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Parker et al.

[11] **3,901,315**

[45] **Aug. 26, 1975**

[54] **DOWNHOLE VALVE**

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[73] Assignee: **Del Norte Technology, Inc.**, Euless, Tex.

[22] Filed: **Apr. 11, 1974**

[21] Appl. No.: **460,031**

[52] **U.S. Cl.** ..... **166/224 A**; 137/461

[51] **Int. Cl.**[2] **E21B 43/12**; E21B 41/00

[58] **Field of Search** ..... 166/72, 224 A; 137/460, 137/461; 251/58

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Primary Examiner—James A. Leppink

[57] **ABSTRACT**

An elongated housing has a pair of displaced, but axially aligned bores communicating with oil well piping. Rolling between oppositely disposed ends of these housing bores is a ball valve, normally urged to a closed valve position by a predetermined spring bias. The ball rolls to an open valve position responsive to a suitable control signal. If the oil well pressure becomes excessive, suitable controls may be actuated to close the valve. The excessive pressure acts as a hydraulic ram to add to the spring force and to drive the ball into a closed valve position. Special seals guard the valve and associated equipment against damage from sand and other abrasives normally found in oil and other fluids issuing from oil wells.

7 Claims, 11 Drawing Figures

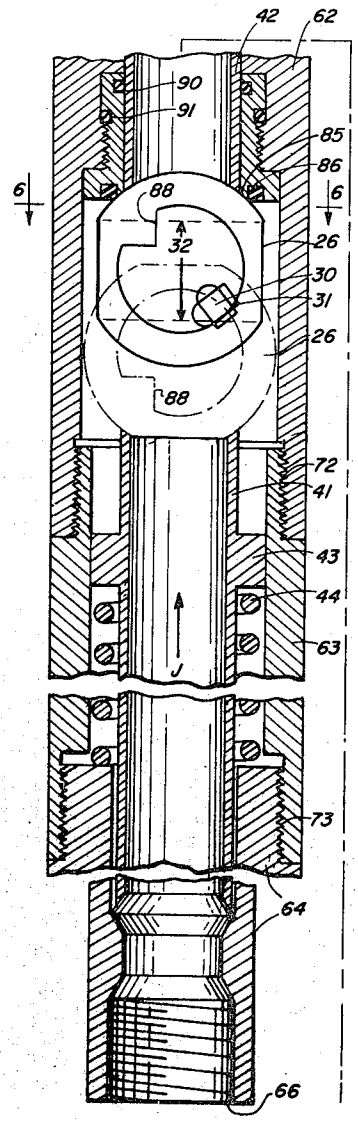


FIG - 1

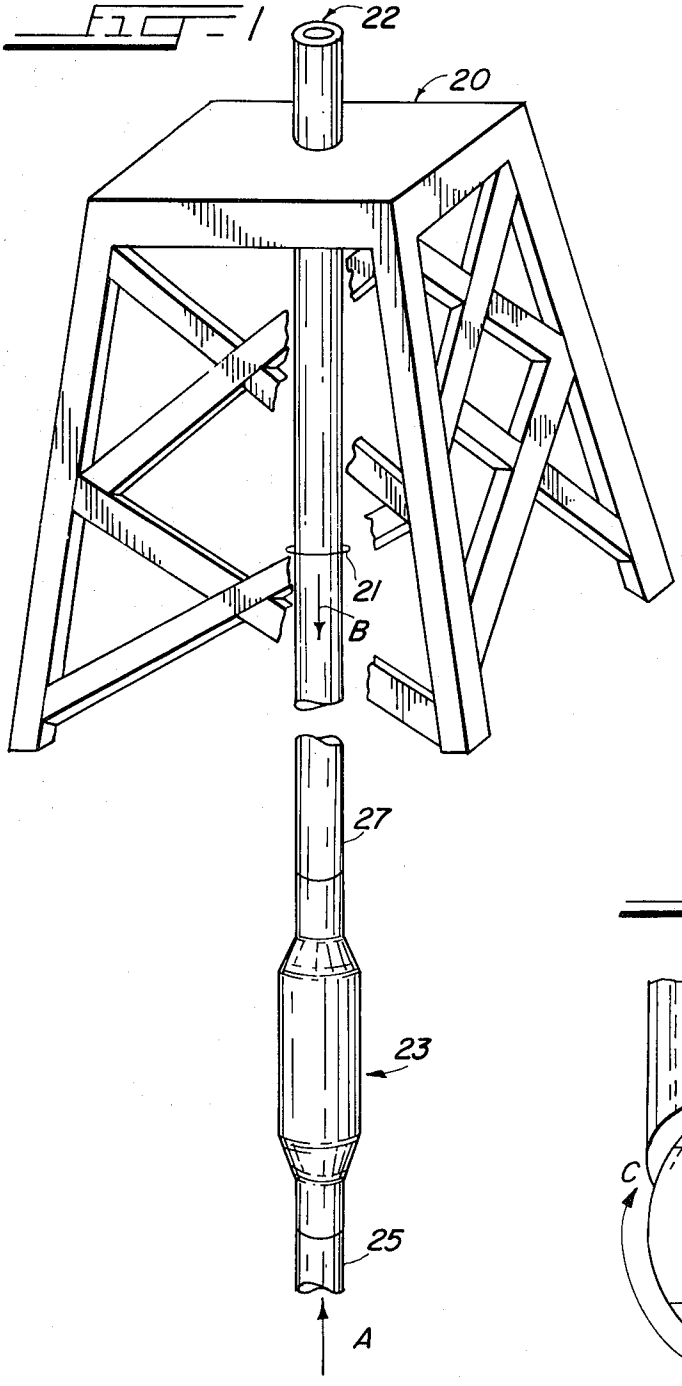


FIG - 2

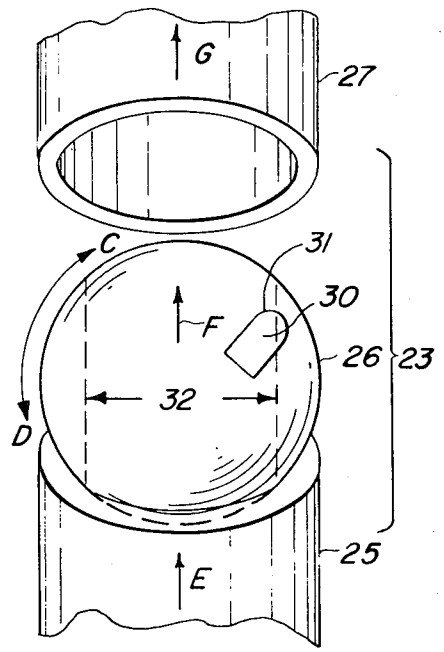


FIG - 3

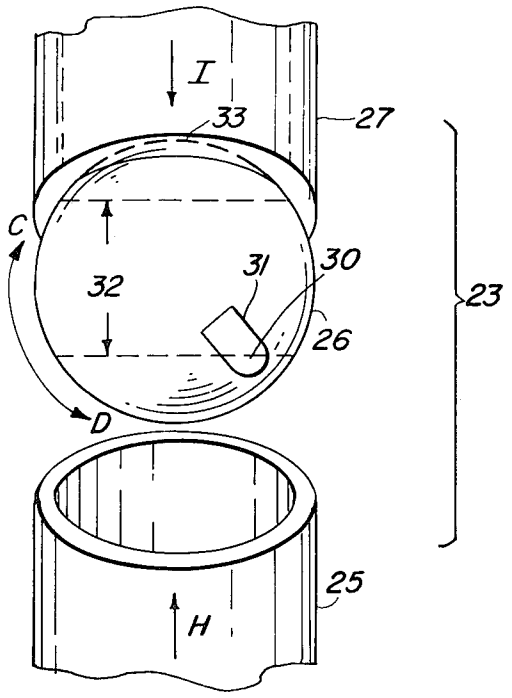


FIG. 4

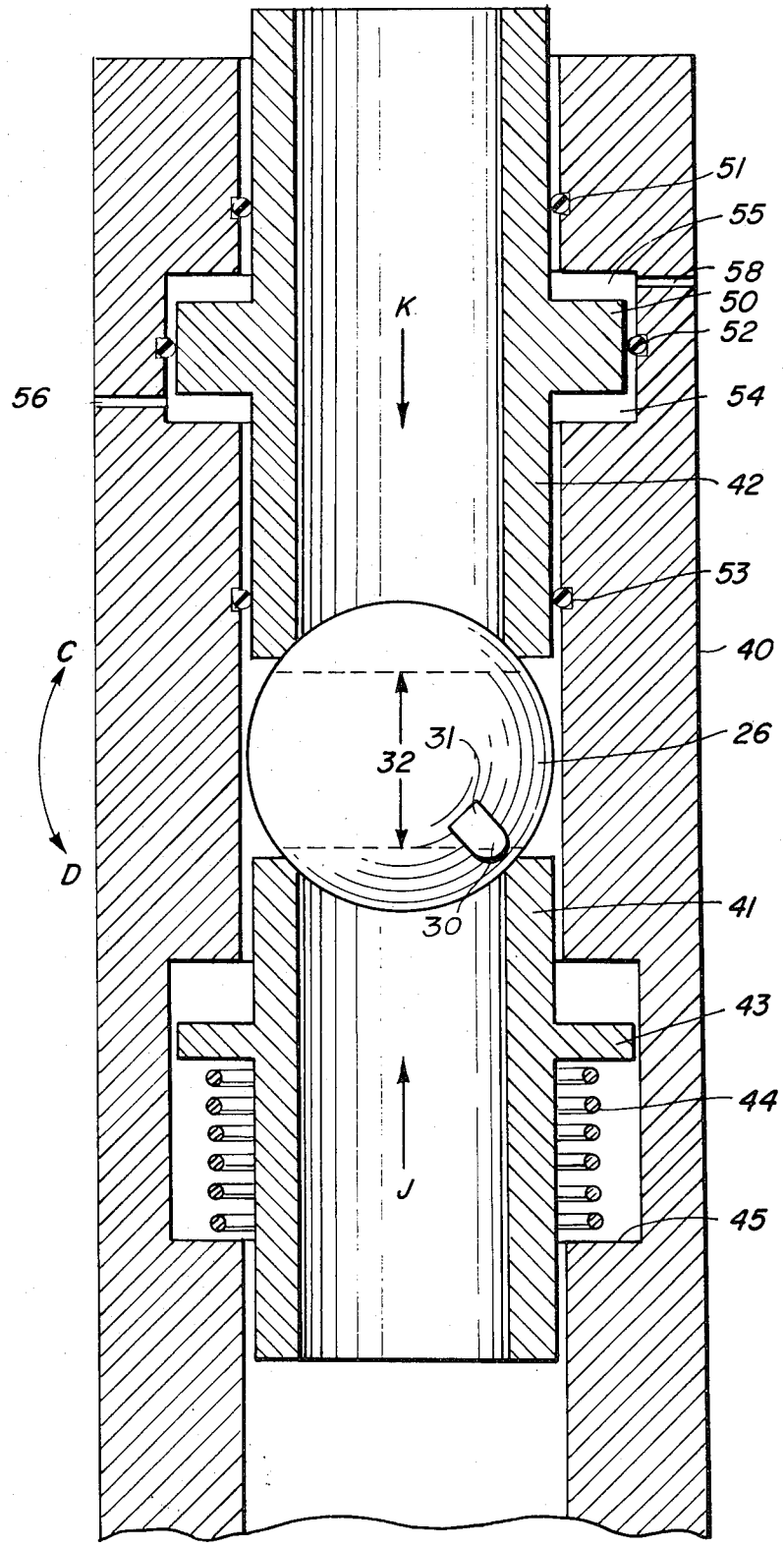


FIG- 5

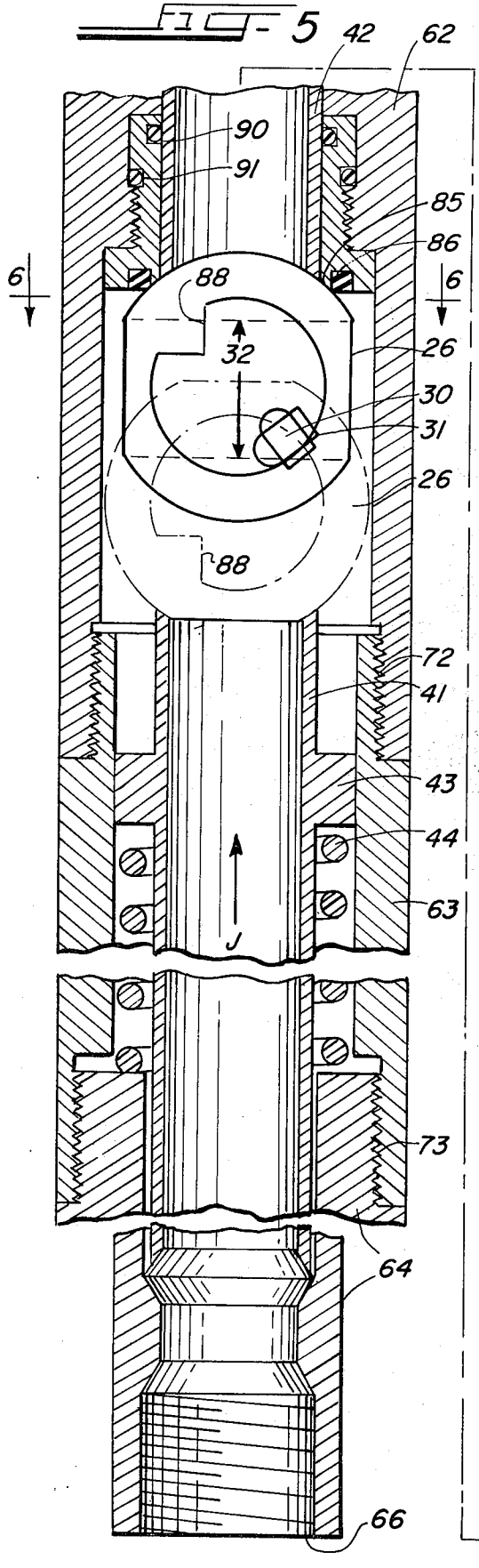

42
62
90
91
85
86
6
6
88
32
26
30
31
26
88
72
41
43
44
63
J
73
64
66

FIG- 5A

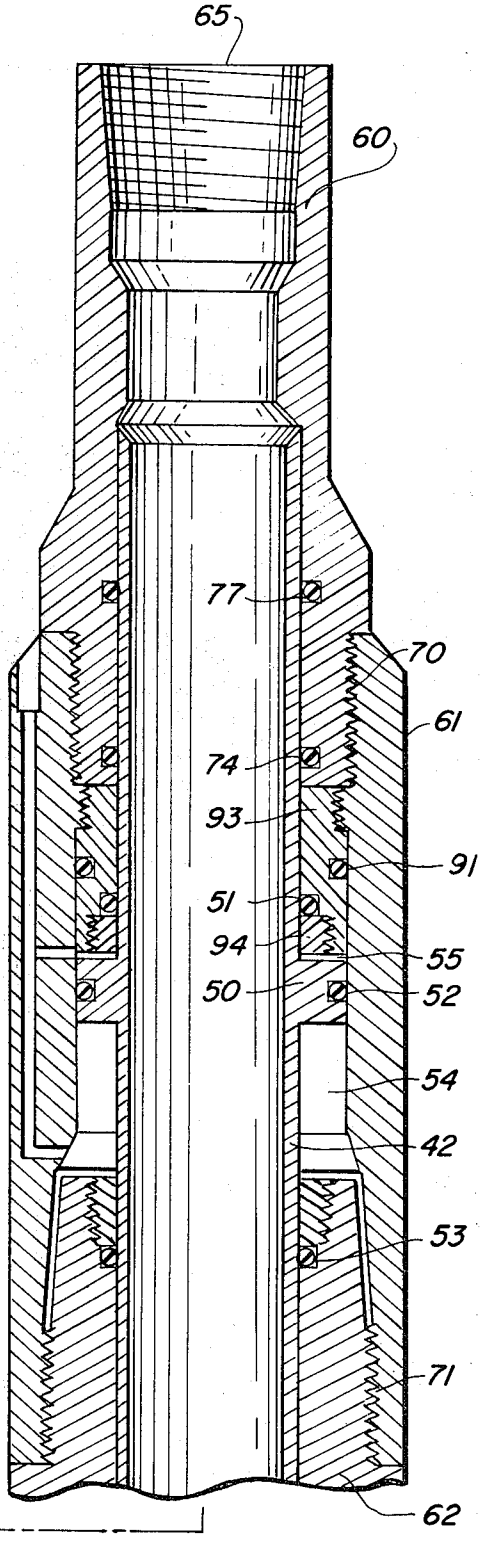

65
60
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70
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74
