April 22, 1958 H. J. EN DEAN ET AL 2,831,539

AUTOMATIC DUAL-ZONE STORM CHOKE

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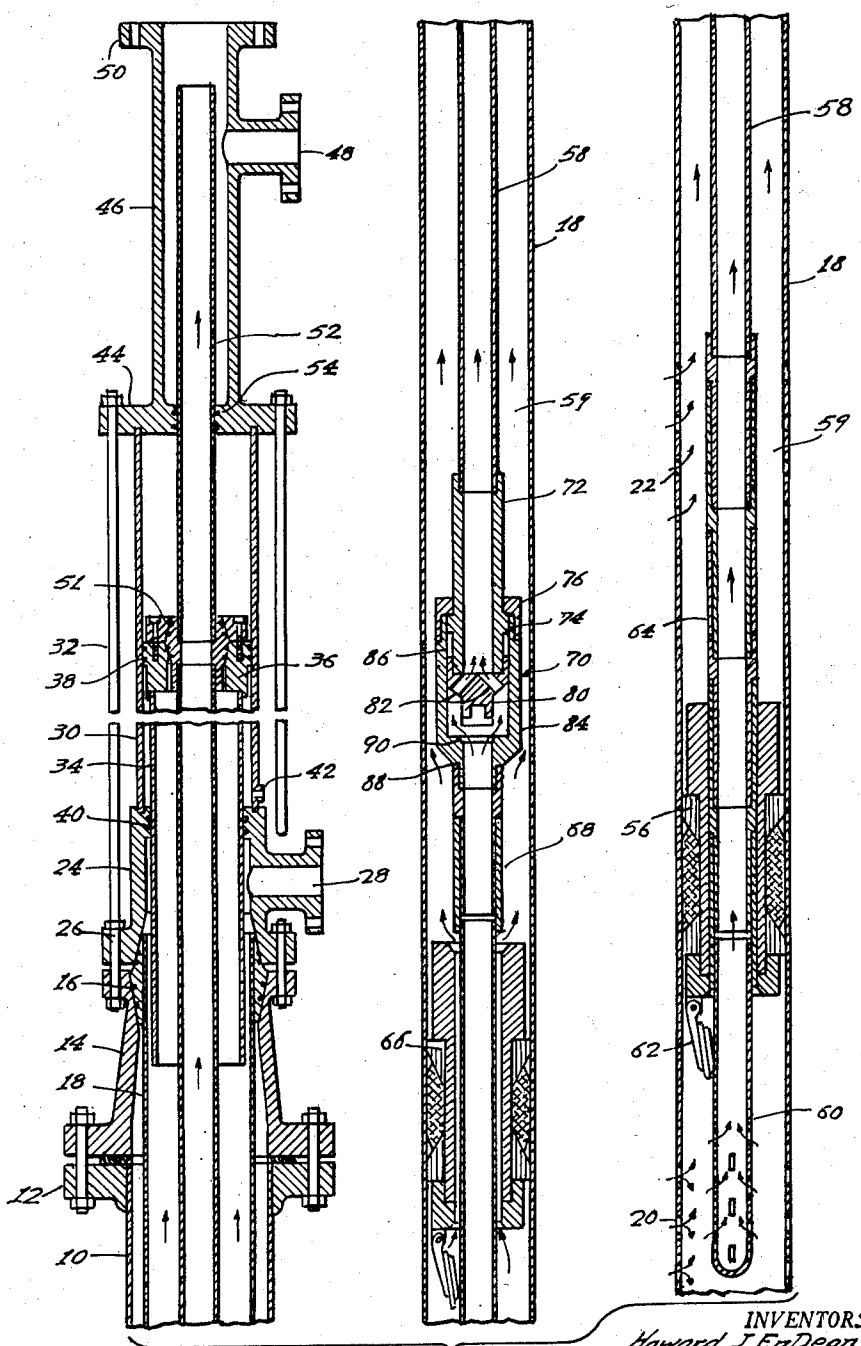



Fig. 1.

