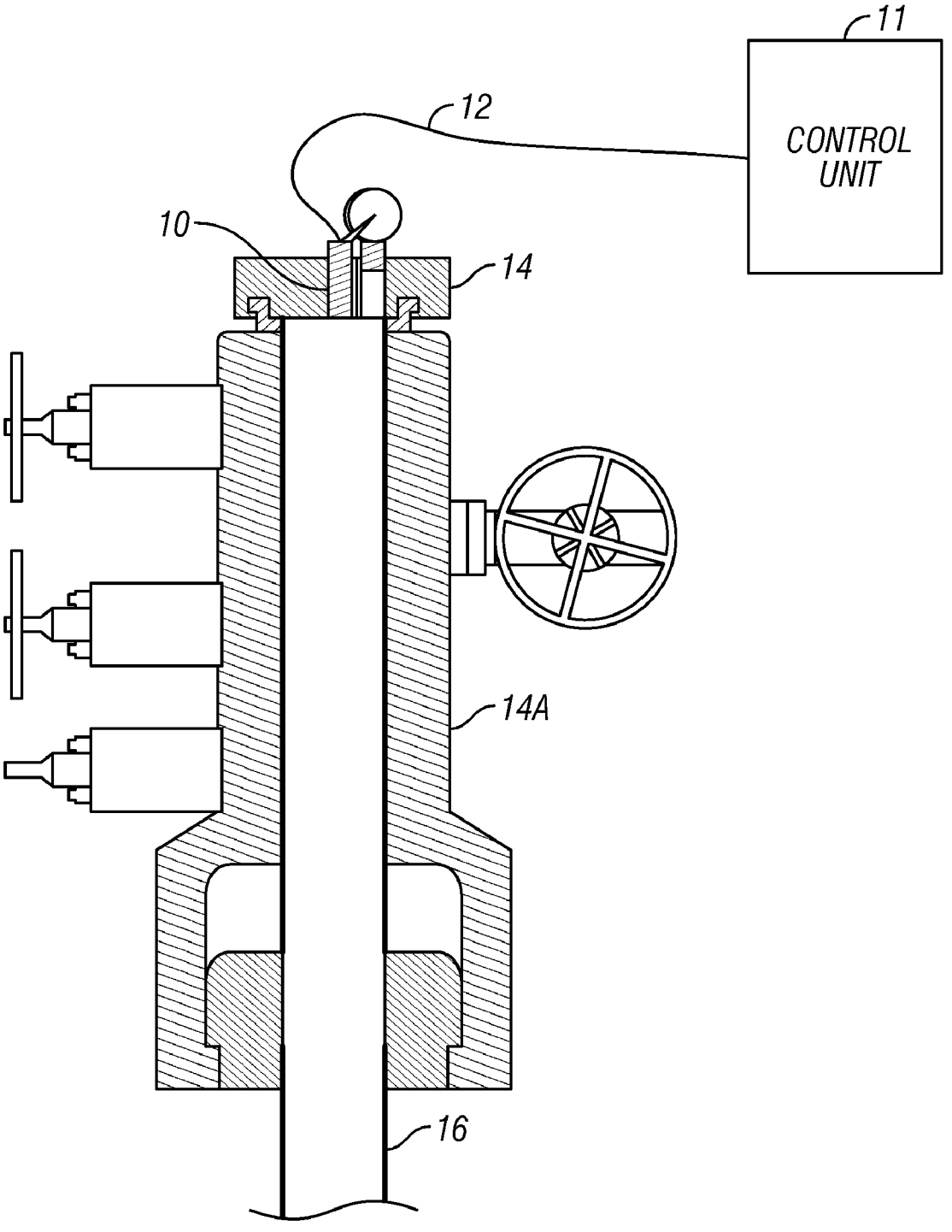


FIG. 1

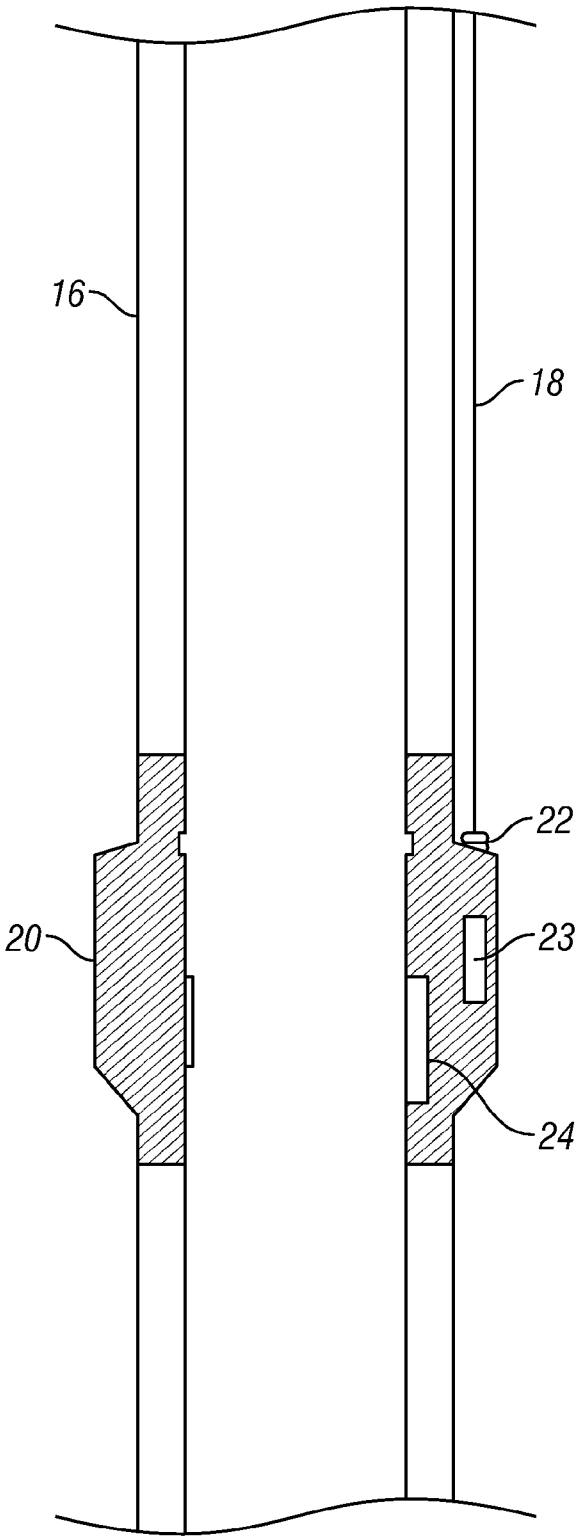


FIG. 2
(Prior Art)