93
91
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94
55
50
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42
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71
62

FIG - 6

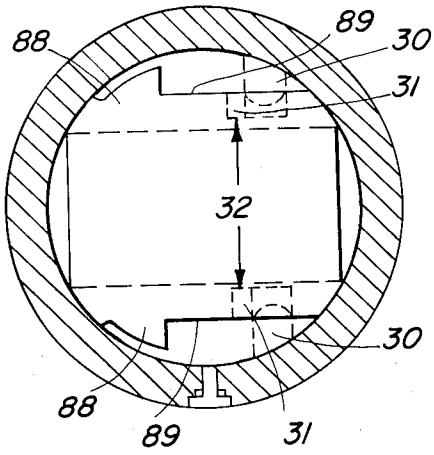


FIG - 7

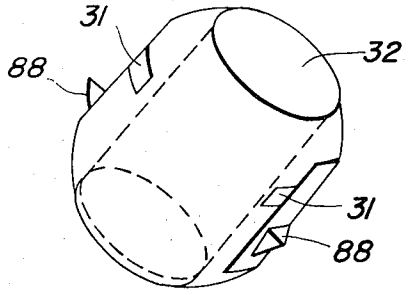


FIG - 10

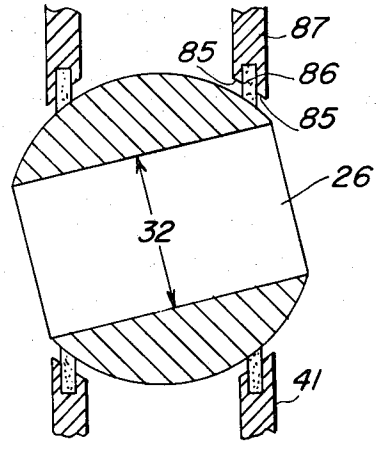


FIG - 8

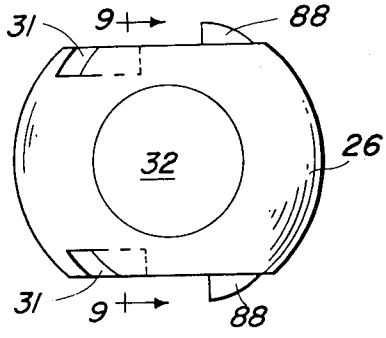
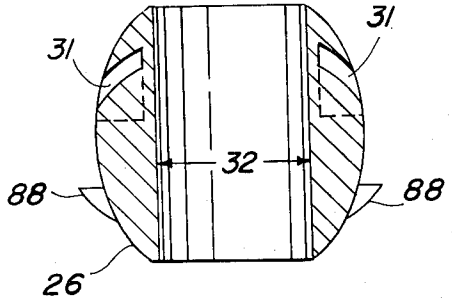


FIG - 9



DOWNHOLE VALVE

This invention relates to ball valves and more particularly to disaster valves for use downhole in oil wells, and especially for use in areas of severe abrasives.

