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SUBSURFACE SAFETY VALVE

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1 Claim. (Cl. 166—65)

This invention concerns an electrically operated subsurface safety valve or storm choke.

It is known to equip wells with subsurface safety valves to stop the flow of production fluid when, for some reason, the well's production cannot be controlled. Valves of this type have been especially useful in offshore wells to prevent blowouts when excessive flow from the well resulting from damage to the wellhead or other surface equipment caused by storms, floating objects, or other happenings necessitate halting of production.

Many of these valves are flow-velocity operated; that is, they are designed to close off the production flow conduit when the velocity of the fluid flowing through the valves reaches a predetermined value. These velocity-type valves are disadvantageous in that they cannot be periodically tested without flowing the well at a high rate for a short period of time to cause closure of the valve.

Other type safety valves employ an external fluid pressure originating at the surface to maintain the valve open and depend upon release of this fluid pressure to cause the valve to automatically close.

In general, it has been difficult to check or test these valves periodically, which checks are necessary to insure that operation of the valve has not been impaired by sand, paraffin, or other foreign matter.

Briefly, the invention comprises an electrically operated subsurface safety valve that is readily tested by opening and closing an electrical circuit at the surface. A conductor cable for conducting current to and from the subsurface valve also would function as a means for setting the valve in and retrieving the valve from the well.

Objects of the present invention are, therefore, to provide a subsurface safety valve that is easily installed and operated; that eliminates the need for a separate valve actuating fluid pressure pipe string; that is reliable; and that is easily checked.

These and other objects of the invention will be apparent from a more detailed description thereof when taken in conjunction with the drawings in which:

FIG. 1 is a vertical partly-sectional view of the valve assembly showing the valve elements in valve open position; and

FIG. 2 is a vertical partly-sectional view of the valve assembly showing the valve elements in valve closed position.

Referring to the drawings in greater detail, in FIGS. 1 and 2 are shown components of the valve assembly, including an anchoring section A, a valve section B, and an electrical valve operating mechanism section C, suspended on an electrical conductor cable 10 in a pipe string 11, two sections of which are shown coupled together by a pipe collar 12.

In detail, the valve assembly includes a hollow housing 13, closed at its lower end and open at its upper end, and which latter end forms a retrieving head 14. A shear plate 15 is secured to the top of head 14, and cable 10 extends through an opening in shear plate 15. A ball type stop member 16 is arranged on cable 10 below shear plate 15 and functions to support the valve assembly on the cable. A plurality of spring biased, pivotal, locking dogs 17 are secured to housing 13 adjacent anchoring section A. Dogs 17 extend through windows or openings 18 in housing 13, and the upper ends thereof

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are biased outwardly by springs 19. Stop pins 20 limit the pivotal action of dogs 17 and prevent further outward movement of their upper ends. Housing 13 has formed therein below dogs 17 upper flow passages 21 and lower flow passages 22. The annulus 23 formed between housing 13 and pipe string 11 is closed off between passages 21 and 22 by cup packers 24 arranged on housing 13. A balanced piston or plunger valve 25, provided with a fluid pressure equalizing passageway 26, fluidly communicating the upper end exterior and the exterior immediate the length of piston 25, is movably arranged in the lower portion of housing 13. A ferromagnetic core or plunger 27, movably arranged in an energizing coil 28 to form a solenoid is connected to the lower end of piston 25. A shoulder 29 formed within housing 13 supports a spring 30, which is used to urge piston 25 upwardly against the action of the solenoid. A lower seal 31, arranged on the interior of housing 13 below port 22, seals off the space between piston 25 and the inner wall of housing 13. An upper seal 32 arranged on the inner wall of housing 13 above port 22 also seals off the space between piston 25 and the inner wall of housing 13 when the valve piston is in its upper position as shown in FIG. 2. When valve piston 25 is in its lower position, as shown in FIG. 1, seal 32 seals off the space between the inner wall of housing 13 and a seal protector sleeve 33 slidably arranged in flow passage 34 between upper and lower passages, 21 and 22, respectively. A spring 35, mounted on a shoulder 36 formed on the inner surface of housing 13, biases sleeve 33 downwardly. Sleeve 33 is provided with a lower tapered surface 37, which engages with an upper tapered surface 38 formed on the upper surface of piston 25 when the valve piston is in its upper position, as seen in FIG. 2. Conductor cable 10 extends from ball 16 at the upper end of the valve to coil 28 of the solenoid, as shown in dotted lines. A snap connection 39 connects the portion of the conductor cable extending through the tool to the portion of the conductor cable extending to the earth's surface.

