

Aug. 29, 1961

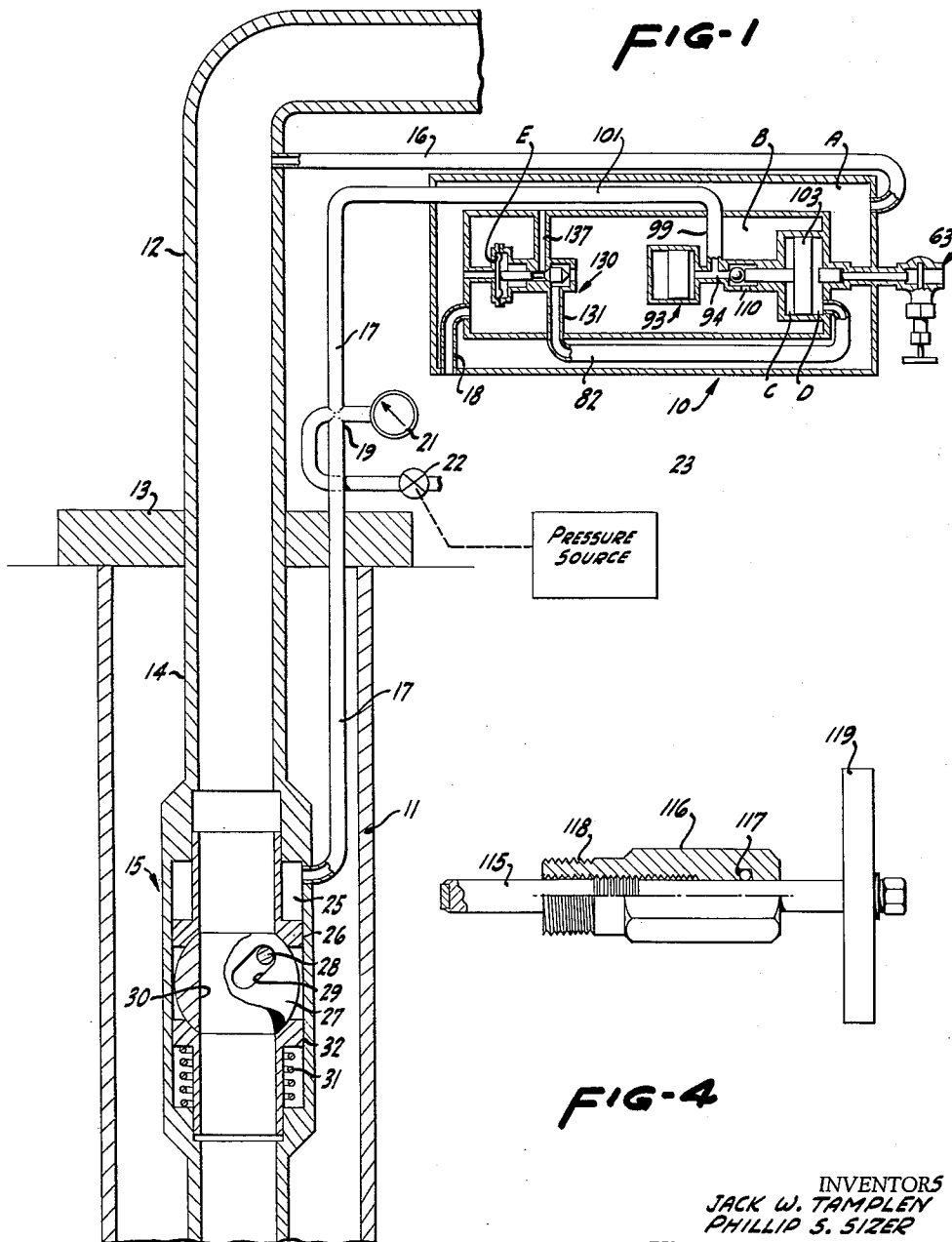
J. W. TAMPLIN ET AL

2,998,070

TAMPER PROOF MANIFOLD

Filed Nov. 17, 1958

4 Sheets-Sheet 1



INVENTORS
JACK W. TAMPLIN
PHILLIP S. SIZER

BY

Mellin and Hanscom
ATTORNEYS

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