The problem of providing means for controlling oil well flow has recently been a subject of great public concern. One reason for this concern is the widely publicized spills wherein oil wells leak into the ocean, for example. The crude oil escaping from the well flows over the ocean surface to contaminate beaches, kill wildlife, ruin private property, and provoke public outcry. One solution to these oil spill problems is to place a disaster valve over the mouth of the well, or in the tubing leading from the well. If there is a disaster or a runaway condition, the valve closes, and no oil or gas can thereafter leave the well.

The usual approach to a solution of disaster valve control is to extend a communication line or duct down the pipe to control the valve. The line or duct might be hydraulic, pneumatic, or electric. One trouble is that the same natural disaster (such as storm, fire, or the like) that causes the oil spill might also cause a failure in the control line. If so, the line or duct is very likely to be broken or otherwise rendered totally inoperative, responsive to the same disaster that broke the pipe leading to the spill. To overcome this problem, some systems have the line or duct placed inside the pipe or tube. However, the installation and removal of this type of line or duct is troublesome, it hinders cleanout, and it may become entangled in a manner which actually prevents the desired valve control.

While various structures have been provided to seal oil wells against blowouts, these structures face a common problem since sand, gravel, and other ambient environmental abrasives tend to damage the valve parts. These abrasives are particularly damaging to metal-to-metal surfaces. Sliding and rotating parts are quickly galled or scored. The valve soon loses its gastight sealing capacity.

This galling and scoring might not be too important if the valves were opened and closed often, or if they were not designed as blowout protection. Then, the progress of the deterioration could be observed and proper maintenance could be undertaken. However, when the valves are standing idle for long periods, and are essentially for emergency protection, and when the valves continuously operate in a sand slurry or other abrasive environment, it is not possible to accurately predict damage prior to valve operation. Thus, an emergency is likely to occur without adequate protection despite the appearance of a valid disaster valve protection.

Accordingly, there is a need for a fail sale disaster valve control system and a method of communicating to such a system at the bottom of an oil well. The system should function well even if the valve is remotely located, far down inside a borehole or deep under the sea. In this connection, the system should function well during emergencies despite long exposure, without interim operations, to hostile environments of sand slurry and other abrasive materials.

A system for so controlling oil well disaster valves is shown and described in a copending application entitled OIL AND GAS WELL DISASTER VALVE CONTROL SYSTEM, Ser. No. **294,289,** filed Oct. **2, 1972.** That system uses the oil well tubing itself as a communication line and, therefore, is as reliable as the tubing. The present invention relates to the mechanical structure of a mechanical disaster valve especially well suited to be controlled by the system shown in the above-identified copending application.

Accordingly, an object of this invention is to provide new and improved disaster valves for use downhole in oil wells. More particularly, an object is to provide a rotating ball valve for sealing such oil wells when well pressure becomes excessive. In particular, an object is to provide such a valve which enables an almost completely unimpeded passage of gas or fluid when open and which reliably seals the oil well when closed. Here, an object is to provide these and other objects despite long exposure of the valves to hostile environments of an extremely abrasive nature.

Still another object of this invention is to provide a fail safe disaster valve for insertion in series in the tubing of an oil well.

Yet another object is to provide a valve which may be forced open by using pump-down assistance (i.e., where oil is pumped back down the tubing at a pressure exceeding the oil well pressure).

In keeping with an aspect of this invention, these and other objects are accomplished by a valve having an elongated housing. A passageway through the housing comprises a pair of displaced but axially aligned bores separated by a discrete space. Oil well piping is connected to the opposite ends of the housing and communicates into each bore. Rolling between these housing bores is a ball valve normally urged to a closed position by a spring. The ball rolls to either an open or a closed position responsive to a suitable control signal sent down the well. If the oil well pressure becomes excessive, it acts as a hydraulic ram and adds to the spring force to drive the ball into a closed position. A special smooth surface bearing material is used to seal against the ball valve surface without galling and without leaving score marks. A number of redundant longitudinally displaced sealing rings are provided for the support and cleaning of sliding parts. Some of the sealing rings act as dirt and sand scrapers while the remaining sealing rings preserve their integrity.

The nature of a preferred embodiment for accomplishing these and other objects is shown in the attached drawings wherein:

FIG. **1** is a perspective view of an oil well tower and tubing incorporating the disaster valves;

FIGS. **2** and **3** schematically illustrate open and closed valve positions, respectively;

FIG. **4** schematically represents the inventive mechanism for selectively operating the ball valve;

FIG. **5** is a cross-sectional view of a practical housing incorporating the principles shown in FIGS. **2–4** (and FIG. **5A** is an extension of FIG. **5** which shows the complete valve when joined to the right-hand end of FIG. **5**);

FIG. **6** is a cross-sectional view of the ball valve and housing taken at line **6—6** of FIG. **5**;

FIG. **7** is a perspective view of the ball valve;

FIG. **8** is a plan view of the ball valve looking down onto the top of FIG. **7**;

FIG. **9** is a longitudinal sectional view taken along line **9—9** of FIG. **8**; and

FIG. **10** is a cross-sectional view of the inventive bearing surface for the ball valve.