In operation, the valve is set by running it in pipe string 11 on conductor cable 10 with the elements in the position shown in FIG. 1; that is, current is applied to solenoid 28 through conductor 10, which causes piston 25 to move downwardly against the bias of spring 30 and to be retained in this position and this permits sleeve 33 to move downwardly under the bias of spring 35 and to be retained in its lowermost position. Fluid flows through passages 22 and 21 through flow passageway 34 during running-in; and dogs 17 are biased outwardly by springs 19. When the desired depth is reached at which the valve is to be placed, dogs 17 latch in the recess formed by the sections of pipe string 11 and collar 12. In its down position, sleeve 33 protects sealing element 32 and prevents it from being blown out of its seat by high velocity fluid. The pressure equalizing passageway 26 in piston 25 prevents high velocity well fluids from contacting sealing element 31, which would tend to blow this element out of its seat. By balancing piston 25, only sufficient force to overcome friction of the sealing elements 31 and 32 is needed to move piston 25 other than the force needed to overcome the bias of spring 30 in opening the valve and the force needed to overcome the bias of spring 35 in closing the valve. This structure permits the use of small electrical operating mechanisms.

Any severance of the electrical current, whether by accident at the wellhead or by operating a switch to close off the current for checking or testing purposes, causes piston 25 to move upwardly under the bias of spring 30. Surfaces 38 and 37 engage, and piston 25 moves sleeve 33 upwardly against the bias of spring 35 until passage 22 is closed off.

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The valve can be retrieved by exerting an upward pull on cable 10, which causes shear plate 15 to rupture and after which cable 10 severs at snap connection 39. After retrieving the upper portion of cable 10, a wire-line tool is run in pipe string 11 which enters the opening in retrieving head 14, engages the inner ends of dogs 17, and moves the outer ends thereof inwardly against the biases of springs 19; it also extends downwardly and engages piston 25 and moves it downwardly to open passages 22. The upper portion of this tool is provided with tongs which engage retrieving head 14. In this manner the valve apparatus is readily removed from the well.

Although the piston actuating mechanism shown and described is a solenoid (a series of solenoids also could be used), an electrical motor suitably connected to piston 25 could be used instead.

Having fully described the apparatus, operation and objects of our invention, we claim:

A subsurface safety valve adapted to be arranged in a well pipe string and connected to an electrical conductor cable comprising a housing provided with upper and lower spaced-apart fluid flow outlet and inlet passages; packer means arranged on the exterior of said housing adapted to close off the annulus between said housing and said pipe string between said upper and lower passages; anchoring means arranged on said housing adapted to anchor said housing in said pipe string; upper and lower sealing means arranged above and below said lower inlet passage on the interior of said housing; a valve piston vertically movable in said housing adapted to engage both of said

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sealing means to close off said lower passage when in an upper position, and adapted to engage only said lower sealing means when in a lower position, said piston being provided with an equalizing passage fluidly communicating the exterior thereof above and below said lower sealing means; first biasing means arranged on said piston adapted to move said piston upwardly; and electrically actuated means arranged in said housing adapted to move said piston downwardly against the bias of said first biasing means, said electrical conductor cable providing means for supplying electrical current to said electrical actuating means; a sleeve movable in said housing above said lower passage adapted to engage said upper sealing means when in its lower position and adapted to be moved upwardly by said piston when said piston moves from said lower to said upper position; and second biasing means arranged in said housing adapted to bias said sleeve downwardly.

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