

Filed Oct. 19, 1954

STORM CHOKE FOR OIL WELLS

2 Sheets-Sheet 1



HIS ATTORNEY

March 19, 1957

H. J. EN DEAN

2,785,755

STORM CHOKE FOR OIL WELLS

Filed Oct. 19, 1954

2 Sheets-Sheet 2

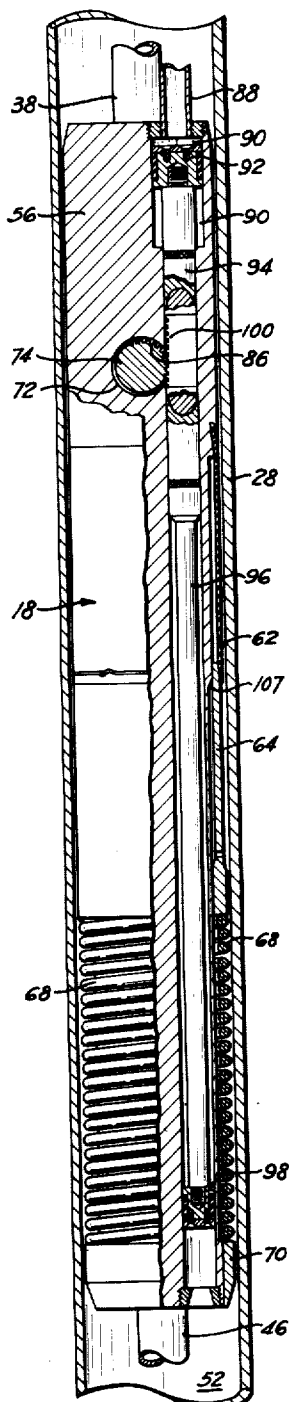


Fig. 4

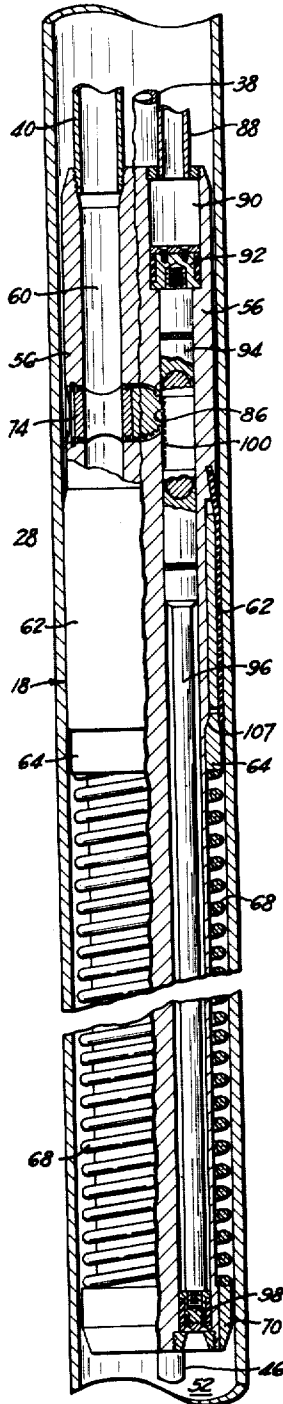


Fig. 5

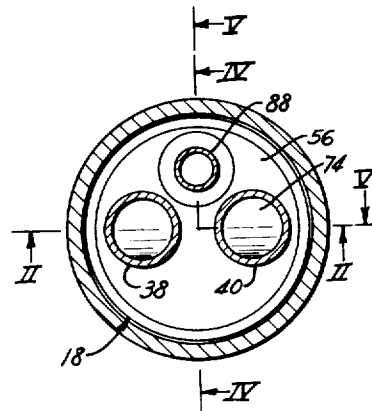


Fig. 3

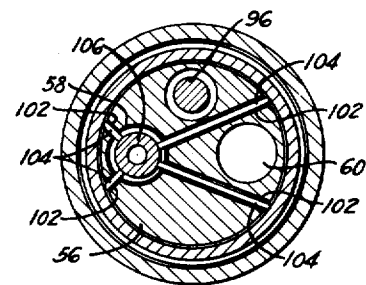


Fig. 6

INVENTOR.
HOWARD J. ENDEAN
BY
Howard Hooke
HIS ATTORNEY

1

2,785,755

STORM CHOKE FOR OIL WELLS

Howard J. En Dean, Pittsburgh, Pa., assignor to Gulf Research & Development Company, Pittsburgh, Pa., a corporation of Delaware

Application October 19, 1954, Serial No. 463,283

9 Claims. (Cl. 166—72)

This invention relates to apparatus to be mounted within a well bore for control of flow in oil and gas wells, and more particularly to a storm choke for shutting off flow of a well.

