WELL FLOW TEST APPARATUS
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ABSTRACT OF THE DISCLOSURE

Combined apparatus applicable to oil well drilling operations that includes a tubing string with a fail-closed valve connected therein to control flow of well fluid. A second concentric tubing string is also connected to the fail-closed valve. The second string forms an annulus with the first tubing string to provide a passage for hydraulic fluid under pressure which may control the operation of the fail-closed valve. The second tubing string has a suspension collar attached therein in order to provide support for both tubing strings at retractable pipe racks in one of a group of blowout preventers that are attached to the well head.

BACKGROUND OF THE INVENTION

Field of the invention

This invention concerns oil well flow-test apparatus generally, and more specifically relates to a combination of apparatus for use with oil well drilling operations which includes provision for employing a fail-closed valve connected into a tubing string which is for use in obtaining a flow test in the nature of a drill stem test.

Description of the prior art

While the individual elements going to make up the combination of this invention are in general each individually known in the prior art, the combination that comprises this invention is particularly applicable to and beneficial in connection with deep water drilling operations where the drilling is carried out from a floating vessel. Thus, for example, a fail-closed valve per se is known and might be employed in a tubing string somewhat similarly as is the case in this invention. However, such prior use of this type valve would have involved a control line for hydraulic pressure to actuate the valve from its fail-closed position to open, as desired; and such hydraulic control line would have required a special arrangement that would limit the manner that the equipment could be manipulated. Consequently, a time saving well flow-test according to this invention would not have been possible. Thus, any such special arrangement is avoided, while at the same time the benefits of having the safety with control that is to be obtained by use of the fail-closed valve is maintained by means of this invention.

Another benefit to be had by employing the combination according to this invention, over any prior art arrangements, is that the tubing employed for carrying out a well flow-test may be supported in a stable manner from the well head equipment. This avoids a difficulty encountered with prior arrangements where drilling is being carried out from a floating vessel. The difficulty would be that involving relative movement vertically between the tubing and the well head equipment, e.g., blowout preventer stack, etc. Such relative vertical movement, and the wear involved therewith, is completely avoided by means of this invention.

SUMMARY OF THE INVENTION

Briefly, this invention concerns well flow test apparatus for use with a well having a plurality of blowout preventers assembled on the well head. The apparatus comprises in combination a first tubing string, and a fail-closed valve connected into said first tubing string for controlling flow of well fluid therethrough. The combination also comprises a second tubing string concentric with said first tubing string and connected to said valve, and means for applying hydraulic pressure in the annulus between said tubing strings to actuate said valve.

BRIEF DESCRIPTION OF THE DRAWING

The foregoing and other objects and benefits of the invention will be more fully set forth below in connection with the best mode contemplated by the inventor of carrying out the invention, and in connection with which there are illustrations provided in the drawings, wherein:

FIG. 1 is a schematic elevation partially broken away to show interior structures, illustrating a well head with blowout preventers mounted thereon and having a floating vessel in place for drilling and completion operations; and

FIG. 2 is an enlarged detail schematic, largely in longitudinal cross-section, showing the connections between the concentric tubing strings and the fail-closed valve to which they are connected.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The invention particularly concerns apparatus to be employed with a well test operation that relates to completion of a drilled well.

FIG. 1 illustrates a floating vessel 11 from which drilling operations have been carried out and underneath which there is a well head 12. The well head 12 includes the usual casing strings, as indicated, e.g., a surface casing 13 and a plurality of inner casings 14. It has attached thereto a series (plurality) of blowout preventers, including a blind ram preventer 15 and a pipe ram preventer 16, as well as others including a so-called Hydril type preventer 17. These elements are all attached together vertically one above another and to the well head 12. These, together with pipe elements as required, form a mud riser column in order that drilling mud circulation may be contained within the equipment up to the vessel 11. This is standard for drilling in deep water.