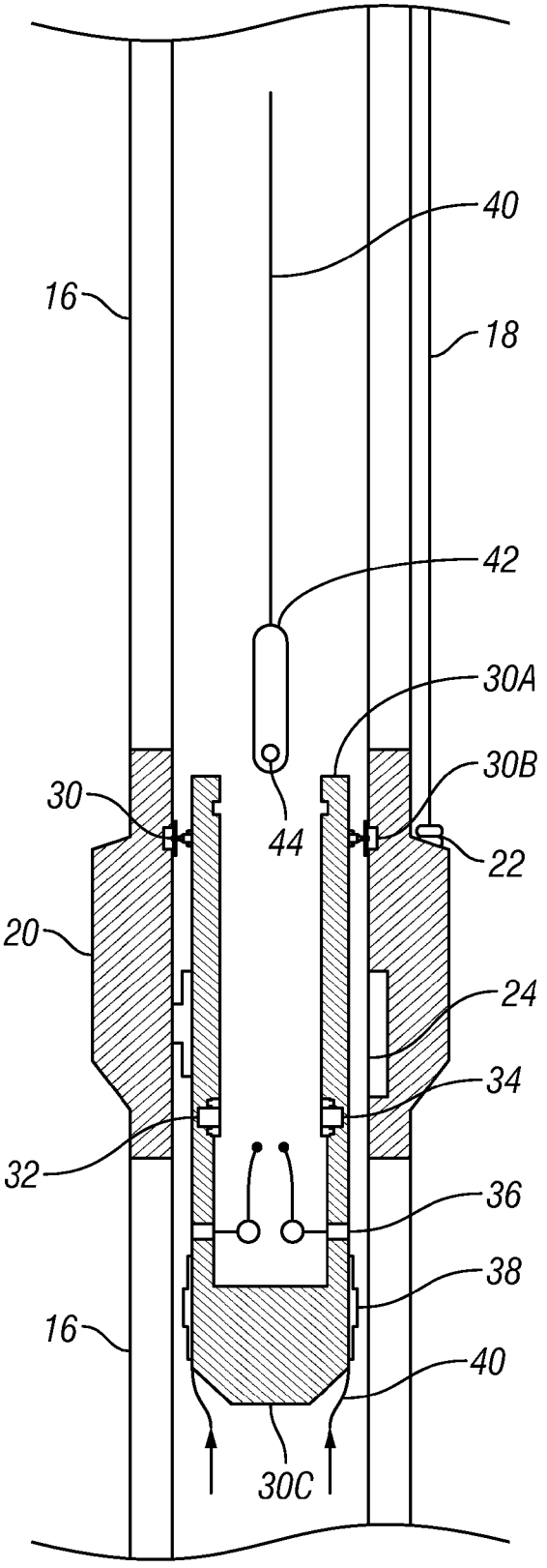


FIG. 3

REMOTELY CONTROLLABLE WELLBORE VALVE SYSTEM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Priority is claimed from U.S. Provisional Application No. 60/977,687 filed on Oct. 5, 2007.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable.

BACKGROUND OF THE INVENTION

[0003] 1. Field of the Invention

[0004] The invention relates generally to the field of wellbore safety and control valves.

[0005] More specifically, the invention relates to wellbore safety and control valves that can be installed in a failed wellbore valve and operated remotely.

[0006] 2. Background Art

[0007] Wellbore valves, such as subsurface safety valves, are used for controlling flow within a well tubing string suspended within a wellbore. Typically, valves of this type include a valve member that is pivotally or rotatably mounted within the bore of a tubular body disposed within the well tubing string for movement between open and closed positions. The valve member is urged by a spring to its closed position, but is typically arranged to be moved to the open position in response to the supply of hydraulic fluid pressure from a remote source at the Earth's surface. The hydraulic fluid pressure acts on a piston forming part of or associated with the valve member. Ordinarily, the valve member is arranged to close automatically under the force of the spring in response to the exhaust of such hydraulic fluid pressure, for example, in the event of failure of a monitored condition in or about the well.

[0008] Other types of valves may be remotely operable, such as by applying pressure signals to a fluid annulus between a wellbore casing and a coaxial tubing string. Such valves are described, for example, in U.S. Pat. No. 4,796,699 issued to Upchruch et al. and include a power supply associated with a valve operator proximate the valve in the wellbore, a signal receiver and a controller that causes the valve operator to open or close the valve in response to signals transmitted from the surface.

[0009] Many such valves are tubing safety valves wherein the body of the valve is disposed within the well tubing string for controlling flow therethrough. Such valves may be of a type in which the valve body is retrievable from within the tubing string, or in which the body is connected as part of the tubing string, i.e., tubing mounted. Typically, such a valve is a flapper pivotally mounted in the bore of the valve body and arranged to be moved to the open position by a flow tube with which an hydraulic piston cooperates to move the flow tube within the bore. Thus, the supply of hydraulic fluid pressure lowers the flow tube to force the flapper to the open position. A spring opposingly acts on the piston to raise the flow tube and thus permit the flapper to close upon the exhaust of hydraulic fluid pressure on the piston.

