

June 18, 1957

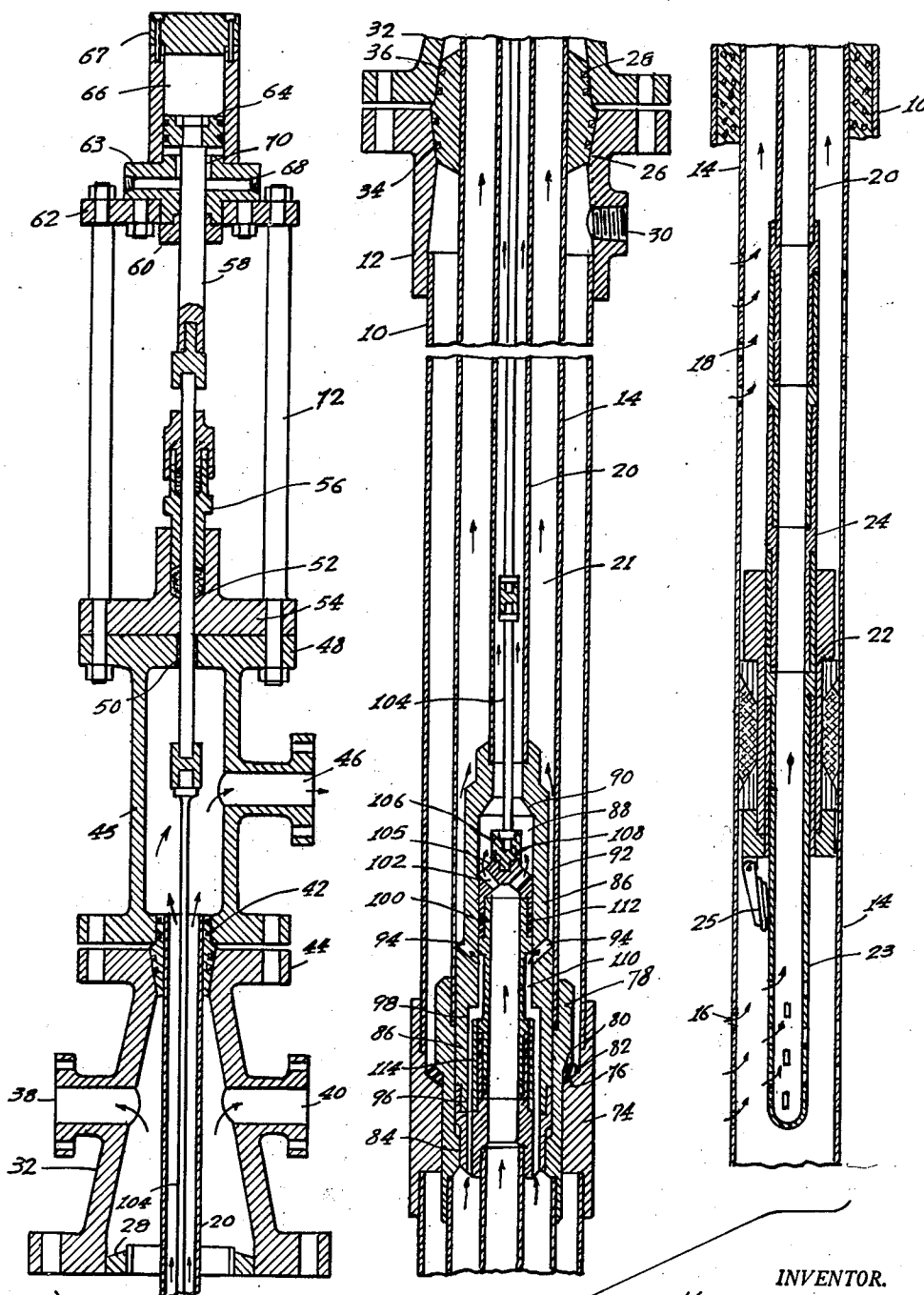
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POSITIVE-ACTION STORM CHOKE FOR DUAL-ZONE COMPLETIONS