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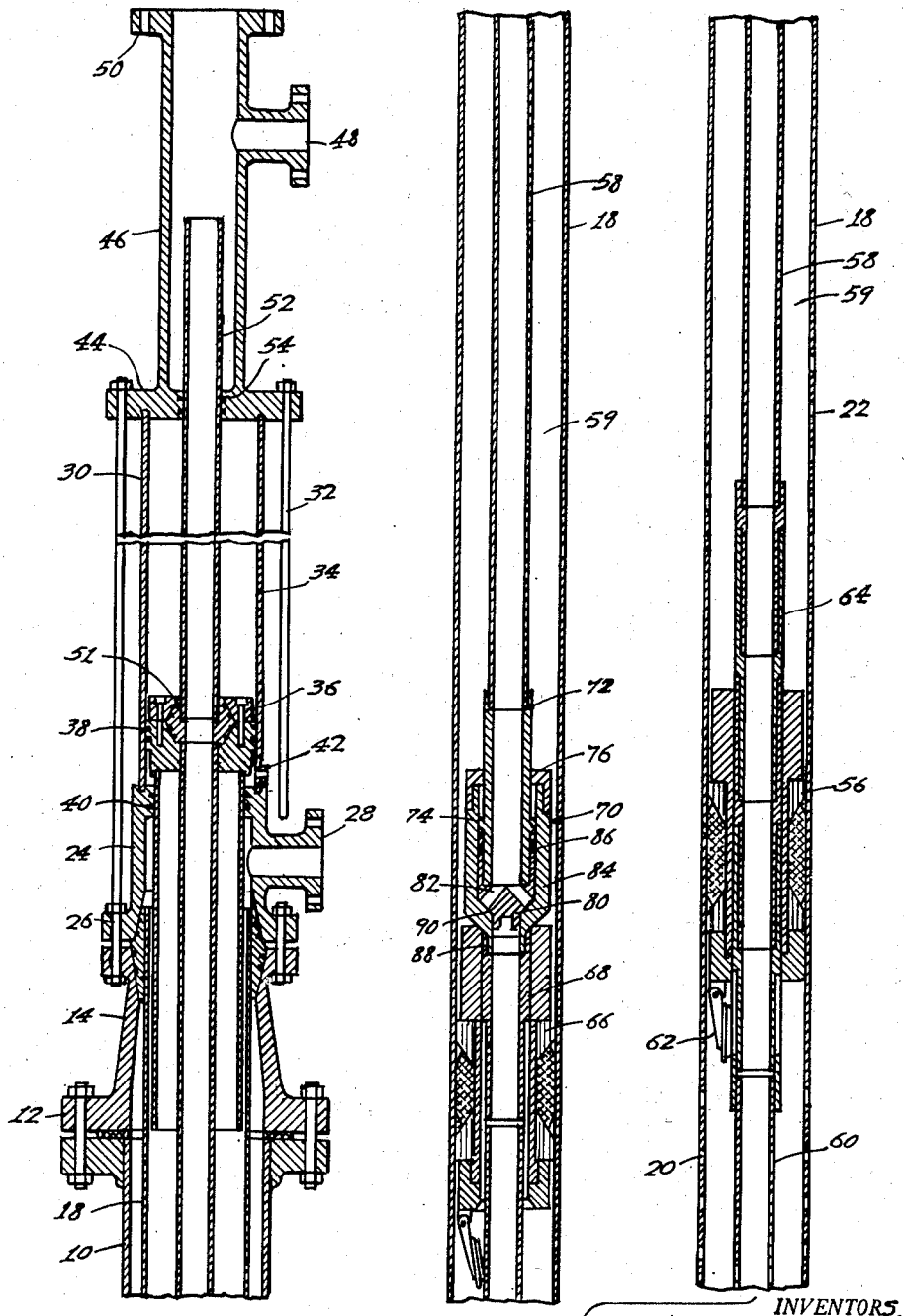



Fig. 2.