The completion operation of particular concern in this invention is that of conducting a flowing well test, where such test is a so-called drill stem test. The time required for drill stem testing is much reduced over other types of well flow testing, but there is the danger of a blowout that could be disastrous. However, this invention provides for a well flow test that is time saving in avoiding the need for removing the blowout preventer assembly while at the same time providing the safety that is to be gained by having a tubing string with a valve connected therein for controlling well pressures.

Thus, the well test is accomplished employing a string of tubing 20 that extends downhole to the formation where a production flow test is to be carried out. Tubing string 20 has connected therein a fail-closed valve 21. This valve may be substantially like a commercial valve manufactured for a similar purpose, but with some modification. Such a commercial valve is one manufactured by Otis Engineering Corporation of Dallas, Tex., and illustrated in the 1964-65 Catalog of Oil Field Equipment & Services published by World Oil at page 3707.

Extending upward from the upper end of valve 21 (when viewed as illustrated in the drawings) there is another tubing string 24 that also connects into the valve 21. This forms an annular space between the inner walls thereof and the outer walls of tubing string 20. This annular passageway provides for application of hydraulic fluid to actuate the fail-closed valve 21, and hold it in an
open position when desired. This is done by means of applying hydraulic fluid pressure to the annulus via any feasible hydraulic fluid connection, e.g., that illustrated which includes a pipe 25 that is connected into the outer tubing string 24 and that has a hydraulic pump 26 (schematically indicated) connected to the outer end thereof.

The inner tubing string 20 carries flow of well fluid from downhole through the valve 21. Thus, the valve 21 acts in the nature of a so-called "Christmas tree" valve which is used to perform a flowing drill stem test. Well fluid will flow up to a mainifold 29 located in the vessel 11. From the manifold there is a piping connection, e.g., a pipe 39 that leads to the facilities (not shown) for carrying out the determinations of a production test.

It will be observed that the well head equipment (which includes the above mentioned blowout preventer group and a series of pipe connections to provide a mud riser column) are all attached to the well head and will thus maintain a steady position relative to the surface of the earth. Consequently, such well head equipment must be attached to the vessel 11 in a manner for providing relative motion therebetween. This is schematically indicated by the illustrated elements including a pair of ears 33 that are attached to the exterior of a mud riser pipe 34. A pair of cables 35 are attached to the ears 33 and run over a pair of pulleys 36 that are carried by the vessel 11. This permits the vessel 11 to move vertically up and down (with wave action or the like) relative to the stationary assembly of blowout preventers and mud riser column, during drilling and well test operations.

It is to be noted that the tubing strings 20 and 24 (along with connected thereto) are supported in a stationary manner from the well head 12 by having a suspension collar 39 that is attached into the tubing string 24. This collar rests on a pair of pipe racks 40 and 41 in the blowout preventer 16. The pipe racks seal the casing annulus from the well at this point while permitting the well flow connection through tubing 20 to pass. If desired, access may be had to the casing annulus for providing a complete circuit of fluid flow through one or both of a pair of so-called "choke" and "kill" lines 44 of the blowout preventer 15.

Fig. 2 is an enlarged detail of Fig. 1 is schematic and makes clear how the hydraulic fluid pressure is applied to actuate the valve 21. Thus, it will be observed that the valve 21 has connected at the upper end thereof both tubing strings 24 and 20 which are concentric with one another forming an annulus 47 therebetween. This annulus 47 is connected to the source of hydraulic pressure, i.e., pump 26, by the pipe 25 that connects into the tubing string 24 (see FIGURE 1) in the manner already indicated above. The flow passage within tubing string 20 is connected through the valve 21 in a standard manner so that the valve structure (not shown) may control the flow through this passage. Actuation of the valve structure is controlled by hydraulic fluid pressure that is applied to a piston chamber 50. There is a passage 51 internally of the body of valve 21 for connecting chamber 50 with the annulus 47. It will be appreciated that the structural arrangement indicated is entirely schematic in nature, e.g., the tubing 20 and 24 might either or both be attached to the valve 21 by a latching structure instead of by threads as shown.