Filed May 26, 1954

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

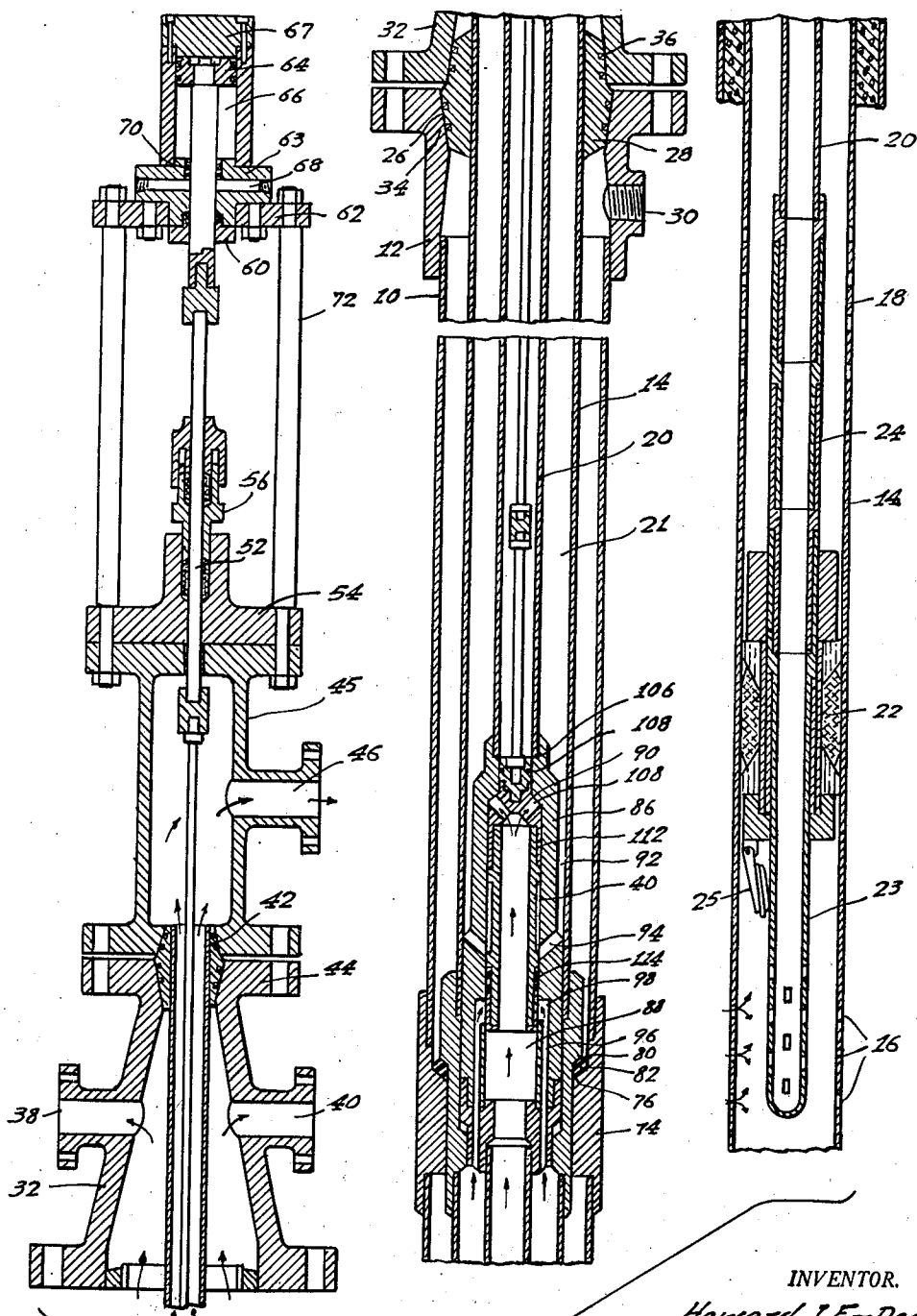


Fig. 2

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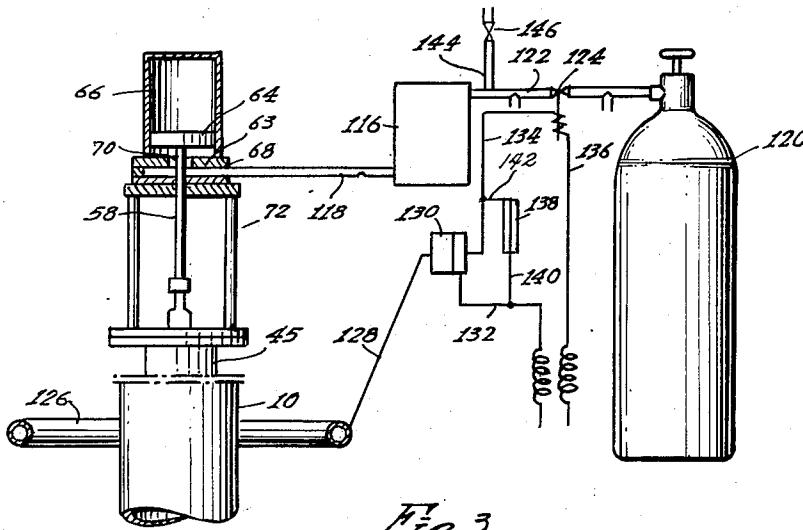
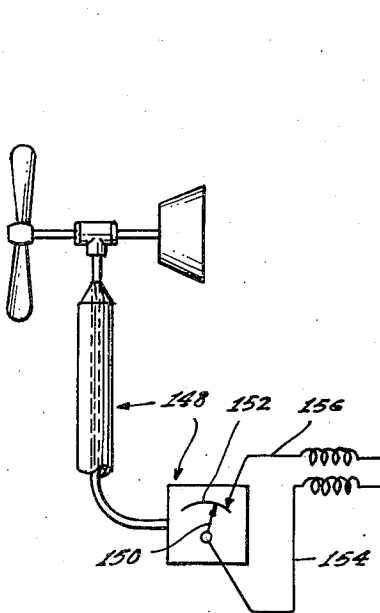
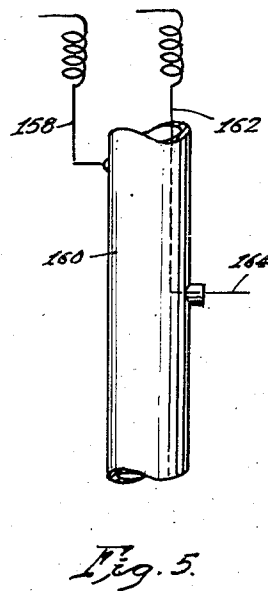
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3 Sheets-Sheet 3



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POSITIVE-ACTION STORM CHOKE FOR DUAL-ZONE COMPLETIONS

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4 Claims. (Cl. 166—73)

This invention relates to apparatus for stopping the flow of fluids in wells and particularly to a storm choke actuated by hazardous or potentially hazardous operating conditions at the well head to shut off flow from each zone of a dual-zone well.

The offshore drilling of oil wells has increased the need of automatic apparatus for shutting down the wells when hazardous or potentially hazardous conditions exist at the well head. In addition to the hazards normally encountered in operations on land, offshore wells may be endangered by abnormal wind or wave conditions caused by storms or by collision of vessels with equipment at the well head. Moreover, rough seas may prevent servicing of the well for extended periods; consequently a choke should shut down the well in the event of rupture or excessive leakage of lines at the well head or from the well to the shore. It is desirable that apparatus be provided for automatically shutting down the production of the well when potentially hazardous conditions exist at the well head to preclude the possibility of fire.

While a storm choke for shutting down the well should be actuated by apparatus at the surface, the choke itself should be located within the well bore in order that any damage that occurs at the surface will not impair the operation of the device. The storm choke should permit conventional methods of well completion to be employed and should permit use of conventional well equipment.