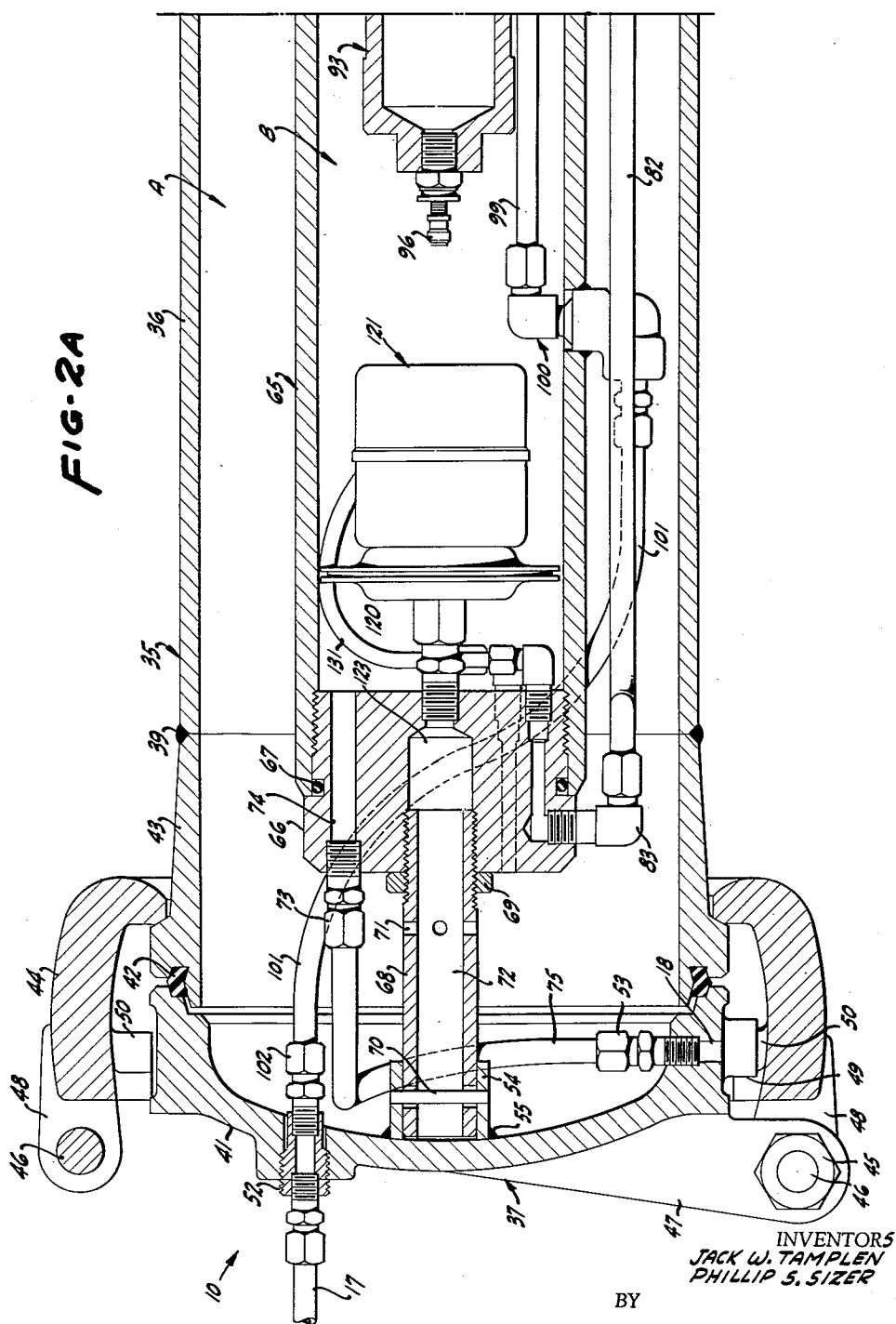
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PHILLIP S. SIZER

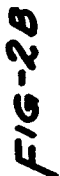
BY

Mellin and Hanscom
ATTORNEYS

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JACK W. TAMPLEN
PHILLIP S. SIZER