Oil and gas wells are sometimes exposed to conditions either within the well or at the well head which may cause serious damage to the well, resulting in substantial or even complete loss of production from the well. When such conditions arise, it is desirable to shut off production from the well until the cause of the hazardous conditions can be corrected. The term "storm choke" is used in this application to designate apparatus for shutting off production from the well when conditions hazardous or potentially hazardous to the operation of the well arise, or when desired by the operator of the well.

The hazardous conditions making it desirable to shut off production from the well may vary widely. For example, if the well head is located on land, rupture of lines, either in the well or at the well head, or fire may endanger continued operation of the well. Off-shore wells may be exposed to hazards from high waves or collision with vessels, in addition to the conditions which are potentially dangerous to wells on shore. The storm choke may provide protection against any one or more potentially hazardous conditions. Since off-shore wells may not be accessible when the hazardous condition arises, or wells may be left unattended for long periods, a storm choke is preferably automatically actuated by a signal initiated by the hazardous condition.

It is desirable that a storm choke be capable of being used with conventional well completion methods and well head equipment. The storm choke should also be dimensionally suitable for installation in standard casing sizes employed in wells and still provide full opening ports which will offer no restrictions preventing the running of instruments or other tools through the device. The ports through which production from the well flows should be sufficiently large in dimension to minimize cutting by sand carried with the production.

Often it is necessary or desirable to shut off a well for maintenance work at the well head or for other reasons. Hence, it is desirable that the well may be readily placed back in production after operation of the storm choke without the necessity of killing the well with fluids followed by swabbing, back-circulation or other well completion procedures.

This invention resides in a storm choke adapted for installation within the casing of a well in which a piston actuated by a net force resulting from a signal indicating the existence of a hazardous or potentially hazardous condition, or the desirability of shutting off the well, moves to close a valve to stop flow from the well. In the preferred embodiment of this invention the storm choke operates automatically when the potentially hazardous operating condition arises to shut off production simultaneously from both zones of a dual zone well.

2

In the drawings,

Figure 1 is a fragmentary vertical sectional view of a well equipped with the storm choke of this invention.

Figure 2 is a vertical sectional view of the storm choke of this invention, prior to its setting in place in the well, with the valve element in the closed position.

Figure 3 is a horizontal sectional view along the section line III—III in Figure 2 showing the upper end of the storm choke.

Figure 4 is a longitudinal view partially in a vertical section taken along the section line IV—IV in Figure 3 of the storm choke set in place in the casing in the closed position to prevent flow from the well.

Figure 5 is a longitudinal view partly in a vertical section taken along the section line V—V in Figure 3 showing the storm choke set in place in the casing and in the normal operating position to allow flow from the well.

Figure 6 is a transverse sectional view along the section line VI—VI in Figure 2 illustrating the apparatus for setting the storm choke in place in the casing.

The storm choke of this invention ordinarily is installed within the casing near the top of the well, for example, at or slightly below the mud line. The installation near the top of the well is for convenience in the installation of the storm choke in the well and to improve its accessibility. Thus, the position of the storm choke near the top of the well is a matter of preference only. The storm choke is operative if set in place in the well at any level above the upper production zone.

Referring to Figure 1, a dual zone well is illustrated in which a surface casing 10 is suspended from a surface casing support 12. The surface casing 10 extends downwardly into the well to the desired depth and the length of the surface casing is not determined by the storm choke of this invention. A lower casing head 14 is supported on the upper surface of the surface casing support 12. An intermediate casing 16 is suspended from the lower head 14, and in the well illustrated in Figure 1 extends downwardly below the storm choke indicated generally by reference numeral 18. The lower casing head 14 may be provided with any desired number of outlets such as those indicated by reference numerals 20 and 22.

