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 APPARATUS FOR CONTROL OF FLOW THROUGH
 THE ANNULUS OF A DUAL-ZONE WELL
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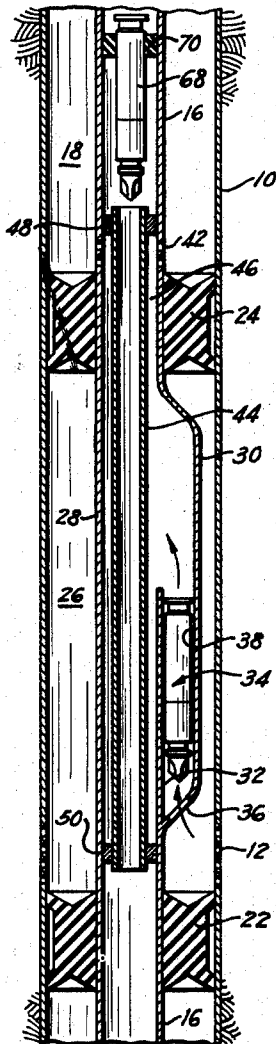


Fig. 1

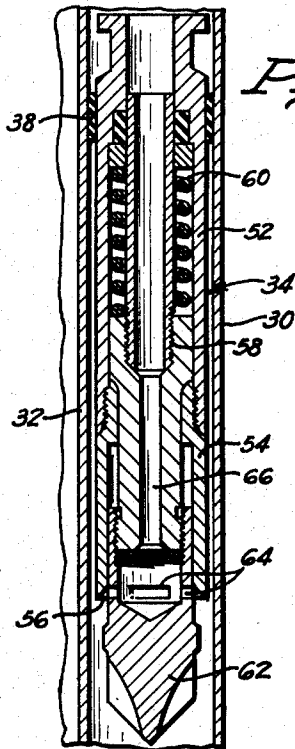


Fig. 2

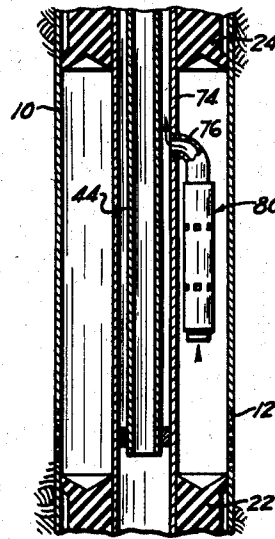


Fig. 3

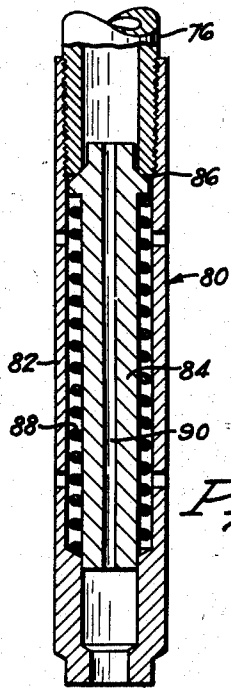


Fig. 4

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1

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APPARATUS FOR CONTROL OF FLOW THROUGH THE ANNULUS OF A DUAL-ZONE WELL

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2 Claims. (Cl. 166—115)

This invention relates to the control of flow from dual-zone wells. It is particularly concerned with apparatus for control of flow from the well through the annulus between the tubing and casing of a dual-zone well.

In oil and gas wells producing from a plurality of zones, it is desirable, and in some areas mandatory, to keep the production from each of the zones separate. In the usual dual-zone well a casing extends down the borehole to the bottom of the well and is perforated at each of the production zones. A tubing string extends downwardly within the casing to a level below the upper production zone for the delivery of production from the lower zone. The annular space between the casing and the tubing string is closed by means of a packer between the upper and lower production zones and production from the upper production zone is delivered to the well head through the annulus between the tubing string and casing.

It is desirable to provide some means for preventing wild, uncontrolled flow from an oil or gas well resulting from a leak in the casing or tubing, or damage to surface connections of the well. The control of the flow may be such as to completely shut down the well or to limit the maximum rate of production. Sometimes it is desirable to cause a reduction in the pressure of the fluids from the well to take place below the surface of the well. A storm choke for completely shutting down the well is particularly desirable in offshore wells to prevent discharging large amounts of oil into the water if the well should be damaged. The apparatus for shutting down the well should preferably be installed below the surface in order to protect it from damage which might be caused by storms, fire, collision, or other causes.