This invention resides in a storm choke positioned below the surface of a dual-zone well, but above the upper production zone for shutting down production from both zones of the well when hazardous or potentially hazardous conditions exist. The storm choke has side passages through which production from the upper zone passes and a central passage through which production from the lower zone passes. A connecting member actuated at the well head in response to hazardous or potentially hazardous conditions moves a mandrel in the storm choke which closes both the side and central passages to flow to shut down production from both zones.

In the drawings:

Figure 1 is a longitudinal sectional view of an embodiment of this invention illustrating the storm choke of this invention in the open position in a dual-zone well. Figure 1 has been divided into sections to enlarge the drawings. The well head is at the upper end of the left hand section and the lower production zone is at the lower end of the right hand section.

Figure 2 is a similar longitudinal sectional view of the embodiment of this invention illustrated in Figure 1 with the storm choke in the closed position.

Figure 3 is a diagrammatic illustration of an embodiment of apparatus at the well head for actuating the storm choke when hazardous or potentially hazardous conditions exist at the well head.

Figure 4 is a diagrammatic showing of apparatus for actuating the storm choke in the event of high winds.

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Figure 5 is a diagrammatic illustration of apparatus for actuating the storm choke in the event of high waves.

Referring to Figure 1, a surface casing 10 is illustrated extending downwardly from a casing head hanger 12 located at the well head. Ordinarily, in offshore wells, the surface casing 10 will be surrounded by a suitable conductor pipe, not shown, cemented to the surface by conventional procedures. The surface casing 10 which is cemented at its lower end extends downwardly to a depth which will be determined by the usual considerations in drilling practice and will not be limited by this invention.

A production casing 14 positioned within the surface casing extends downwardly from the well head at least to a position immediately above the lower production zone of the well. In some instances, the production casing 14 will extend completely to the bottom of the bore hole, as illustrated in the drawings, in which event it is perforated at 16 opposite the lower production zone and at 18 opposite the upper production zone. The production casing 14 is cemented in position in the well to seal the space between the well bore and the outer surface of the casing to prevent flow along the outer surface of the casing between the upper and lower production zones.

A tubing string 20 extends through the production casing 14 from the well head to the lower production zone. The resulting annulus 21 between the tubing string 20 and the casing 14 provides a passage for production from the upper zone, as hereinafter described. The tubing string 20 is provided with a perforated production tube 23 at its lower end through which oil from the lower production zone passes into the tubing and flows upwardly through the tubing to the well head. Flow through the annulus 21 from the upper production zone to the perforated tube 23 is prevented during normal operation in the usual manner by a production packer 22 engaging the inner surface of the casing immediately above the lower production zone and a tubing seal packer 24, which forms a portion of the tubing string, fitting snugly within packer 22. A cap 25 at the lower end of the packer 22 is held open by perforated tube 23.

The casing head hanger 12 has a tapered inner surface 26 at its upper end for the support of a casing hanger 28 from which the production casing 14 is suspended. Casing head hanger 12 is ordinarily provided with a side outlet 30.

A casing head 32 flanged at its lower and upper ends is mounted directly above the casing head hanger 12. The lower end of the casing head 32 rests on the upper surface of the casing hanger 28. Leakage between the casing hanger 28 and the casing head hanger 12 and between casing hanger 28 and casing head 32 is prevented by packing 34 and 36, respectively.

The upper end of the casing 14 opens into the casing head 32 at the upper surface of the casing hanger 28. Thus, production through the annulus 21 is discharged into the casing head 32 which is provided with side outlets 38 and 40 to which suitable valves and lines, not shown, for the control and distribution of production are attached. The tubing string 20 is supported at its upper end by a tubing hanger 42 which in turn is supported in an upper flange 44 of the casing head 32. A flanged tubing head spool 45 on the upper end of the casing head 32 and the tapered upper surface of the tubing hanger 42 forms a chamber into which the upper end of the tubing string 20 opens. Production through the tubing is discharged into the tubing head spool 45 from which it is discharged through a side outlet 46 equipped with suitable connections, not shown, for control of the tubing production.