A production casing hanger 24 having a downwardly tapered lower surface is supported on the outwardly flared inner surface 26 at the upper end of the lower casing head 14. A production casing 28 hangs from the production casing hanger 24 down into the well. In the well illustrated in Figure 1 of the drawings, the production casing 28 extends through the upper production zone and continues downwardly to the lower production zone. Production casing 28 is perforated at 30 in the upper producing zone and at 32 in the lower producing zone, respectively.

An upper casing head 34 is mounted on the upwardly tapered surface of the production casing hanger 24. Supported in the upper end of the upper casing head 34 is a tubing hanger 36 provided with two vertical passages through which two strings of tubing identified as upper production tubing 38 and lower production tubing 40 extend. The tubing hanger 36 is provided with recesses in the upper end for the reception of tubing slip locks 42 which are secured to the upper production tubing 38 and lower production tubing 40. Directly below each of the recesses in the tubing hanger 36 are tubing slip seals 43. A tubing head cap 44 is secured to the upper casing head 34. The outlets from the well head connections illustrated in Figure 1 are connected to suitable piping and valve arrangements, not shown, for control of the fluids delivered from the well.

The upper production tubing 38 and lower production tubing 40 extend downwardly below the lower surface of the tubing hanger 36 through the production casing 28

3

and are connected to the upper end of the storm choke 18. A tubing string 46 which communicates with the lower production tube 40 through the storm choke 18 is suspended from the lower end of the storm choke 18 and extends downwardly within the production casing 28 to the lower production zone. A packer 48 of conventional design equipped with a spring loaded cap 50 to close its lower end is set in the usual manner in the annular space 52 between the tubing string 46 and production casing 28. The packer 48 is located between the upper and lower production zones to prevent flow from one zone to the other through the annular space 52. Packer 48 is preferably positioned immediately above the lower production zone as illustrated in Figure 1. The tubing string 46 is provided with a perforated lower end section 54.

Referring to Figure 2 of the drawings, the storm choke consists of a storm choke body 56 having a pair of vertical passages 58 and 60 extending longitudinally through the storm choke from its upper end to its lower end. Passages 58 and 60 are threaded at their upper ends to receive the lower ends of tubing 38 and tubing 40, respectively, to deliver flow from each of the passages to the well head. The tubing string 46 is suspended from the lower end of the storm choke 18 in a manner to permit flow from the tubing string 46 into passage 60 and thence into tubing 40. Passage 58 communicates at its lower end with the annular space 52.

A tubular casing seal 62 of a flexible oil resistant material, such as neoprene, is secured to the outer surface of the body 56. Directly below the casing seal 62 in Figure 2 of the drawings is a sleeve 64 adapted to slide along the outer surface of the storm choke body 56. The upper end of the sleeve 64 is tapered at 66 and extends between the lower end of the seal 62 and the outer surface of the storm choke body 56. The lower end of sleeve 64 rests on a helical spring 68 surrounding the storm choke body 56 and supported in place by a spring retainer 70 secured to the lower end of the storm choke body 56.

A chamber 72, best shown in Figure 4, intersecting passages 58 and 60 extends through the storm choke body 56. Referring to Figure 2, a valve plug 74 having ports 76 and 78 in alignment with the passages 58 and 60 respectively is rotatably seated in the chamber 72. The valve plug 74 is illustrated in Figure 2 in position with ports 76 and 78 perpendicular to the passages 58 and 60 to prevent flow through the passages. Valve plug 74 is held in position in chamber 72 by means of retaining rings 30 and 32. Leakage from either of the passages 58 or 60 between the valve plug 74 and the wall of the chamber 72 is prevented by packing rings 34. Gear teeth are cut on the outer surface of valve plug 74 to form a pinion gear 86 on the section of the valve plug 74 between the passages 58 and 60.