This invention resides in apparatus for separate delivery of production and control of flow through the annulus of a dual zone well having a tubing string extending down the well through a casing. Production from the lower zone of the well is delivered through the tubing string and production from the upper zone is delivered through the annulus between the tubing and casing. Packing elements engaging the tubing string and the casing isolate a section of the annulus adjacent the upper production zone. A flow passage allows flow from the upper production zone into the tubing string between the packing elements. A flow control device is positioned in the flow passage. Perforations in the tubing string above the upper of the packing elements allows return of flow delivered into the tubing string from the flow passage to the annulus above the upper packing element. A sleeve within the tubing string is open at each end into the tubing string and is packed off from the tubing string above the perforations and below the flow passage to carry production from the lower zone of the well past the portion of the tubing open to production from the upper zone.

In the drawings, Figure 1 is a vertical sectional view of a portion of a dual-zone well showing a preferred embodiment of an assembled device for shutting off flow through the annulus.

2

Figure 2 is a vertical sectional view, showing in detail the pressure-differentially operated shutoff valve for control of annulus flow employed in the embodiment illustrated in Figure 1.

Figure 3 is a vertical sectional view, similar to Figure 1, of another embodiment of a flow control device, constructed according to this invention, for limiting the maximum rate of flow through the annulus.

Figure 4 is a vertical sectional view illustrating details of construction of the maximum flow valve employed in the embodiment in Figure 3.

As disclosed in Figure 1 of the drawings, a casing 10 is installed in a borehole of a dual-zone well. The casing 10 is perforated at 12 to receive fluids produced from the upper zone of a dual-zone well and at 14 to receive fluids from the lower producing zone of a well. Extending downwardly within the casing 10 is a tubing string 16 having a diameter sufficiently smaller than the diameter of the casing to form an annulus 18 through which production from the upper production zone is delivered to the well head. The tubing string 16 can be open or provided with a perforated nipple 20, as shown, at its lower end through which fluids from the lower producing zone of the well enter.

A section of the annulus 18 adjacent the perforations 12 in casing 10 is isolated by means of a lower packer 22 and an upper packer 24, which packers may be of conventional design. The lower packer is located between the upper and lower production zones to prevent mixing of the fluids from the two zones. The upper packer 24 is positioned above the upper production zone in order that the isolated section, designated by reference numeral 26, will receive flow which enters through perforations 12. Ordinarily, the upper packer 24 will be positioned near the upper end of the well to facilitate servicing the flow control apparatus. However, in some instances, for example, when high pressures are encountered, it may be desirable to install the upper packer 24 at a relatively low level in the well adjacent the upper production zone in order to reduce the pressure of the well fluids and thereby relieve much of the tubing and casing from high pressures caused by the well fluids. Location of packer 24 adjacent the perforations for the upper production zone also allows protection against failures in substantially all of the casing above the upper zone. In the drawings, the lower production packer 22 has been positioned immediately below the perforations 12 and the production packer 24 has been positioned directly above the perforations 12 to facilitate illustration and description of the invention.

Forming a part of the tubing string 16 is a storm choke mandrel 28 having an expanded section indicated by reference numeral 30 positioned between the upper packer 24 and lower packer 22. A baffle 32 extends upwardly from the lower end of the mandrel to form a chamber in which a shutoff valve 34, actuated by pressure differential, is positioned. An opening 36 in the lower end of the chamber formed in the mandrel permits fluids to flow from the isolated annular zone 26 into the storm choke mandrel 28. Leakage around the outer surface of the shutoff valve, indicated generally by reference numeral 34, is prevented by suitable packing means, indicated diagrammatically by element 38. The tubing string 16 is perforated at 42, above the upper packer 24, to allow flow into the annulus 18 above that packer.

A pack-off sleeve 44 is mounted within the storm choke mandrel 28 and extends from above the perforations 42 to below the baffle 32. The pack-off sleeve 44 is of relatively small diameter to form an annular opening 46 between it and the storm choke mandrel 28 through which annulus production flows. Packing elements 48 and 50 at the upper and lower ends of the pack-off sleeve 44,

3

respectively, prevent flow between the isolated annular zone 26 and the pack-off sleeve 44.

Referring to Figure 2 in which the shutoff valve 34 is illustrated in detail, the valve consists of a valve cage formed by screwing together an upper section 52 and a lower section 54. The lower end of the section 54 of the valve cage forms a valve seat 56. A tubular valve stem 58 is adapted to slide within the valve cage from the lower, open position illustrated in the drawings to an upper position in which the valve is closed. The valve stem 58 is urged downwardly to the open position by a compressed helical spring 60. A valve plug 62 mounted on the lower end of the valve stem is provided with ports 64 and central passage 66 through which annular production flows when the valve is opened.

Referring to Figure 1 of the drawings, a pressure-differentially operated shutoff valve 68 similar to the valve 34 illustrated in Figure 2 is mounted in the tubing string 16 for control of flow from the lower production zone. A suitable packing element 70 prevents leakage around the outer surface of valve 68.