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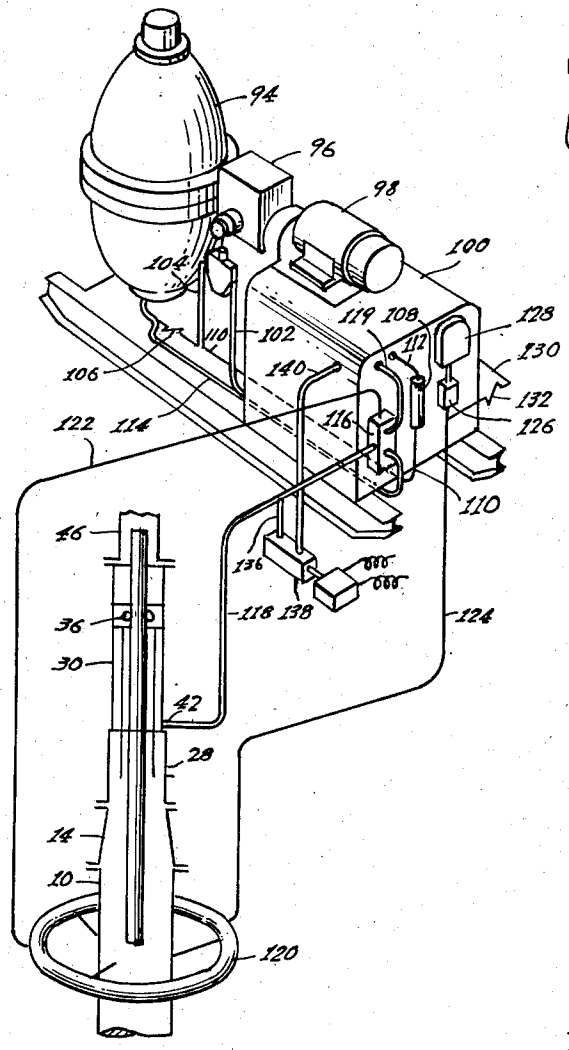



Fig. 3.

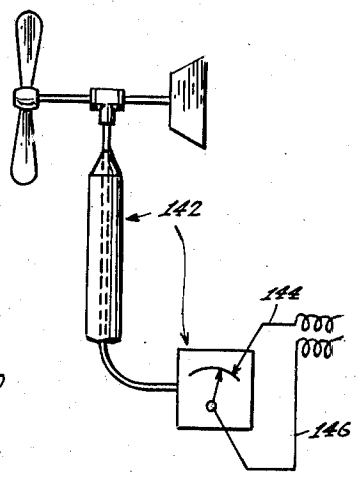



Fig. 4.

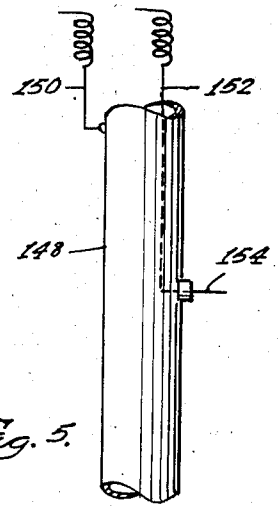



Fig. 5.

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United States Patent Office 2,831,539 Patented Apr. 22, 1958



2,831,539

# AUTOMATIC DUAL-ZONE STORM CHOKE

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6 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 the 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 wall completion to be employed and should permit use of conventional well equipment.

This invention resides in an automatically operating storm choke responsive to hazardous or potentially hazardous conditions at the well head and operated by moving a portion of the tubing string downwardly in the well to actuate valve means within the well and simultaneously close off production from each zone of a dual-zone well.

Figure 1 is a longitudinal sectional view of an embodiment of this invention in its open and producing position in a dual-zone well. Figure 1 has been divided into three sections with the well head at the upper end of the left hand section and the lower producing zone at the lower end of the right hand section.

Figure 2 is a sectional view, similar to Figure 1, of the storm choke of this invention in the closed position.

Figure 3 is a schematic drawing of apparatus at the well head for actuating the storm choke.

Figure 4 is a schematic drawing of a device actuated by high winds for operating the storm choke.

Figure 5 is a schematic illustration of a device for operating the storm choke when exposed to high waves.

Referring to Figure 1 of the drawings, the well is illustrated having a surface casing 10 provided with a flange 12 at its upper end. The surface casing 10 is of conventional structure and extends down into the well bore any desired distance, depending upon the purpose of the surface casing in the particular well. The surface casing 10 is closed at its lower end by a conventional cementing procedure.



A casing head 14 secured to the upper surface of flange 12 provides support for a casing boll weevil 16 from which production casing 18 is suspended. The production casing may extend all of the way to the bottom of the bore hole, but in any event will extend down to a position immediately above the lower production zone of the well. The casing 18 is cemented in the usual manner between the upper and lower production zones to prevent flow between the two zones. If production casing 18 is extended below the lower production zone, it is perforated as indicated by reference numeral 20 at the lower production zone, as well as at the upper production zone as indicated by reference numeral 22.