As shown in Figure 3 of the drawings, a hydraulic pressure tube 88 is connected to the upper end of the storm choke 18. Referring to Figure 4, the hydraulic pressure tube 88 opens into a hydraulic cylinder 90 in the upper end of the storm choke body 56. A hydraulic piston 92 in the cylinder 90 is movable vertically in the cylinder in response to the pressure of the hydraulic fluid therein. A piston rod 94 connected to the lower surface of the piston 92 extends downwardly through an extension 96 of the cylinder 90 which opens at its lower end into the annular space 52 between tubing string 46 and production casing 28. A lower piston 98 is mounted on the lower end of the piston rod 94. Pistons 92 and 98 and piston rod 94 move and function as a unit. Suitable seals to prevent leakage of hydraulic or well fluids are provided between the pistons 92 and 98 and the walls of the cylinder. The piston rod 94 is moved by the difference in the force exerted against the piston 92 by the hydraulic fluid in hydraulic cylinder 90 and the force exerted against the piston 98 by the fluid in the annular space 52.

4

On the surface of the piston rod 94 is a rack gear 100, the teeth of which are in engagement with the pinion gear 86 on the valve plug 74. Upon movement of the piston rod 94, the rack gear 100, through engagement with pinion gear 86, will rotate the valve plug 74.

Apparatus for setting the storm choke in the well is illustrated in Figures 2 and 6 of the drawings. Referring to Figure 6, a plurality of conduits 102 extends from the passage 58 through the wall of the storm choke body 56. A spring lock pin 104, slidably fitting in each of the conduits 102, engages the inner surface of the sleeve 64 surrounding the storm choke body 56. The spring lock pins 104 are prevented from moving inwardly by a keeper 106 in the passage 58 and from moving outwardly by a sloping shoulder 107 on the inner surface of sleeve 64.

Referring to Figure 2, the keeper 106 has an upper collar 108 and a lower collar 110 spaced therefrom to form a groove 112 in which the inner ends of spring lock pins 104 rest. Movement of the keeper 106 in the passage 58 during well completion is prevented by engagement of the pins 104 with the collars 108 and 110. Collars 108 and 110 are held in place on the keeper 106 by shear pins 114 and 116 respectively.

Apparatus for initiating a signal causing automatic operation of the storm choke of this invention is shown diagrammatically in Figure 1 of the drawings. In the apparatus illustrated, pressure tubing 88 extends upwardly from the hydraulic cylinder 90 to the well head and passes outwardly through a side outlet 120 on the upper casing head 34. A line 122 connects the pressure tubing 88 with a vessel 124 suitable for storing a hydraulic fluid under pressure. A line 126 from the top of the storage vessel 124 is connected with a solenoid-operated three-way valve 128. One of the ports of valve 128 is connected through a line 130 with a cylinder 132 of a gas under pressure. Another port of valve 128 is vented to the atmosphere through a line 134. In the particular control apparatus illustrated in Figure 1, the storm choke is made to operate as a result of temperatures at the well head above a predetermined limit. A thermostat 136 is adapted to close a circuit through lead lines 138 and 140 to a suitable source of electric current, not shown, for operation of the valve.

In the completion of the well, production casing 28 is run to the bottom of the well and perforated. The packer 48 is then set in the casing, preferably just above the lower perforations by conventional procedures. The tubing string 46, storm choke 18, upper production tubing 38 and lower production tubing 40 are assembled as illustrated in Figure 1 and lowered into the well until the perforated lower end section 54 of the tubing string 46 is directly above cap 50 of the packer 48. The cap 50 is closed at this stage of the operation. The well head connections are assembled as shown with the exception that the tubing slip locks 42 are replaced with slick joints.

Production from the upper production zone is commenced by conventional circulation procedures. After the flow from the upper production zone has been established, the assembly is lowered until the perforated lower end section 52 of the tubing string 46 has opened cap 50 and is below the packer 48 to receive flow from the lower production zone. The slick joints are then removed and replaced with the tubing slip locks 42 which are secured to tubings 38 and 40 to support the tubing string and storm choke assembly.

The casing seal 62 is set against the casing 28 by removing keeper 106 with a fishing tool. The keeper 106 may be either lifted from its position illustrated in Figure 2 or pushed down into the well. When a sufficiently great force is exerted on the keeper 106, one of the shear pins 114 or 116 is broken to free the corresponding collar 108 or 110 and permit movement of the keeper 106. The spring lock pins 104 are then forced inwardly

into conduits 102 by the shoulder 107 as the sleeve 64 is pushed upwardly by spring 68. Upward movement of the sleeve 64 between the casing seal 62 and the storm choke body 56 forces the seal against the casing to prevent flow of well fluids between the storm choke and the casing. Production from the lower production zone is then established by conventional swabbing procedures.