The upper flange 48 of the tubing head spool is provided with a central opening 50 through which a polish

rod 52 passes. Mounted on the upper surface of flange 48 is a bushing 54 forming a support for a stuffing box 56 of conventional design. The polish rod 52 passes through the bushing 54 and stuffing box 56 and is connected at its upper end to a piston rod 58. The piston rod 58 extends through a packing gland 60, flange 62, and cylinder base 63 and is connected at its upper end to a hydraulic piston 64 in a hydraulic cylinder 66. The hydraulic cylinder is closed at its upper end by a cylinder head 67. Hydraulic fluid is introduced into, or is withdrawn from, the hydraulic cylinder 66 through inlet 68 in the base 63 and passage 70 between the piston rod and the base. Heavy tie rods 72 support the flange 62 above bushing 54.

Forming a part of the surface casing 10 is a storm choke casing unit 74 having a shoulder 76 extending inwardly into the annular space between the surface casing 10 and production casing 14. A storm choke casing insert 78 secured at its top and bottom to sections of the production casing 14 has an outwardly extending shoulder 80 resting on packing 82 which in turn rests on shoulder 76 to prevent any flow which might develop between the surface casing 10 and production casing 14. The storm choke casing insert 78 is a tubular member having an inwardly extending shoulder 84 at its lower end.

In the description of this invention, the tubing string 20 is divided into an upper section and a lower section. The upper section is the portion of the tubing string above the storm choke of this invention and the lower section is the portion of the tubing string below the storm choke. A tubular member suspended from the lower end of the upper section of the tubing string 20 forms a storm choke body 86. The storm choke body 86 has an opening of substantially the tubing diameter at its upper end and a central bore 88 of enlarged diameter in its lower portion. A tapered section joining the opening in the upper portion of the storm choke body and the central bore 88 forms a valve seat 90 for stopping flow through the tubing when the storm choke operates.

The storm choke body 86 is provided with longitudinal grooves in its outer surface at its upper end which form passages 92 between the outer surface of the storm choke body and the inner surface of the production casing 14. Diagonal conduits 94 extend from the lower end of the grooves into the central bore 88 of the storm choke body. Vertical conduits 96 run from the lower end of the storm choke body, parallel to the central bore 88, to a position spaced below the opening of the diagonal conduits 94 into the central bore, and join chambers 98 which open into the central bore.

It is not essential to the invention that the storm choke casing unit 74 and storm choke casing insert 78 be as illustrated in detail in the drawings. The annulus between the surface casing 10 and production casing 14 is closed by cementing; hence, the arrangement of shoulders 76 and 80 with packing 82 is not necessary to prevent flow between casing 14 and surface casing 10. Similarly, a packer on the inner surface of the production casing 14 of suitable internal diameter to receive the storm choke body 86 may be employed to seal the space between the outer surface of the storm choke body 86 and the inner surface of the production casing 14, and possesses the advantage of allowing greater depth tolerance in positioning the storm choke body.

A tubular mandrel 100, closed at its upper end except for diagonal passages 102, is suspended within the central bore 88 of the storm choke body 86 by any suitable connecting member which in turn is connected at its upper end to the lower end of the polish rod 52. In the embodiment illustrated in the drawings the connecting member is a sucker rod 104; however, a steel cable has the advantage of being able to transmit the necessary lift even though the surface pipe were bent. The mandrel 100 has a tapered upper surface 105 adapted to engage

the valve seat 90 of the storm choke body and also has a plug 106 on its upper end of proper diameter to enter the opening in the upper end of the storm choke body 86. Leakage between the plug 106 and the walls of the storm choke body when the mandrel is in the upper, closed position is prevented by packing 108.