[0010] U.S. Pat. No. 3,799,258 shows a typical tubing mounted valve of this type wherein the piston is an annular piston disposed about the flow tube within an annular pressure chamber between the flow tube and valve body. The piston urged to its closed position, enabling the flapper to close, by means of a coil spring compressed between the valve body and the flow tube. However, when valves of this type are installed at great depths, it is difficult for a coil or similar metal spring of acceptable size and strength to overcome the hydrostatic head of the hydraulic fluid in the control line leading to the pressure chamber, and thus raise the flow tube to permit the flapper to close.

[0011] In the event of failure of the control line and/or the valve actuator, the valve will close. Valve closure causes the well to cease producing fluid until which time the well can be repaired. Such loss of production can be costly. Further, repairing a failed wellbore valve in a well that is capable of producing fluid is difficult and expensive Typically the well must be "killed" by pumping fluid having sufficient density to cause the producing subsurface formations to stop moving fluid into the wellbore, or a "snubbing unit" or similar device must be used that enables the wellbore production tubing to be removed while the wellbore has substantial pressure at the surface.

[0012] There exists a need for a replacement and/or repair valve that can be inserted into a defective valve body and operated remotely.

SUMMARY OF THE INVENTION

[0013] A remotely operable wellbore valve system according to one aspect of the invention includes a valve configured to be coupled to a wellbore conduit and to selectively close the conduit. The valve is disposed in a valve body configured to open an existing wellbore valve by longitudinal motion therethrough and to sealingly engage an interior of the existing wellbore valve. The system includes a valve actuator and a signal receiver in communication with the valve actuator. The signal receiver is configured to detect command signals transmitted from the Earth's surface and to cause the actuator to operate the valve in response to the detected command signals

[0014] Other aspects and advantages of the invention will be apparent from the following description and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. **1** shows a surface (wellhead) control system for a remotely operable wellbore valve.