The invention provides a disaster valve for use downhole in an oil well, or in a similar non-accessible environment. More particularly, FIG. 1 symbolically represents a tower 20 positioned over an oil well 21. Extending from the tower 20 and down into the oil well 21 is a tubing 22 for conveying oil from the well to any suitable tank, pipe, or container. Oil goes up the tubing 22, as indicated by the arrow A, and any signals for controlling the valve must be transmitted down the tubing in direction B.

As the well is drilled, drilling mud is used to facilitate the cutting and removing of down-well material. Later, during pumping, the oil flowing up the pipe is a mixture of almost anything which is fluid enough to be pumped. The mixture might include sand, gravel, rock chips, and the like. Thus, the valve 23 is continuously bathed in an abrasive slurry of ambient material.

If an accident occurs, the oil could gush forth, up the tube 22, and over the nearby land or water. This would use an environmental problem of polluted land or water. Therefore, it is desirable to provide disaster valve 23 which may be connected into the tubing 22 to prevent or stop the gushing flow of oil up the tube.

According to the invention, the valve 23 (FIGS. 2, 3) may include a ball valve 26 (see also FIGS. 7–9) which is rolled into a selected position by a balancing of forces acting upon the ball. When oil well pressure increases and becomes excessive, signals are sent to close the ball against a spring bias and causing the ball valve to roll to a closed position. If desired, the ball valve may be forced from the closed position and back to an open position by pumping oil down the tubing and into the well. The principle of this invention is schematically shown in FIGS. 2 and 3. In each of these figures, there is a tube 25 extending upwardly from the well to a ball valve 26, and a tube 27 extending from the valve upwardly to the tower 20 and thereafter to any suitable tank, pipe line or container.

The ball valve 26 is fixed in position by a pin in a slot, at the pivot point 30. There are a pair of pins embedded in the wall on opposite sides of the valve housings so that the ball valve may roll in either of the directions C or D. The pin may slide in a slot 31 in the ball. A central bore 32 extends through the ball 26.

It is important to note that the ball is not fixed to require purely rotational movement about any given pivot point. Rather, the ball floats freely with the pins moving in the slots in any manner of minimum force and resistance. Therefore, although the ball must move between the displaced longitudinal limits, it does not have to follow any specific path during its excursion between the opened and closed valve positions. Thus, there is no reason why the same score lines will be repeated each time that the valve moves. During one operation, the valve might have a sliding motion followed by a turning motion and during the next operation the valve might turn, then slide, and the next operation might be a pure turning or rotation.

In the open valve position, the ball 26 is fully rotated as far as it will go in direction D (FIG. 2), and the bore 32 of ball valve 26 is aligned with the passage through the oil well tubing 25, 27. Thus, oil or gas may flow freely, as indicated by arrows E–G. However, in the closed valve position, the ball valve 26 is fully rotated in direction C (FIG. 3), to a seated position. The ball valve bore 32 is now perpendicular to and not in communication with the passage through the tubing 25, 27. Instead, the unbroken ball side 33 seats itself on tubing 27 and acts as a stopper. Oil or gas pressure H, in tubing 25, is contained within the well and does not reach tubing 27.

Accordingly, if the well pressure acting on the ball valve 26 is not excessive, the valve is normally forced to the open valve position (FIG. 2). However, if the well pressure does become excessive (arrow H), the ball valve is forced into the closed position (FIG. 3). Thereafter, if it is necessary or desirable to force open the valve, oil or gas may be pumped back down the tubing 27 in direction I to overcome the excessive pressure H and thereby return the ball valve 26 from the closed position (FIG. 3) to the open position (FIG. 2).

One way of providing means for exerting the balanced forces is shown in a greatly simplified FIG. 4. Here again, the ball valve 26 is pivoted and rolled on pins secured to the inside walls of the valve housing at the pivot point 30. Again, these pins project into slots 31 formed in the ball, thereby enabling the ball to float, slide, or roll, as distinguished from a pure pivoting action. A cylindrical housing, sleeve, or casing 40 extends across the entire width or height of the possible ball valve movement.

Any mechanism required for applying the balanced forces to the ball is also contained within the housing 40. More particularly, inside the housing 40 are two slidingly disposed cylindrical or tubular rams or actuators 41, 42 for driving the ball in either of two opposite directions. Ram or actuator 41 has a shoulder 43 resting upon one end of a coiled spring 44. The other end of the coiled spring rests upon a housing ground point 45, at any suitable portion of the housing 40. Coiled spring 44 here rests on a shoulder 45 formed inside the tubing. Thus, the coiled spring 44 normally urges the ram or actuator 41 in direction J with a predetermined force established by the constants of spring 44.