Centrally located on the outer surface of the mandrel 100 is a circumferential groove 110 of reduced diameter which provides passages between the outer surface of the mandrel and the wall of the central bore 88 of the storm choke body. The circumferential groove 110 is sufficiently long to extend from the chambers 98 to the lower end of the diagonal conduits 94 in order to permit flow from the vertical conduits 96 in the lower end of the storm choke body to the passages 92 and thereby permit flow from the annulus 21 below the storm choke device to the annulus 21 above the storm choke device during normal operation. Leakage of fluid between the outer surface of the mandrel and the inner surface of the storm choke body is prevented by packing 112 and 114. The lower section of the tubing string 20 is suspended from the lower end of the storm choke body 86.

In the completion of the well, the storm choke casing unit 74 is installed with the installation of the surface casing 10, preferably at about or below the mud line. The production casing 14, with the storm choke casing insert 78 in the casing string, is lowered into the well and cemented between the production casing 14 and bore hole in the usual manner. Prior to setting of the cement, the casing string is lowered to its final location at which shoulder 80 engages the packing 82. The tubing string 20, with the storm choke body 86 and storm choke mandrel 100 installed, is lowered into the well to bring the perforated section 23 at the lower end of the tubing string immediately above the cap 25 at the bottom of the production packer 22. The tubing hanger 42 is replaced during the well completion with a suitable slick joint which will allow vertical movement of the tubing string.

At this stage of the completion of the well, the cap 25 is closed to prevent flow from the lower producing zone into either the tubing string 20 or the annulus 21; and the storm choke body 86 is above the storm choke casing insert 78. With the storm choke mandrel 100 in the lower position in the storm choke body 86 illustrated in Figure 1, production from the upper zone is established by back circulation with oil base mud, oil or water as required to reduce the weight of the mud sufficiently for the pressure of the upper zone to overcome the hydrostatic pressure of the well fluid. Once flow has been established, the storm choke mandrel 100 is raised by means of sucker rod 104 to bring the tapered surface 105 into contact with the seat 90 and the circumferential groove 110 out of communication with the chambers 98. Some flow may then pass from the upper production zone upward through annulus 21 and between the outer surface of the storm choke body 86 and the casing 14 to the outlets 38 and 40.

The tubing string is then lowered by means of the slick joint which has replaced the tubing hanger 42 until the tubing string is below production packer 22 and in communication with the lower production zone. At this position the storm choke body 86 rests on the packing on the shoulder 84 to prevent leakage between the storm choke body and the production casing 14. All of the production from the well is then shut down and the temporary slick joint is replaced with the tubing hanger 42 and the well head connections completed.

To start the well in operation after the completion described above, or operation of the storm choke, pressure is built up in the upper section of the tubing string to overcome the pressure drop across the packing 108 in the upper end of the mandrel. The weight of the mandrel 100 and sucker rod drops the mandrel to the position illustrated in Figure 1 which allows flow to proceed from both zones. Production from the lower zone passes up through the tubing string 20 and the mandrel 100 to the

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well head. Flow from the upper zone is through annulus 21, vertical conduits 96, chambers 98, circumferential groove 110, conduits 94, passages 92 and annulus 21 to the well head.

For operation of the storm choke, the hydraulic fluid inlets 68 are connected to a suitable source of hydraulic fluid which when exposed to hazardous conditions at the well head will be under sufficient pressure to raise the piston 64 and thereby raise the mandrel 100 and shut down production from both zones. An embodiment of apparatus suitable for actuating the storm choke device of this invention to shut down production of both zones of a dual-zone well simultaneously, when there is danger of collision at the well head or the temperature at the well head is sufficiently high to indicate a hazardous condition, is illustrated schematically in Figure 3 of the drawings. The hydraulic piston 64, hydraulic cylinder 66, cylinder base 63, supporting tie rods 72 and tubing head spool 45 are illustrated in Figure 3; however, the portion of the well head equipment between the tubing head spool 45 and some point on the surface casing 10 below the casing head hanger 12 has been omitted for simplification of the drawing.