A casing production housing 24 mounted on the upper end of the boll weevil 16 and secured to casing head 14 by any suitable means, such as bolts 26, has a side outlet 28 for the discharge of production from the upper production zone. A hydraulic cylinder 30 is mounted on the upper end of the casing production housing 24 and held in place by means of tie rods 32. A piston liner 34 is secured at its upper end to a hydraulic piston 36 in the hydraulic cylinder 30 and extends downwardly through the open upper end of the casing production housing 24. Leakage of hydraulic fluid past the piston 36 or past the piston liner 34 into the casing production housing 24 is prevented by packing rings 38 and 40, respectively. The piston liner 34 is of sufficient length to extend through the packing rings 40 when the piston 36 is at its uppermost position. Hydraulic fluid is introduced into the hydraulic cylinder through an inlet 42.

The upper end of the hydraulic cylinder 30 is closed by the lower flange 44 of a slick joint housing 46. The slick joint housing is provided with a flanged side outlet 48 and an upper flange 50 for the installation of conventional well head fittings.

Secured in a boll weevil 51 mounted on the piston 36 and extending upwardly through an opening in the flange 44 is a slick joint 52 which serves as an extension of the tubing. The slick joint 52 is of sufficient length to extend above the flange 44 when the piston 36 is in its lowermost position and above upper flange 50 when the piston is at its uppermost position. Leakage from within the slick joint housing 46 into the hydraulic cylinder 30 is prevented by packing rings 54. The boll weevil 51 in the piston 36 supports the tubing string 58 which extends down into the well to the lower production zone. A perforated production tubing section 60 is attached to the lower end of the tubing 58. The tubing string 58 extends downwardly within the casing 18 to form an annulus 59 through which production from the upper zone passes.

Immediately above the lower production zone of the well is a production packer 56 which may be of conventional design. The production packer 56 is anchored firmly in place and provided with a ring of resilient material which prevents leakage of production between the outer surface of the packer 56 and the inner surface of the casing 18 in the usual manner. Production packer 56 is equipped with a pivotally mounted cap 62 at its lower end to close the tubing to upward flow unless the cap 62 is held in the open position. Flow through the annular space between the inner surface of the production packer 56 and the tubing string 58 is prevented by tubing seal packers 64 which close the annular opening. Tubing seal packers (sometimes referred to as tubing sealing nipples or as packer subs) are conventional elements having rings of packing material of slightly larger diameter than the tubing. The rings of packing engage the inner wall of the packer to prevent flow between the inner wall of the packer and the outer surface of the tubing string. It is preferred that several tubing seal packers be installed in the string of tubing, as illustrated in the

drawings, to permit vertical movement of the tubing without breaking the seal and allow a reasonable depth tolerance in setting the packer.

A second production packer 66 which may be identical with the production packer 56 is installed by the usual methods above the upper production zone. In the string of tubing normally positioned immediately above the second production packer 66 is a tubing seal packer 68, ordinarily of the same construction as tubing seal packers 64, and which is adapted to close the annular space between the tubing and the production packer 66 during the hazardous or potentially hazardous conditions, in the manner described later. The production packer 66 may be at any position above the level of the upper production zone. In the embodiment illustrated in the drawings, tubing seal packer 68 is secured directly to the lower end of the storm choke device of this invention.

The storm choke device, indicated generally by reference numeral 70, is mounted on the string of tubing 58 immediately above the level of the upper production packer 66 in order that the tubing seal packer 68 will engage the packer 66 in the manner to be described. Throughout this description that portion of the tubing string below the storm choke device 70 is designated as the lower section and that portion above the storm choke device is identified as the upper section. A hollow mandrel 72 suspended from the lower end of the upper section of the tubing string 58 has a ring 74 protruding from its outer surface to support a bushing 76 surrounding the mandrel. A valve plug 80 on the lower end of the mandrel 72 is provided with openings 82 through which tubing production passes during normal operation.

Extending downwardly from the bushing 76 and secured thereto by any suitable means such as screw threads is a tubular valve body 84 having an enlarged bore at its upper end in which the lower end of the mandrel 72 and the valve plug 80 slide. Leakage between the valve body 84 and the mandrel is prevented by packing 86 held between the ring 74 and the upper end of the valve plug 80. The valve body 84 tapers at its lower end to a nipple 88, having an inner diameter substantially the same as the tubing 58, from which the tubing seal packer 68 and lower section of the tubing string are suspended. A valve seat 90 is provided between the smaller opening of the nipple 88 and the enlarged bore of the valve body 84 for engagement with the valve plug 80 to shut down flow through the tubing 58.