The other ram or actuator 42 is controllable. More particularly, as here shown, actuator 42 is a cylindrical tube having an outwardly extending circumferential piston portion 50. Any suitable sealing means, such as O-rings 51–53 seal the actuator 42 against the walls of a cylinder formed inside the housing 40. Thus, two working chambers are formed on opposite sides of piston 50, one work chamber 54 is between O-rings 52, 53, and the other work chamber 55 is between O-rings 51, 52. A first port 56 is in communication with work chamber 54 and a second port 58 is in communication with work chamber 55. The ram or actuator 42 moves in direction K if a suitable medium such as a hydraulic fluid (for example) is pumped through port 58 and into work chamber 55 while the medium is drawn from work chamber 54 and out port 56. The spring loaded ram or actuator 41 follows the movement of actuator 42, as translated through the ball valve 26.

If the pumping direction of the control medium is reversed, hydraulic fluid enters port 56 and leaves port 58. This time, ram or actuator 42 moves in a direction opposite to K, and the ram or actuators 41 follows in direction J responsive to compression of spring 44. Thus, the ball valve 26 rolls or otherwise moves in direction C when the control medium, such as hydraulic fluid, is pumped into port 56 and in direction D when the control medium is pumped into port 58. The above-identified copending application shows a system for commanding the mechanism pumping the medium through these ports.

The ultra-simplified mechanism of FIG. 4 would be most difficult to manufacture and, therefore, is not realistically attainable at a reasonable cost. Also, in an abrasive environment, the seat of the ball valve would score and the O-rings would quickly be scrubbed away. Accordingly, a more practical embodiment is shown in FIG. 5.

The valve housing **40** is made from any suitable number (here five) of elongated stainless steel tubes **60–64**, each having a round cross section. To assist in making the assembly, any suitable number of additional housing pieceparts, such as **93, 94,** may be provided, wherever necessary. These pieceparts may be simple threaded rings with suitable O-ring receiving grooves formed therein. The central passageway through these tubes form displaced and axially aligned bores through the housing. The tubes **60** and **64** are threaded or otherwise formed at **65, 66** to be connected to the ends of oil well tubings **27, 25,** respectively. The tubes **60–64** are threaded at their ends to be connected together. Thus, tube **60** screws into tube **61** at threads **70.** Tube **61** screws into tube **62** at threads **71.** Tube **62** screws into tube **63** at threads **72.** Tube **63** screws into tube **64** at threads **73.** Each of these threaded sections is suitably machined to provide seats which receive O-ring seals. For example, O-ring **74** fits into a notch or space near an end of threads **70,** which notch is readily accessible for seal insertion when tube **60** is unscrewed from tube **61.**

By a simple visual comparison of FIGS. **4** and **5,** it is apparent that the practical embodiment of FIG. **5** has many more than the three O-rings **51-53** shown in FIG. **4.** The three O-rings **51–53** in or nearest the working chambers of FIG. **5** perform the functions described above in connection with FIG. **4.** Each of the two O-rings **91** seals together two threaded housing parts. The added O-rings **90, 74, 77** primarily perform a mechanical scraping function to remove the abrasive environmental debris such as sand, gravel, rock chips, and the like. Various materials may be used for the O-rings so that each successive scraper removes the progressively finer grit seeping past the preceding scraper.

FIG. **5** shows the ball valve **26** positioned between the aligned bores leading through the housing **40** and connected to the well tubing attached at **65, 66.** The ball valve **26** is shown in a closed valve position by means of heavily inked lines and in an open valve position by means of lightly inked lines. The ball valve **26** is moved between these two positions responsive to the action of the two rams or actuators **41, 42.**

The ram or actuator **42** is a long tube sliding on bearing surfaces formed by the inside edge of the O-ring seals **74, 53, 51, 77.** The ram or actuator **41** is also a long tube, but it does not necessarily require the O-ring seals since no control medium or hydraulic pressure is involved. However, any suitable number of scrapers may be provided. Therefore, tube **41** is here shown merely floating on the spring **44.**

The position of the ball valve **26** depends upon a balancing of the force of spring **44** against the forces in the two working chambers **54, 55.** When the spring **44** force and well pressure (arrow J) overcomes the hydraulic pressure in work chamber **55,** the ball valve **26** is forced to roll or otherwise move into the closed valve position shown by the heavily inked lines. However, when the hydraulic pressure in work chamber **55** overcomes the force of spring **44** and well pressure (arrow J), the ball valve **26** is forced to roll or move into the open valve position shown by the lightly inked lines.

An annular gasket or seal **86** (see also FIG. **10**), which may be in the nature of an uncompressible gasket or O-ring with a square cross section, is fitted into a notch formed in the end of a threaded housing section **87.** A Teflon-glass composition is preferred for this O-ring. Thus, when the ball valve **26** is in a closed position, it is forced against the uncompressible sealing gasket or ring **86.** A backup metal-to-metal seal is formed in the threaded section at the outer periphery **85** of the seal **86,** to guard against seal failure. This metal-to-metal seal will not become effective except at the extreme limit of the seal **86** effectiveness.