During normal operation of the well, the pressure on the hydraulic fluid in the upper end of the hydraulic cylinder 90 is sufficient to overcome the force exerted by the fluids from the upper production zone against the piston 98. Hence, the piston rod 94 is moved to the lower position illustrated in Figure 5. At this position, the valve plug 74 is rotated to a position at which the ports 76 and 78 communicate with passages 58 and 60, respectively.

When the temperature at the well head exceeds the predetermined maximum, the thermostat 136 closes the circuit to the solenoid valve 128 to operate that valve and place lines 126 and 134 in communication. The pressure on the hydraulic fluid is relieved and the pressure exerted by the annulus production fluids moves piston 98 upward to the position shown in Figure 4. At this position, the ports 76 and 78 in valve plug 74 are in the position illustrated in Figure 2 of the drawings to prevent flow through passages 58 and 60.

After the hazardous condition has been corrected, production from the well can again be established by merely restoring the pressure on the hydraulic fluid to move the piston rod 94 to the lower position illustrated in Figure 5. The downward movement of the piston rod 94 actuates valve plug 74 through the gears 100 and 86 to place the ports 76 and 78 in communication with the passages 58 and 60.

The storm choke of this invention has been illustrated and described in combination with conventional fittings at the well head. It will be appreciated that the storm choke can be used with other well head apparatus providing suitable outlets and apparatus for the control and distribution of the production of the well, and allowing completion of the well. Other apparatus and circuits for actuating the storm choke can be employed. For example, the piston rod can be connected by mechanical linkage to control apparatus and circuits for moving the piston to actuate the valve.

The storm choke has been illustrated in an embodiment suitable for use in dual zone wells. If used in a well producing from a single zone, it is necessary only to have a single passage through the storm choke body. In addition, in a single zone well a tubing string in addition to casing below the storm choke is not necessary, but may be desirable for reasons entirely separate from the use of the storm choke.

I claim:

1. A storm choke adapted for arrangement in a casing of a well comprising a storm choke body having a passage extending longitudinally therethrough a packer engaging the storm choke body and the casing to prevent flow around the outer surface of the storm choke body, a rotatable valve in the passage having a port therethrough positioned to communicate with the passage during normal operation of the well, a pinion gear on the valve, a cylinder in the body open to the well fluids below the storm choke body, a piston movable in the cylinder, a rack gear on the piston in position to engage the gear on the valve, a hydraulic fluid pressure line extending from the upper end of the cylinder to the surface at the upper end of the well, a source of hydraulic fluid under pressure connected with the fluid pressure line, and means for release of the pressure on the hydraulic fluid in response to hazardous conditions whereby the piston moves upwardly in the cylinder and rotates the valve to move the port out of communication with the passage.

2. A storm choke adapted for arrangement in the casing of a dual zone well comprising a storm choke body,

a pair of longitudinal passages through the body, a tubing connected to the upper end of the storm choke body at each of the passages and extending to the well head for separate delivery of production from each of the two passages to the well head, a valve plug rotatably mounted in the body and extending across each of the passages, said valve plug having a port normally communicating with each of the passages to permit flow therethrough when the well is operating, a packer in the well separating the upper and lower producing zones, a tubing string extending downwardly from one of the passages through the casing to a position below the packer, a cylinder in the body open at its lower end to the annular space between the casing and the tubing string, a piston movable in the cylinder, means for supply a fluid under pressure into the cylinder above the piston, gear means connecting the piston and the valve plug whereby movement of the piston in response to change in the relative magnitudes of the forces on the ends of the piston rotates the valve plug from the open position to close the passages.

3. A storm choke adapted for arrangement within the casing of a dual zone well comprising a storm choke body, a pair of passages extending longitudinally through the storm choke body from its upper to its lower end, a tubing connected at the upper end to each of the passages extending to the well head for separate delivery of fluids passing through the two passages, a tubing string extending from the lower end of one of the passages downwardly within the casing into the well and communicating with the lower production zone, the outer surface of the tubing string being spaced from the inner surface of the casing to form an annular space therebetween, a rotatable valve plug in each of the passages, said valve plug having a port therethrough communicating with the passage during normal operation of the well to allow flow through the passage, a packer between the upper and lower production zones engaging the tubing and casing to prevent flow between the two zones, a cylinder in the storm choke body open at its lower end to the annular space between the casing and the tubing, a piston movable in the cylinder, the lower end of said piston being exposed to the fluid in the annular space between the casing and tubing string, means for supplying a hydraulic fluid under pressure into the cylinder above the piston to hold the piston in a lower position at which the valve is open, a gear train connecting the piston with the valve, and means for releasing the pressure on the hydraulic fluid whereby the piston moves upwardly to close the valves.