Completion of the well with the storm choke device of this invention is accomplished in the following manner. The lower production packer 56 is set in the casing in the usual manner immediately above the lower production zone. The upper production packer 66 is set at any desired level above the upper production zone. The tubing string is then lowered until the perforated production tubing 60 is slightly above the cap 62 which is closed. During operations of this type, the well is dead due to the casing being filled with mud of sufficient density to counterbalance the pressure of the producing zones. In this position the tubing seal packers 64 are above the upper end of production packer 56 to permit flow between the inner surface of the packer and the outer surface of the perforated production tube 60, which has a smaller outer diameter than the tubing seal packer 64, into the tubing string 58. With the tubing string in this position, piston 36 and slick joint 52 are attached to the upper end of the tubing string with the piston at the upper end of the hydraulic cylinder 30.

A suitable valve is connected to the upper end of slick joint 52. Production from the upper production zone is then established by circulation procedures through the tubing string 58 and annulus 59 for reducing the hydrostatic head sufficiently that the pressure exerted by the upper production zone may establish natural flow. Flow is continued alternately through outlet 28 and slick joint 52 until all drilling fluid has been removed from the well bore. With the storm choke device at sufficient depth, production can also be established by conventional swabbing procedures.

With annular production established, the tubing string is lowered sufficiently for perforated section 60 to force cap 62 open and for tubing seal packers 64 to engage production packer 56 and support the lower end of the tubing. Upon continued downward movement of the tubing string, the valve plug 80 engages valve seat 90 to shut down production through the tubing. Production from the upper production zone is then directed upwardly through the annulus 59, then between the upper production packer 66 and the lower end of the tubing seal packer 68, and then out through the outlet 28 in the casing production housing. Accessory valve equipment attached to slick joint 52 is removed, conventional well head fittings attached to flange 50 and hydraulic equipment for actuation of the system connected to inlet 42. The hydraulic system is then actuated to raise the piston which in turn lifts the valve plug 80 from the valve seat 90 to open the tubing string. Production is then established from the lower production zone to the tubing string by conventional means, such as swabbing, if necessary. Since the fluid column of the tubing string has been lightened during completion of the upper zone of the well, in all probability production will be established as soon as valve plug 80 is lifted. If desired, production from the upper zone may be shut down after it has been established, and while lower zone production is being established, by lowering the tubing string sufficiently far to move the tubing seal packer 68 into production packer 66.

The hydraulic system may be connected to any conventional control means for releasing the pressure on the hydraulic system in response to hazardous conditions at the surface. For example, the hydraulic system may be controlled by a thermostat which will actuate circuits to release the pressure on the hydraulic system when the temperature exceeds a predetermined limit, such as would be caused by a fire. Other possibilities are controls which will be responsive to sudden changes in pressure resulting from a line breaking or controls actuated by floats responsive to abnormally high waves.

For the purpose of illustrating means for releasing the pressure on the hydraulic fluid in the hydraulic cylinder 30 when hazardous conditions exist at the well head, apparatus is diagrammatically shown in Figure 3 for protecting the well head against collision. Hydraulic fluid for the hydraulic cylinder 30 is maintained under pressure in an accumulator 94 by any convenient pump 96 driven by a motor 98. The motor 98, which is illustrated as an electric motor in Figure 3, but may be a gasoline motor, is mounted on the top of a low pressure reservoir 100 for the hydraulic fluid. An inlet line 102 extends from the reservoir 100 to the inlet of the pump 96 for delivery of the hydraulic fluid to the pump and an outlet line 104 extends from the outlet of the pump to the accumulator 94. A check valve 106 in line 104 prevents back flow from the accumulator to the pump. A pressure relief valve 108 is connected through a line 110 to the outlet line 104 for release of excessive pressures on the hydraulic fluid. The pressure relief valve 108 discharges through a line 112 into the reservoir 100.

A delivery line 114 extends from the bottom of the accumulator 94 to a three-way valve 116 mounted on the side of the reservoir 100. In the apparatus illustrated in Figure 3, three-way valve 116 is pneumatically operated. Valve 116 is normally open to deliver hydraulic fluid from the line 114 to a line 118 connected with the inlet 42 of the hydraulic cylinder 30, and will allow flow from both lines 118 and 114 through a pressure release line 119 to the reservoir 100 when actuated by a potentially hazardous condition, as will be described.