During normal operation of the well, production from the lower zone passes through perforations 14 in the casing 10, and the perforated nipple 20, into the tubing string. The fluid flow continues through the pack-off sleeve 44 and pressure-differentially operated valve 68 and then through the upper section of the tubing string 16 to the well head. The fluids from the upper production zone pass through the perforations 12 in the casing 10, and then through opening 36 in the storm choke mandrel 28, through the ports 64 and central passage 66 in the shutoff valve 34, and through the annular opening 46 to the perforations 42.

If there is a failure of the casing or of the surface lines through which the annulus production passes, the increased flow results in an increase in the pressure drop through the valve 34. When the pressure drop is sufficient to overcome the force exerted by spring 60, the valve plug 62 moves upwardly to a position at which the valve ports 64 are covered and the plug 62 engages the valve seat 56. The valve 34 closes with a snap action and is held in the closed position until the well is re-pressured to be put back into operation. The shutoff valve 68 operates in the same manner for the tubing production if the pressure drop through valve 68 overcomes the force exerted by the spring in that valve, which excessive pressure drop may be caused by failure of the tubing or of the surface lines for tubing production.

This invention is suitable for controlling the rate of flow through the annulus of a dual-zone well as well as for providing means for automatically shutting down flow through the annulus of the well. The embodiment of the invention illustrated in Figure 3 of the drawings limits the maximum rate of production through the annulus.

Referring to Figure 3, a tubing section 74 is substituted for the storm choke mandrel 28 between the upper packer 24 and lower packer 22. The tubing section 74 is tapped and an elbow 76 connected thereto between the two packers. A bottom hole choke, indicated generally by reference numeral 80, adapted to limit the rate of flow to a predetermined maximum is secured to the lower end of elbow 76.

The details of the bottom hole choke 80 are illustrated in Figure 4 of the drawings. A hollow cage 82 is connected to the lower end of elbow 76 by any suitable means such as the screw threads illustrated. A choke element 84 within the cage 82 is provided with a seat 86 which is urged against the lower end of the elbow 76 by a compressed spring 88. The choke element 84 has a central

4

passage 90 extending longitudinally through it. The dimension of the central passage 90 is determined by the maximum rate of flow to be allowed from the upper production zone of the well. During operation of the well, fluids from perforations 12 flow through central passage 90 and continue through elbow 76 and the annulus surrounding pack-off sleeve 44 to the perforations 42. It will be appreciated that the bottom hole choke could also be installed in mandrel 28 with little modification.

This invention provides a simple, readily assembled means for controlling flow through the annulus of a dual-zone well. The invention is particularly useful as a storm choke for a dual-zone well in which the annulus production is shut down completely when damage to the well occurs. Other uses of the invention are to limit the maximum rate of production from the zone producing through the annulus by means of a suitable choke in the isolated portion of the annulus, or to close in that zone by means of a plug choke.

I claim:

1. Apparatus for installation down the hole of a dual zone well for control of flow through the annulus of the dual zone well comprising a tubing string for delivery of fluid from the lower zone of the well, a casing surrounding the tubing string with an annulus therebetween, perforations in the casing at the upper production zone of the well, a first packer between the tubing and casing above the perforations, a second packer between the tubing and casing below the perforations, said first packer and second packer isolating a portion of the annulus into which the perforations in the casing open, a tubular mandrel connected in and forming a part of the tubing string between the first packer and second packer, said mandrel having an expanded section extending laterally toward the casing whereby the opening in the mandrel is of larger horizontal cross section area than the opening in the tubing string, a vertical baffle in the mandrel forming a vertical cylindrical chamber in the expanded section of the mandrel, said chamber opening upwardly at its upper end into the mandrel, a flow control device mounted in the chamber, sealing means engaging the flow control device and the walls of the chamber to prevent flow therebetween, said flow control device being retrievable through the opening at the upper end of the chamber, a passage into the lower end of the chamber allowing flow from the isolated section of the annulus into the flow control device, perforations in the tubing string above the first packer, a sleeve retrievably mounted in the tubing string, said sleeve having an outer diameter smaller than the inside diameter of the tubing string and extending from above the perforations in the tubing string to below the opening in the upper end of the chamber, a first packing element between the sleeve and the tubing string above the perforations in the tubing string, and a second packing element between the sleeve and the tubing string below the opening at the upper end of the chamber to prevent mixture of fluid in the tubing string from the lower production zone and fluid from the upper production zone.

2. Apparatus as set forth in claim 1 in which the flow control device is a pressure-differentially operated shut-off valve.

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