A reservoir 116 adapted to withstand high pressures is provided at the well head for storage of hydraulic fluid for operation of the hydraulic piston 64. A line 118 extends from the bottom of reservoir 116 and is connected with inlet 68 in the base 63. A cylinder 120 of a gas under pressure is connected with the reservoir 116 above the level of the hydraulic fluid therein by a line 122. A solenoid valve 124 in line 122 controls flow of the gas from cylinder 120 through line 122. Solenoid valve 124 is closed during normal operation of the well.

A pneumatic safety ring 126 is supported around the surface casing 10 of the well at any desired elevation. A line 128 connects the pneumatic safety ring 126 with a pressure switch 130 in the circuit from a source of electrical energy to the solenoid valve 124. The switch 130 is connected to the source of electrical energy through a lead line 132 and to the solenoid valve through a lead line 134. The circuit from the solenoid valve to the source of electrical energy is completed through lead line 136. In parallel with the pressure switch 130 is a thermostatic switch 138 which is connected to electrical lead lines 132 and 134 through lead lines 140 and 142, respectively.

In the event of collision of some object with the pneumatic safety ring 126, a pressure wave is transmitted through line 128 to pressure switch 130 to close the contacts in that switch and complete the electrical circuit to the solenoid valve 134. The solenoid is energized to open the valve 124 and allow the flow of the compressed gas from the cylinder into the reservoir 116. The hydraulic fluid is forced through line 118, into inlet 68, through passages 70, and into the hydraulic cylinder 66 below piston 64. The hydraulic piston is raised which lifts piston rod 58 and sucker rod 104 (not shown in Figure 3) thereby raising the mandrel 100 in the storm choke body 86 to the position illustrated in Figure 2 to shut down production from both zones of the well. Once the mandrel is raised to the upper position, the pressure from the producing zones of the well holds the mandrel in that position until it is desired to commence operation of the well again. When the well is to be started in operation again, the solenoid valve 124 is reset and the pressure on the hydraulic fluid is relieved through a lead line 144 and valve 146. The mandrel is then dropped to the lower or normal producing position, in the manner described for the commencement of operation on completion of the well.

The apparatus illustrated diagrammatically in Figure 3 may receive its signal in response to other hazardous conditions. For example, in Figure 4 a wind velocity indicator, indicated generally by reference numeral 148, actuates a moving contact 150 to close a circuit to a contact 152 which has been preset for the circuit to be

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closed when the wind exceeds the maximum velocity which will allow safe operation of the well. Contact 150 can be connected to lead line 132 through a line 154 and contact 152 can be connected to lead line 134 through a lead line 156. When the circuit is closed between contacts 150 and 152, solenoid valve 124 is actuated to bring the storm choke device of this invention into operation.

The apparatus illustrated in Figure 5 operates the storm choke when the waves rise above a height believed to be safe. A lead line 158 is connected to a conducting member 160 which is supported in any suitable manner at the desired elevation at the well head. A second lead line 162 is insulated from the conducting member 160 and is connected at its lower end to a wave height contact 164, also insulated from member 160. When the waves are sufficiently high to cover contact 164, the circuit between lead lines 158 and 162 is closed through the salt water. Lead lines 158 and 162 may be connected in a circuit to the solenoid valve 124 to operate that valve when the circuit is closed.

I claim:

1. A dual zone well comprising a casing extending from a well head through an upper production zone to a lower production zone, a tubing string extending from the well head and upper production zone through the casing to the lower production zone, said tubing string having an outer diameter less than the inner diameter of the casing to form an annulus between the tubing string and casing, perforations in the casing at the upper production zone, means between the upper production zone and lower production zone closing the annulus, a storm choke body forming a part of the tubing string above the level of the upper production zone, means engaging the casing and storm choke body to prevent flow from the portion of the annulus below the storm choke body to the portion of the annulus above the storm choke body, a central bore in the storm choke body, passages at the upper end of the storm choke body from the central bore communicating with the annulus above the storm choke body, conduits extending from the annulus below the storm choke body substantially parallel to the central bore and opening into the central bore at their upper end, a hollow mandrel slidable in the central bore, said mandrel having passages therein permitting flow from the tubing string below the storm choke body through the mandrel and storm choke body to the tubing string above the storm choke body and from the conduits to the passages when in a normal position and movable to an upper position preventing flow from below the storm choke body to above the storm choke body, a connecting member secured at its lower end to the mandrel extending upwardly to the well head, and means at the well head for moving the connecting member to move the mandrel from the normally open position to the upper position to shut down production from both zones.