Surrounding the surface casing 10 of the well is a pneumatic safety ring 120 which may be supported at any desired height or allowed to float on the surface of the water. An air line 122 extends from the pneumatic safety ring 120 to the top of three-way valve 116 for operation of that valve in response to a signal from the pneumatic safety ring. A second air line 124 extends from the pneumatic safety ring to a pressure switch mounted on the end of the reservoir 100. The pressure switch 126 is operatively connected to a motor control switch 128 in the electric circuit to the motor 98. Compressed air for the operation of the pneumatic safety ring and pneumatically operated pressure switch is supplied to the line 130 from any convenient source, not shown. A check valve 132 in line 130 prevents dissipation of a signal from the pneumatic safety ring through line 130.

During normal operation of the well, the pump 96 maintains a supply of hydraulic fluid under pressure in accumulator 94. The hydraulic fluid flows from the accumulator through lines 114 and 118 and three-way valve 116 to the hydraulic cylinder 30 to maintain the piston 36 in the raised position. If an object approaching the well head strikes pneumatic safety ring 120, a compression wave is transmitted through line 122 to the three-way valve 116 to throw the valve and place line 114 in communication with pressure release line 119, thereby by-passing the hydraulic cylinder 30. The compression wave is also transmitted through line 124 to pressure switch 126 which throws motor control switch 128 and shuts down the pump 96. Pressure in the hydraulic cylinder is released by flow through line 118 and valve 116 to line 119.

The apparatus at the well head may also be made responsive to other potentially hazardous conditions. For this purpose a line 136 extends from line 118 to a solenoid operated two-way valve 138 which is connected to a line 140 for delivery of hydraulic fluid to the reservoir 100. The solenoid valve 138 may be operated by an electric signal received from any desired source. As mentioned above, a thermostat may be made to close the circuit when the temperature at the well head exceeds a predetermined level. Other devices for supplying a signal to operate the valve 138 are illustrated in Figures 4 and 5. In Figure 4, a wind velocity indicator, indicated generally by reference numeral 142, is provided with preset contacts. When the wind velocity exceeds a velocity which is predetermined to be the maximum safe velocity, the indicator 142 closes the circuit between electrical lead lines 144 and 146, thereby closing a circuit to the solenoid valve 138 to operate that valve and release pressure of the hydraulic fluid through lines 136 and 140. The motor can be allowed to continue running or another solenoid may be connected in a circuit with lead lines 144 and 146 to throw motor control switch 128 and shut down the pump.

In the apparatus in Figure 5, an electrically conducting member 148 is set at any desired height at the well head. An electrical lead line 150 is connected to the member 148 and in the circuit to the solenoid operated valve 138. A second electrical lead line 152 is insulated from member 148 and connected to a wave height contact 154. When the waves are sufficiently high to cover contact 154, the circuit to electrical lead lines 150 and 152 is closed to operate solenoid valve 138 and release the pressure of the hydraulic fluid in cylinder 30.

Release of the pressure on the hydraulic system will cause the piston to drop because of the weight of the tubing string. As the piston drops, the valve plug 80 moves down against the valve seat 90 to close tubing production. Downward movement of the tubing string also causes the tubing seal packer 68 to enter the upper casing production packer 66 and prevent flow through that packer, thereby shutting down the production from the upper production zone, as illustrated in Figure 2.

In the preferred embodiment of this invention which has been described, actuation of the storm choke is obtained by release of pressure on the hydraulic fluid in the hydraulic cylinder. This arrangement has the advantage that it is actuated by the weight of the tubing. It is not necessary for the storm conditions to set machinery into operation, other than the simple devices for release of the pressure on the hydraulic system, to cause the storm choke to shut down the production. However, if desired, the storm choke device of this invention may be actuated by means other than loss of hydraulic pressure. For example, an electric motor responsive to hazardous conditions may operate through suitable gear mechanism to lower the tubing string to shut down production.

The storm choke device of this invention is readily adaptable to conventional automatic control systems for activation under hazardous production conditions. The device is of simple design and construction and may be serviced without difficulty by field personnel. In addition, conventional well completion procedures for bringing in production may be employed.