4. Apparatus for a dual zone well comprising a casing extending from the well head to the lower production zone having perforations in the casing at the upper and lower production zones, a packer positioned within the casing between the upper and lower production zones, a storm choke within the casing near the upper end thereof engaging the inner walls of the casing to prevent flow between the storm choke and the casing, said storm choke comprising a body having a first passage and a second passage extending longitudinally therethrough from the lower to the upper end of the body, a tubing string secured to the lower end of the body and extending from the second passage below the packer, a casing head at the well head, a tubing hanger supported by the casing head, a first tubing extending upwardly from the first passage in the storm choke body through a first passage in the tubing hanger, a second tubing extending upwardly from the second passage in the storm choke body through a second passage in the tubing hanger, slip locks supporting the first and second tubings in the tubing hanger, a valve chamber extending transversely of the storm choke body intersecting the first passage and the second passage, a valve plug rotatable in the valve chamber, a first port and a second port in the valve plug in alignment with the first passage and the second passage respectively, said valve ports communicating with the respective passages

7

during normal operation of the well, a cylinder extending vertically through the storm choke body, a piston slidably mounted in the cylinder, said piston being exposed to well fluids at its lower end, a rack gear extending vertically along the surface of the piston, a pinion gear on the valve plug engaging the rack gear, a pressure line opening into the cylinder above the piston for supplying hydraulic fluid under pressure, means for maintaining the hydraulic fluid under pressure whereby the piston is held at a lower position in the cylinder and means for releasing the pressure on the hydraulic fluid whereby the piston moves upward in the cylinder and rotates the plug valve through the gears to shut off the well.

5. A storm choke adapted for arrangement within the casing of a well comprising a storm choke body, packing means engaging the storm choke body and the inner surface of the casing to prevent flow of well fluids therebetween, a passage extending through the storm choke body from its upper end to its lower end to allow flow of well fluids therethrough, a valve plug rotatably mounted in the body extending across the cylinder, said valve plug having a port extending therethrough in alignment and communicating with the passage during normal operation of the well to allow flow of well fluids through the passage in the storm choke body, a cylinder in the storm choke body, said cylinder having a first opening at one end for admission of well fluids, a hydraulic fluid pressure line opening into the cylinder at the end opposite said first opening, a piston in the cylinder exposed at one end to well fluids and at the other end to the hydraulic fluid, means linking the piston and valve plug adapted to rotate the valve upon movement of the piston, a source of hydraulic fluid under pressure connected to the hydraulic fluid pressure line, and means for changing the pressure on the hydraulic fluid whereby the piston moves in response to the change in the relative pressures on its ends to rotate the valve and thereby move the port therein out of communication with the passage in the storm choke body to shut down the well.

6. A storm choke adapted for arrangement in a well having a casing and a tubing string extending downwardly in the casing comprising a storm choke body in the tubing string having a passage extending longitudinally therethrough to permit flow through the tubing string, a valve plug rotatably mounted in the storm choke body and extending across the passage, said valve plug having a port therein positioned to communicate with the passage and allow flow therethrough during normal operation of the well, a packer below the storm choke body engaging the casing and tubing string, a cylinder in the storm choke body, an actuating fluid pressure line opening into the cylinder at one end, said cylinder having a passage communicating with the well fluids at the end opposite the actuating fluid pressure line, a piston slidable in the cylinder, said piston having one end exposed to the actuating fluid and the other end exposed to the well fluids, means linking the piston and valve plug adapted to rotate the valve plug upon movement of the piston in the cylinder, a source of actuating fluid connected to the pressure line, and means for changing the pressure on the actuating fluid and thereby changing the relative pressure on the end of the piston whereby the piston moves in the cylinder to rotate the valve plug and shut down the well.