2. A dual-zone well comprising a casing extending downwardly from a well head through an upper production zone to a lower production zone, a tubing string extending from the well head downwardly through the casing to the lower production zone, said tubing string having an outer diameter smaller than the inner diameter of the casing to form an annulus through which production from the upper zone flows, perforations in the casing for the admission of production from the upper production zone, means for closing the annulus below the level of the perforations, a storm choke body forming a part of the tubing string above the upper production zone, a central bore extending through the storm choke body from an inlet at its lower end to an outlet of smaller diameter than the central bore at its upper end, a valve seat joining the upper end of the central bore with the outlet, upper passages in the storm choke body communicating with the central bore at one end and the annulus above the storm choke body at the other end, lower passages in the storm choke body communicating with the annulus

below the storm choke body at their lower end and with the central bore at their upper end, a tubular mandrel slidable within the central bore, said mandrel having a ring of reduced diameter in its outer surface permitting communication between the upper and lower passages when the mandrel is in a lower normal position, ports opening from within the tubular mandrel into the central bore of the storm choke body, a connecting member attached at its lower end to the mandrel and extending to the well head, and means at the well head for moving the connecting member to move the mandrel from the lower normal position permitting flow through the storm choke to an upper position at which the mandrel engages the valve seat and at least one of the passages is out of communication with the ring of reduced diameter on the mandrel whereby flow from both production zones is prevented.

3. A storm choke for substantially simultaneously shutting down production from a dual-zone well having a casing extending down the well at least to immediately above the lower production zone, a tubing string extending down the well within the casing to the lower production zone and means for sealing the annulus between the tubing string and casing below the upper production zone comprising a hollow storm choke body in the tubing string, means preventing flow between the storm choke body and the casing, said storm choke body having a central bore, upper passages extending from the central bore to the annulus above the storm choke body, lower passages extending from the central bore to the annulus below the storm choke body, a mandrel slidable in the central bore, said mandrel being open at its lower end and having outlet ports extending through its walls from the opening therein whereby tubing production normally flows through the mandrel, conduits formed by the mandrel normally allowing flow from the lower passages to the upper passages, a connecting member attached to the mandrel and extending through the tubing string to the well head, means at the well head for raising the connecting member to lift the mandrel in the storm choke body and move the outlet ports against the storm choke body and the conduits out of communication with at least one of the passages to shut down production from both zones.

4. A storm choke for substantially simultaneously shutting down production from a dual-zone well having a casing extending down the well to below the upper production zone, a tubing string within the casing extending down the well to the lower production zone, and means for closing the annulus formed by the casing and tubing string below the upper production zone, said storm choke comprising a tubular storm choke body in the tubing string above the upper production zone, means preventing flow from below the storm choke body to above the storm choke body between the storm choke body and the casing, said tubular storm choke body having a central passage extending therethrough communicating at each end with the tubing string, a valve seat in the central passage, an upper passage in the storm choke body extending from the central passage to the annulus between the casing and tubing string above the storm choke body, a lower passage in the storm choke body extending from the annulus below the storm choke body to the central passage, a hollow mandrel slidable in the central passage having ports therein to allow flow from the tubing string through the mandrel, a surface on the mandrel adapted to engage the valve seat and prevent flow through the mandrel when the mandrel is in the upper position, a portion of the outer surface of the mandrel being spaced from the wall of the central passage to permit flow from the lower passage to the upper passage when the mandrel is in the normal operating position, a connecting member extending from the mandrel to the well head, and means at the well head for moving the connecting member to move the mandrel from the normal position to the upper position to prevent flow from the well.

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