We claim:

1. In a well producing from an upper and lower production zone, said well having a casing extending downwardly from a well head at least to immediately above the lower production zone and a tubing string concentric with the casing and extending downwardly from the well head through the casing to the lower production zone, said tubing string having an upper section and a lower section, a production packer in the casing between the upper production zone and lower production zone, and a tubing seal packer in the lower section of the tubing string engaging the production packer to prevent flow between the upper and lower production zones, the improvement comprising an upper production packer in the casing above the level of the upper production zone, an upper tubing seal packer forming a part of the lower section of the tubing string and positioned during operation of the well immediately above but spaced from the upper production packer and adapted to engage the packer to prevent flow between the outer surface of the tubing string and limit downward movement of the tubing string when the tubing string is lowered, a valve body at the upper end of the lower section of the tubing string above the upper tubing seal packer, a valve plug within the valve body and connected to the lower end of the upper section of the tubing string, said valve plug being vertically movable relative to the valve body from an upper position to a lower position, conduits in the valve body and valve plug constructed and arranged to allow flow between the lower section and upper section when the valve plug is in the upper position and prevent flow when the valve plug is in a lower position, a hydraulic cylinder at the well head, a hydraulic piston movable in the hydraulic cylinder, said upper section of the tubing string being supported by the hydraulic piston, hydraulic fluid under pressure in the hydraulic cylinder supporting the piston in an upper position and means for releasing the pressure on the hydraulic fluid whereby the upper section of the tubing string moves downwardly of its own weight to move the valve plug to the lower position relative to the valve body to close the conduits and thereby shut down tubing production and the lower section of the tubing string moves downwardly to move the upper tubing seal packer into the upper production packer and shut down production from the upper production zone.

2. In a well producing from an upper and lower production zone, said well having a casing extending downwardly from a well head below the upper production zone and a tubing string concentric with the casing and extending downwardly from the well head through the casing to the lower production zone, said tubing string having an upper section and a lower section, a production packer in the casing between the upper production zone and lower production zone, and a tubing seal packer in the

lower section of the tubing string engaging the production packer to prevent flow between the upper and lower production zones, the improvement comprising an upper production packer in the casing above the level of the upper production zone, an upper tubing seal packer forming a part of the lower section of the tubing string spaced above the upper production packer during operation of the well when the tubing string is in an upper position and adapted to engage the upper production packer and impede downward movement of the tubing string when the tubing string is lowered, a valve body forming a part of the lower section of the tubing string, a valve plug suspended from the upper section of the tubing string and constructed and arranged to move vertically within the valve body relative thereto, conduits in the valve body and the valve plug arranged to permit flow from the lower to the upper section of the tubing string when the valve plug is in an upper position relative to the valve body, said conduits being closed to prevent flow when the valve plug is in a lower position relative to the valve body, means for supporting the upper section of the tubing string in an upper position to permit flow from the well, and means for releasing the support of the upper section of the tubing string whereby the upper section of the tubing string moves downwardly of its own weight to move the valve plug into engagement with the valve body to shut down tubing production and to move the upper tubing seal packer into engagement with the upper production packer to shut down production from the upper production zone.

3. A dual-zone well comprising a casing extending down the bore hole at least to below the level of the upper zone, a tubing string extending downwardly within the casing to communicate with the lower zone, said tubing string having an upper section and a lower section, the outer diameter of the tubing string being smaller than the inner diameter of the casing to form an annulus therebetween for delivery of production from the upper zone to the well head, a packer in the casing below the upper production zone closing the annulus below the upper production zone, a second packer in the casing above the upper production zone, said second packer having an opening extending vertically therethrough through which the lower section of the tubing string passes, the diameter of the opening in the second packer being larger than the outside diameter of the lower section of the tubing string to form an annulus around the tubing string through which production from the upper zone passes, a section of enlarged outside diameter in the lower section of the tubing string normally spaced above the second packer and adapted to engage the second packer and close the annulus between the tubing string and second packer when the tubing string is moved to a lower position, a valve body at the end of one section of the tubing string above the second packer, a valve plug within the valve body and connected to the other section of the tubing string, conduits in the valve body and valve plug arranged to allow flow from the lower section to the upper section of the tubing string when the upper section of tubing is in an upper position, said valve plug adapted to move vertically relative to the valve body to close the conduits when the upper section of tubing is in a lower position, and means for moving the tubing string downwardly to close the conduits in valve body and valve plug and move the enlarged section of the tubing string into engagement with the second packer to shut down simultaneously both zones of the well.