OPERATION

During a well drilling operation (particularly from a floating vessel) and after having reached an interval in the formations being drilled where it is desired to test the flow thereof, the well will be conditioned in a usual manner for isolating such formation interval. Then the well will be perforated in order to provide passages for well fluid to flow through.

Thereafter, in order to carry out a well flow test according to this invention (which involves a maximum of control with a minimum of time required) a tubing string, e.g., 20, will be made up and run into the hole with the valve 21 included in the string and located so as to have it close to the well head structure when the drilling is in place downhole. In addition, the concentric tubing string 24 will be made up beginning with its concentric tubing string 24 will be made up beginning with its connection to the top of the valve 21, so that the above described annular passageway is provided between the tubing strings 20 and 24. This annular passage is used for applying hydraulic pressure to control the actuation of the valve 21.

As these tubing strings 20 and 24 (with the valve 21 connected therein) are lowered into position through the well head plus attached blowout preventer elements, the pipe racks 40 and 41 of the blowout preventer 16 will be extended so as to contact the tubing 24 and permit the suspension collar 39 to rest thereon. When these conditions have been effectuated the tubing strings will be supported from the well head and there will be no relative movement with respect to well head equipment for causing wear and possible leakage of well fluid pressure.

Then the well test procedures may be carried out as desired with flow of fluids from the well upward within the tubing string 20 under control of the valve 21. The valve 21 may be closed as desired or will automatically close should the hydraulic control passage be severed. During these operations complete circuit for flow of various fluids may be maintained (as already indicated) by having fluids from the casing annulus of the well flow to the surface via the blowout preventer 15 and its control lines 44. The other portion of such circulation path is through the interior of tubing string 20.

It will be appreciated that this invention provides the ability to carry out a well flow test that has the advantages of time saving and added safety since the test may be made without trippling the blowout preventer array but with the control valve being a fail-safe type and located at or below the well head. It will be especially appreciated that in drilling from a floating vessel the operation of a well test of the sort involved here is particularly hazardous because possible blowout of a well could occur on account of the movement of the vessel both horizontally and vertically. Such movement is at least difficult to control and thus the well head equipment is subjected to strains and stresses with relatively high possibility of rupture. Of course, such rupture would tend to permit a loss of control of the well. Thus, while equipment has been available for accomplishing similar results as those described above, the prior elements and arrangements for using such equipment involved much additional time and inconvenient equipment that is avoided by this invention.

1 claim:

1. Well flow test apparatus for use with a well having a riser pipe and a plurality of blowout preventers assembled on the well head, comprising in combination a first tubing string, a fail-closed valve connected into said first tubing string for controlling flow of well fluid through said first tubing string, said fail-closed valve including a variable opening passage, and pressure actutable means for adjusting said variable opening passage, said pressure actutable means being communicable with said annular passage, and said first tubing string being communicable with said variable opening passage, a second tubing string concentric with said first tubing string and connected to said valve, said first and second tubing strings being of different outside diameters whereby to define an elongated annulus therebetween, and said fail-closed valve connected therewith being supportably positioned within said riser pipe, means for applying hydraulic pressure in the annulus between said tubing strings to actuate said valve.
2. Well flow test apparatus according to claim 1 wherein one of said blowout preventers has pipe rams, and further including a suspension collar connected into said second tubing string for cooperating with said pipe rams to support said tubing strings from the well head.

3. Well flow test apparatus according to claim 2 wherein said fail-closed valve is located adjacent to the well head when said tubing strings are supported from the well head.

4. Well flow test apparatus according to claim 1 wherein said pressure actutable means is communicated with said elongated annular chamber passage disposed within said valve and, extends axially of the latter.

5. Well flow test apparatus according to claim 4 further including
a vessel floatably supported above and spaced from said well head in a body of water;
a mud riser elongated column extending upwardly in said body of water, having the lower end thereof connected to said well head and having the upper end at the water surface; and

6. means for attaching said column to said vessel with freedom of relative movement therebetween.

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