While various materials may be used to make the gasket **86,** a preferred embodiment uses approximately **85%** Teflon and **15%** glass. Whether or nor this exact (**85–15%**) mixture is used, the glass may preferably be particles uniformly mixed with and embedded in the Teflon. The overall consistency of this mixture is firm enough to preclude significant compression (i.e., about **0.005** – 0.010inch) responsive to any reasonably anticipated valve pressure. The particle size and dispersion is such that the mixture has a smooth surface which does not mark or score the ball. The strength of the material is adequate to serve as a valve seat bearing surface.

From an inspection of FIG. **5,** it is easily seen that the diameter of the bearing and sealing ring **86** is greater than the diameter of the actuator ram **42.** The ram force pushing the bearing and sealing seat **86** acts inside the diameter thereof, thus aiding the accuracy of the seating of ball **26** against the ring **86.** The floating nature of the ball movement, unrestrained by fixed pivot points, helps insure near perfect valve and seat aligment.

If the valve forces exceed all reasonably anticipated pressure so that seal **86** is unduly compressed, the metal seats **85** are forced against the metal surface of the ball valve. There is a metal-to-metal seal, perhaps with the residue of Teflon and glass material between the metal surface. Hence, there is a redundancy giving reliability.

To help position the ball valve **26** in either the opened or closed positions, a pair of opposed dogs or stops **88, 88** are integrally formed on the ball. When the ball rolls or otherwise moves, it comes to rest in alignment at either the open valve or the closed valve position. When the dogs or stops **88** encounter the opposing plates **89,** after rolling in either direction C or D, in both the open and the closed valve positions, the ball valve **26** rests firmly and properly aligned on the pins at pivot points **30** and stops **88.**

The forces of spring **44** and the hydraulic pressures are selected so that spring force, augmented by well pressure, overcomes the hydraulic forces to close the valve in case of well failure. For example, the valve chambers **54, 55** may be arranged so that something less than perhaps **300** pounds per square inch of hydraulic pressure may force the valve **26** open against the force of the spring **44,** which may be in the order of **800** pounds, for example. If the hydraulic pressure falls or if the well pressure increases any significant amount, the **800** pounds of the spring force drives the valve shut. Hence, there is a somewhat hair trigger effect, giving a fail safe spring biased valve closure operation. Also, if oil is pumped down the well in excess of

the **800** pound spring force, the valve is forced open.

Those who are skilled in the art will readily perceive how various modifications may be made. Therefore, the appended claims are intended to cover all equivalent structures falling within the true scope and spirit of the invention.

We claim:

1. A disaster valve for oil well blowout protection, said valve comprising a housing having an internal cavity with a floatingly rolling ball valve therein, said ball valve having a passageway therethrough which may be either aligned with or rotated to seat against and seal entrance to said cavity, a pair of actuators positioned to move said ball valve with a rotational movement in either of two opposite directions, bias means for normally urging one actuator to drive said ball to a seated position, means for selectively causing the other actuator to either overcome or not overcome the force of said bias means for rolling said ball along a predetermined path to a position aligned with the entrance to said cavity when the force of said bias means is overcome, stop means formed on said ball to align it in both said aligned and sealed positions, sealing means for protecting said valve against abrasive materials ambiently dispersed in the environment of the valve, at least some of said tubes having O-ring sealing grooves formed therein or at the end thereof to provide said sealing means, at least one of said O-rings being a non-compressible gasket seal for engaging said ball valve when in said closed valve position, the diameter of said gasket being greater than the diameter of the other of said O-rings and said metal-to-metal seal surrounding both the inside and outside periphery of said gasket as a backup seal in case said non-compressible seal fails.

2. The valve of claim **1** wherein said housing is an elongated housing having a pair of displaced and axially aligned bores which are connectable to associated tubing, said ball valve being movable with at least some rolling motion between said bores, the passageway in said ball valve being either aligned with one of said pair of bores or rotated to seat itself against and seal the other of said pair of bores, and said stop means comprising means for floatingly restraining said ball in said housing while enabling said ball to move freely along the predetermined path.

3. The valve of claim **1** wherein said gasket comprises an almost uncompressible material which is about **85%** Teflon and **15%** glass.

4. The valve of claim **1** wherein said housing comprises a plurality of threaded tubes which may be threaded together and interconnected to form an integral unit, each of said actuators comprising another tubing slidingly disposed within said housing, and a plurality of O-ring members formed between said sliding tubular members to scrape debris when said actuators move.

5. The valve of claim **1** wherein said sealing means comprises scrapers positioned between at least one of said actuators and said housing.

6. The valve of claim **1** wherein said non-compressible gasket comprises Teflon mixed with glass particles.

7. The valve of claim **1** wherein said housing comprises a plurality of hollow threaded tubes which may be connected to each other by said threaded sections to form an integral unit with said ball cavity therein, said actuators comprising other tubings slidingly disposed within said housing, and said O-rings being positioned between said actuator and tubes longitudinally displaced along the length of said actuator.

* * * * *