[0016] FIG. **2** shows a typical prior art hydraulically operated wellbore valve.

[0017] FIG. **3** shows one example of a wellbore valve system according to the invention.

DETAILED DESCRIPTION

[0018] U.S. Pat. No. 6,899,178 issued to Tubel et al. discloses an acoustic wireless communication device for transmitting signals from a wellbore to the Earth's surface. The principle of the device disclosed in the Tubel et al. '178 patent may be used to transmit control signals from the Earth's surface to a valve controller disposed in the wellbore. The acoustic based wireless communication device is able to transmit data to the surface through the wellbore tubing string, while also transmitting data through the fluids in the wellbore.

[0019] An example of a system used to transmit command or control signals from a wellhead (typically at the Earth's surface) is shown in FIG. **1**. A "tree cap" **14**, which may be a threaded coupling affixable to the top of a conventional well-

head system **14**A ("christmas tree"), includes a wireless signal transducer **10** such as an acoustic transducer. The signal transducer receives electrical signals over a cable **12** in electrical communication with a control unit **11**. The control unit **11** may include a programmable computer (not shown separately) and suitable transducer drivers (not shown separately) configured to impart signals to the transducer **10** so that the transducer **10** wirelessly transmits control commands to a valve system (FIG. **3**) disposed in the wellbore.

[0020] A wireless receiver or transceiver unit (see FIG. **3**) disposed in the wellbore can receive acoustic commands such as may be transmitted from the device shown in FIG. **1**. Such commands can be of appropriate character, depending on the particular application for the communication system. In the present example, and as will be further explained with reference to FIG. **3**, the commands sent by the wireless communication system from the surface may include commands to open, maintain open or close a valve inserted into the wellbore. In addition to or in substitution of the wireless signal communication system shown in FIG. **1**, other methods of signal communication such as a communication/system interrogation sonde may be inserted into the wellbore device for control and/or diagnostic purposes, and such will be explained in more detail below with reference to FIG. **3**. One method for inserting such a sonde would be at the end of armored electrical cable (wireline). See, e.g., U.S. Pat. No. 4,806,928 issued to Veneruso.

[0021] Using any of the foregoing devices, for example, other commands that can be sent from the surface to a device in the wellbore include commands to maintain power supply to a device, shut off power supply to a device, regulate power levels in the device, transmit diagnostics, etc. The receiver portion of the wireless system or a wireline device can be hung off in the wellbore using standard type wireline locks landed in landing nipples, or hung off by a slips type arrangement.

[0022] In one example the wellbore device is a remotely controllable wellbore valve that can be used to temporarily, or permanently, replace the function of a hydraulically operated subsurface safety valve. Referring to FIG. **2**, a typical hydraulically actuated wellbore valve is shown. The valve **20**, which may be a subsurface safety valve, is coupled within a production tubing **16**. The production tubing **16** extends inside the wellbore to the wellhead system (**14**A in FIG. **1**) and provides a conduit for fluids to move from selected subsurface formations to the surface. The valve **20** includes features an hydraulic line connection **22** coupled to an hydraulic control line **18** extending to the surface. The hydraulic line connection **22** conducts hydraulic fluid to an actuator **23**. When pressurized, the actuator **23** provides force to overcome a spring (not shown) which ordinarily maintains a flapper **24** in a closed position (transverse to the cross section of the tubing **16**). Thus, the actuator **23** opens the valve flapper **24**. As explained in the Background section herein, failure of the actuator **23** may cause the flapper **24** to remain closed, thus requiring extensive well workover operations to replace the defective actuator and/or flapper.

[0023] FIG. **3** shows an example remotely operable valve system **30** intended to be inserted into the wellbore and "landed" in the defective hydraulically operated valve **20**. The example valve system **30** can be inserted into the wellbore using, for example, armored electrical cable ("wireline") or tubing conveyance. When the valve system **30** is moved through the defective hydraulically operated valve **20**, the body **30**A of the example valve will move the flapper **24** of the defective valve **20** to open. The valve body **30**A may include landing nipples **30**B to engage a nipple profile (not shown) in the defective valve **20**. The valve body **30**A may be sealingly engaged to the defective valve **20** using O-rings or other suitable sealing elements **30**B.