7. Apparatus for a dual-zone well comprising a casing extending from the well head to the lower production zone having perforations in the casing at the upper and lower production zones, a packer positioned within the casing between the upper and lower production zones, a storm choke within the casing near the upper end thereof engaging the inner walls of the casing to prevent flow between the storm choke and the casing, said storm choke comprising a body having a first passage and a second passage extending longitudinally therethrough

8

from the lower to the upper end of the body, a tubing string secured to the lower end of the body and extending from the second passage below the packer, a first tubing extending upwardly from the first passage in the storm choke body to the well head, a second tubing extending upwardly from the second passage in the storm choke body to the well head, a valve chamber extending transversely of the storm choke body intersecting the first passage and the second passage, a valve plug rotatable in the valve chamber, a first port and a second port in the valve plug in alignment with the first passage and the second passage respectively, said valve ports communicating with the respective passages during normal operation of the well, a cylinder extending vertically through the storm choke body, a piston slidably mounted in the cylinder, said piston being exposed to well fluids at its lower end, a rack gear extending vertically along the surface of the piston, a pinion gear on the valve plug engaging the rack gear, a pressure line opening into the cylinder above the piston for supplying hydraulic fluid under pressure, means for maintaining the hydraulic fluid under pressure whereby the piston is held at a lower position in the cylinder and means for releasing the pressure on the hydraulic fluid whereby the piston moves upward in the cylinder and rotates the plug valve through the gears to shut off the well.

8. A storm choke adapted for arrangement within the casing of a dual-zone well comprising a tubing string extending downwardly within the casing below the level of the upper producing zone, a packer engaging the tubing string and the casing of the well below the level of the upper producing zone to prevent flow between the two producing zones, a storm choke body in the tubing string, packing means extending from the outer surface of the storm choke body to prevent flow between the storm choke body and the casing, said storm choke body having a first and a second passage therethrough, the tubing string being connected at the lower end of a passage to extend down below the packer to the lower producing zone and at the upper end of a passage to extend upwardly to the well head, a rotatable valve plug positioned in the chamber to extend across the first and second passage, said valve plug having a first port and a second port communicating with the first passage and second passage respectively to allow flow therethrough during normal operation of the well, a pinion gear on said valve plug, a cylinder in the storm choke body, a piston slidable in the cylinder, an actuating fluid supply line opening into the cylinder at one end, an opening from the end of the cylinder opposite the actuating fluid supply line to the well fluids below the storm choke body, a rack gear on said piston engaging the pinion gear on the rotatable valve plug, and means for changing the pressure on the actuating fluid whereby the relative pressures on the ends of the piston are changed to move the piston in the cylinder and thereby rotate the valve plug to shut down the well.

9. A storm choke adapted for arrangement within the casing of a dual-zone well comprising a storm choke body, packing means extending from the outer surface of the storm choke body to the inner surface of the casing to prevent flow of well fluids therebetween, a pair of passages extending from the upper to the lower end of the storm choke body, a tubing string connected at the lower end of one of the passages extending downwardly in the casing to below the level of the upper zone of the well, a packer between the lower and the upper zone of the well engaging the tubing string and casing to prevent flow from the upper zone into the tubing string, a rotatable valve plug in each of the passages in the storm choke body having a pinion gear thereon, a port in each of the valve plugs communicating with the passages through the storm choke body during normal operation of the well to allow flow of fluids therethrough, a cylinder in the storm choke body, a piston slidable in the

9

cylinder, an actuating fluids supply line opening into the upper end of the cylinder above the piston, an opening below the piston extending from the cylinder through the storm choke body to allow well fluids to enter the cylinder and exert pressure against the the lower end of the piston, a rack gear on the piston engaging the pinion gears, and means for releasing the pressure on the actuating fluid whereby the pressure of the well fluids moves the piston to rotate the valve plugs to the closed position.

5

10

10

References Cited in the file of this patent

UNITED STATES PATENTS

891,065	Heeter	June 16, 1908
1,492,856	McCurdy	May 6, 1924
1,834,063	King et al.	Dec. 1, 1931
2,351,322	Crake	June 13, 1944

FOREIGN PATENTS

294,927	Germany	Nov. 1, 1916
---------	---------	--------------