4. In a well for producing from an upper and a lower zone during normal operation of the well, said well having casing extending downwardly from a well head to below the upper production zone and a tubing string concentric with the casing and extending downwardly through the casing below the upper production zone to communicate with the lower production zone, said tubing string having an upper section and a lower section, and means between the upper and lower production zone adapted to engage the tubing and casing to close the annular space between the casing and tubing to prevent flow between the upper and lower production zones, the improvement comprising a packer engaging the casing above the upper production zone, the lower section of the tubing string extending through the packer and having its outer surface spaced from the packer to allow flow between the casing and tubing string during normal operation of the well, a sealing member mounted on the lower section of the tubing string at a position spaced above the packer when the tubing is in an upper position and adapted to engage the packer to prevent flow between the outer surface of the tubing string and the packer and limit downward movement of the tubing string when the tubing string is lowered, a valve body positioned above the packer and connected at one end of one section of the tubing string, a valve plug positioned in the valve body and connected at one end of the other section of the tubing string, a conduit in the valve body allowing flow through the valve body into the section of the tubing string to which the valve body is connected, a conduit in the valve plug allowing flow through the tubing string and valve plug, said valve plug being vertically movable in the valve body relative thereto from a position at which the conduits in the valve body and valve plug allow flow from one section of the tubing string to the other to a position at which the conduits in the valve plug are covered by the valve body to prevent flow from one section to the other upon movement of one section of the tubing relative to the other section, the conduits being open to allow flow when the upper section of tubing is at an upper position and closed when the upper section of tubing is at a lower position, a hydraulic cylinder at the well head, a hydraulic piston slidable within the hydraulic cylinder, said upper section of the tubing string being supported by the hydraulic piston and adapted to discharge tubing production through the hydraulic piston to a production outlet, a hydraulic fluid under pressure in the hydraulic cylinder normally holding the piston in an upper position at which the sealing member is positioned above the packer and the conduits in the valve body and valve plug are open to flow, and means for releasing the pressure on the hydraulic fluid whereby the weight of the upper section of the tubing string lowers that section relative to the lower section to close the conduits and lowers the lower section of the tubing string to bring the sealing member into contact with the packer to shut down the well.

5. Apparatus as set forth in claim 4 in which the valve body is in the upper end of the lower section of tubing and the valve plug is connected in the lower end of the upper section of tubing.

6. Apparatus for control of flow from both zones of a dual zone well having an upper and a lower production zone comprising casing extending downwardly from a well head to the lower production zone, a tubing string concentric with the casing and extending downwardly through the casing below the upper production zone to communicate with the lower production zone, said tubing string having an upper section and a lower section, means between the upper and lower production zone adapted to engage the tubing and casing to close the annular space between the casing and tubing to prevent flow between the upper and lower production zones, a packer engaging the casing above the upper production zone, the lower section of the tubing string extending through the packer and having its outer surface spaced from the packer to allow flow between the casing and tubing string during normal operation of the well, a sealing member mounted on the lower section of the tubing string at a position spaced above the packer when the tubing is in an upper position and adapted to engage the packer to prevent flow between the outer surface of the tubing string and the packer and limit downward movement of the tubing

string when the tubing string is lowered, a valve body positioned above the packer and connected at one end of one section of the tubing string, a valve plug positioned in the valve body and connected at one end of the other section of the tubing string, a conduit in the valve body allowing flow through the valve body into the section of the tubing string to which the valve body is connected, a conduit in the valve plug allowing flow through the tubing string and valve plug, said valve plug being vertically movable in the valve body relative thereto from a position at which the conduits in the valve body and valve plug allow flow from one section of the tubing string to the other to a position at which the conduits in the valve plug are covered by the valve body to prevent flow from one section to the other upon movement of one section of the tubing relative to the other section, the conduits being open to allow flow when the upper section of tubing is at an upper position and closed when the upper section of tubing is at a lower position, a hydraulic cylinder at the well head, a hydraulic piston slidable within the hydraulic cylinder, said upper section of the tubing string being supported by the hydraulic



piston, a hydraulic fluid under pressure in the hydraulic cylinder normally holding the piston in an upper position at which the sealing member is positioned above the packer and the conduits in the valve body and valve plug are open to flow, and means for releasing the pressure on the hydraulic fluid whereby the weight of the upper section of the tubing string lowers that section relative to the lower section to close the conduits and lowers the lower section of the tubing string to bring the sealing member into contact with the packer to shut down the well.

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