[0024] A lower end **30**C of the valve body **30**A may be suitably shaped to cause the flapper **24** to open. Flow ports **36** may be provided at a selected position along the length of the valve body **30**A to enable fluid flow through the upper part of the valve body **30**A while maintaining a suitably sealed enclosure for batteries and control electronics **38**. Such electronics **38** may include an acoustic transducer (not shown separately) for receiving acoustic commands from the system at the surface, or, alternatively, may include an acoustic or electromagnetic transducer for communication with a sonde **42** moved through the tubing **16** using an armored electrical cable **40**. A corresponding transducer **44** in the sonde **42** may provide one or two way signal communication between the sonde **42** and the valve system **30**.

[0025] A valve flapper **34** is disposed in the valve body **30**A such that upon receipt of a suitable command or otherwise as will be further explained, the electronics **38** will cause an actuator (not shown) to open or close the flapper **34**.

[0026] The wireless communication system explained above with reference to FIG. **1** may be configured to transmit command signals to the valve system **30**. The valve system electronics **38** may be configured to receive commands from the surface system (see FIG. **1**) and generate a signal that operates the flapper **34**. The flapper **34** is only one example of a valve which can be used with a valve system according to the invention. Other types of valve, for example, a ball valve or a sliding sleeve valve may be used in other examples, and the illustrated flapper is not intended to limit the scope of the invention. The valve system **30** should also include a "fail safe" feature, e.g., a spring (not shown) which causes the flapper **34** or other valve to automatically close in the event of actuator fault or failure. The valve system **30** may also transmit or store in a local recording device (not shown separately) certain information that can be communicated to the surface in response to surface-sent commands.

[0027] Referring again to FIG. **1**, control unit **11** may be programmed to send commands to the valve system (**30** in FIG. **3**), which could include, for example, "maintain valve in open position", "open valve" or "close valve." As mentioned above, an auxiliary wireline communication sonde (**42** in FIG. **3**) may be lowered into the tubing **16** to enable communication with the valve system.

[0028] Example command configurations and valve system responses may include one or more of the following. When the valve system is in the open position, a "maintain valve in open position" signal can be transmitted to the system from the surface at selected time intervals, e.g., every 15 seconds. If the downhole valve system electronics (**38** in FIG. **3**) does not detect the maintain valve open command within the predetermine time, the electronics could be programmed so that after a selected delay (e.g., 5 seconds) the valve would automatically be closes. After such closing, the valve would remain closed, and the system electronics would wait for detection of an "open valve" command from the surface (via wireless or using the sonde). The electronics (**38** in FIG. **1**) could scan for the open valve command at predetermined intervals, e.g., every 30 seconds.

[0029] A possible advantage of a valve system configured as explained above is that if an accident occurs at the surface, or there is external electrical power failure or a failure within the wireless valve control unit (**11** in FIG. **1**) the downhole valve would not receive the "maintain valve in open position" command within the predetermined time intervals. The downhole valve would therefore automatically close. The valve will be opened only upon receipt of the appropriate command fin the surface, as previously explained.

[0030] A valve system according to the above description can be retrofitted into wellbores where an hydraulically or electrically operated valve does not function due to failure in the control line or cable from the wellhead to the valve. It is also possible to install the wireless valve system as a primary subsurface safety valve in new wells.

[0031] While the invention has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments can be devised which do not depart from the scope of the invention as disclosed herein. Accordingly, the scope of the invention should be limited only by the attached claims.

What is claimed is:

1. A remotely operable wellbore valve system, comprising:

a valve configured to be coupled to a wellbore conduit and to selectively close the conduit, the valve disposed in a valve body configured to open an existing wellbore valve by longitudinal motion therethrough, the valve body configured to sealingly engage an interior of the existing wellbore valve;

a valve actuator; and

a signal receiver in communication with the valve actuator, the signal receiver configured to detect command signals transmitted from the Earth's surface and to cause the actuator to operate the valve in response to detected command signals.

2. The system of claim **1** wherein the signal receiver is configured to detect acoustic signals transmitted through wellbore fluid inside the conduit.

3. The system of claim **1** wherein the signal receiver is configured to detect acoustic signals transmitted along wellbore conduit.

4. The system of claim **1** wherein the signal receiver is configured to detect signals transmitted from a sonde disposed in the wellbore at the end of an armored electrical cable.

5. The system of claim **1** wherein the signal receiver and the valve actuator are configured to maintain the valve in an open position upon detection of maintenance signals from the surface at selected time intervals, and to close the valve if the maintenance signals are not detected.

6. The system of claim **1** wherein the valve comprises a flapper.

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