BY

Mellin and Hanscom

ATTORNEYS

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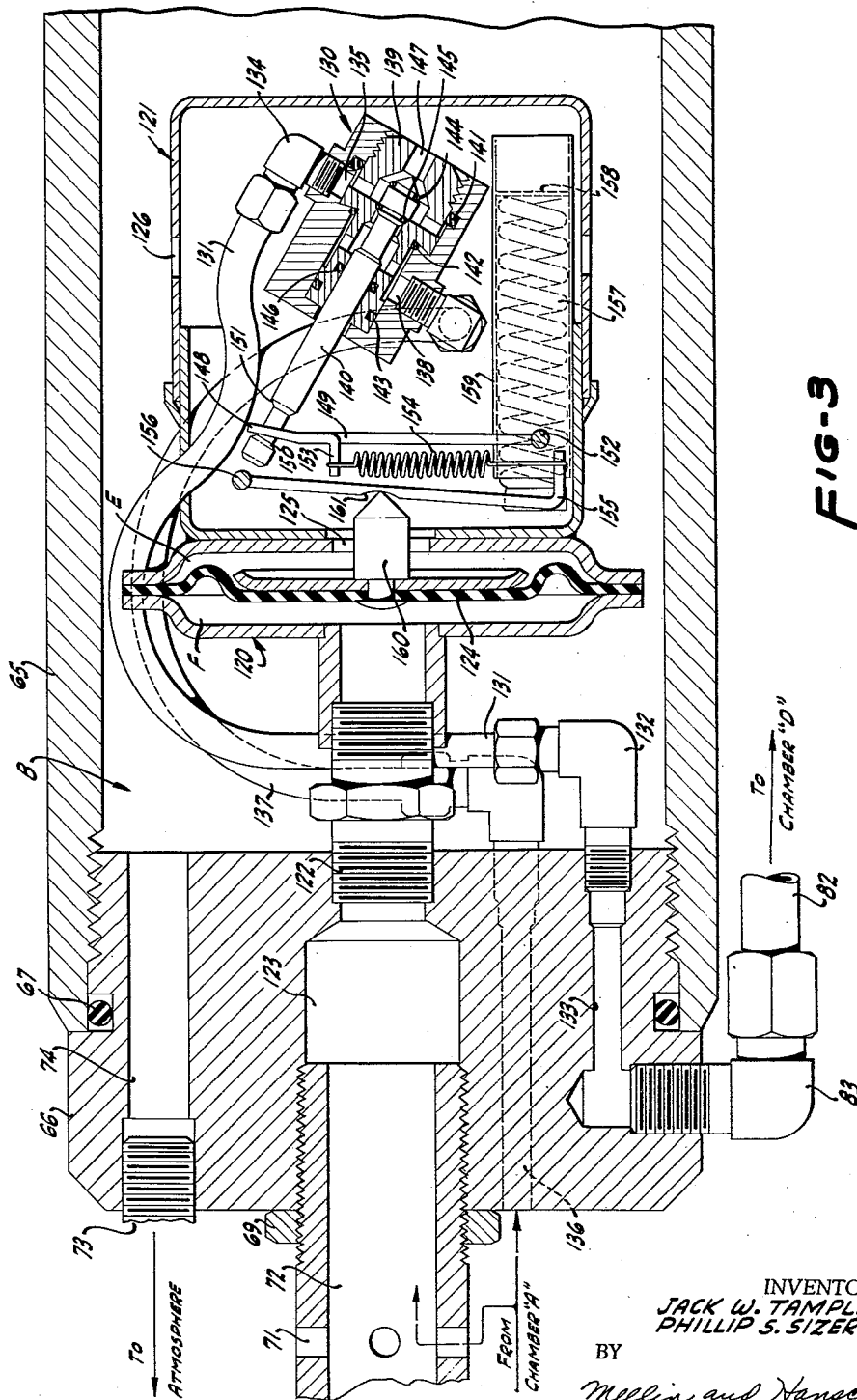
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4 Sheets-Sheet 4



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JACK W. TAMPLEN
PHILLIP S. SIZER

BY

Mellin and Hanscom

ATTORNEYS

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TAMPER PROOF MANIFOLD

Jack W. Tamplen, Celina, and Phillip S. Sizer, Dallas, Tex., assignors to Otis Engineering Corporation, Dallas, Tex., a corporation of Texas

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This invention relates to means for automatically stopping fluid flow in an oil well tubing string upon rupture of the tubing string or flow line above a safety valve made up therein, or upon rupture of the means or accessory lines connecting the means to either the flow line or safety valve.

This invention resulted from the necessity of finding a way of closing in an oil well were it to be sabotaged or otherwise caused to flow uncontrolled. This situation has recently occurred in certain foreign countries where the wellheads of a number of wells were destroyed by dynamiting and other means and the wells flowed out of control for considerable lengths of time. In such cases tremendous quantities of oil are lost, and it is often extremely dangerous to close the well in. Some such wells have become exhausted before finally being closed in.

Numerous subsurface safety valves are currently available, which may be installed in a well tubing below the surface of the ground and which will stop fluid flow through the tubing upon rupture of the flow line above the wellhead. Their use alone, however, does not prevent the well from being sabotaged, since they can be secured at the wellhead in the open position and the flow line then sabotaged. This invention remedies that deficiency in that the safety valve in the tubing string will be closed if any of the following are ruptured: the surface flow line, the means of this invention itself, the accessory line connecting the flow line and the means of this invention, or the accessory line connecting the safety valve and the means of this invention.

Hence, a principal object of this invention is to provide means for closing in a well upon rupture of the means, the accessory lines, the flow line, or tubing string at any point above the safety valve made up in the tubing string.

Another object is to provide means which, if tampered with or damaged in any material respect, will cause the safety valve in the tubing string to close, thus closing in the well.

Another object is to provide such means which can be readily reset to cause the safety valve to open and thus to cause the well to resume flowing.

Other objects and advantages will become apparent in the course of the following detailed description.

In the drawings, forming a part of this application, and in which like parts are designated by like reference numerals throughout the same,

FIG. 1 is a schematic representation of a system embodying the invention showing the manifold connected to control the operation of the subsurface safety valve in a well string.

FIGS. 2A and 2B are elevational sectional views of the manifold used in FIG. 1, with FIGS. 2A and 2B illustrating the left and right halves, respectively, of the manifold.

FIG. 3 is an elevational sectional view of the automatic reset pilot valve used in the manifold.

FIG. 4 is an elevational sectional view of a reset tool for use with the manifold.

Referring now to the drawings, and specifically to FIG. 1 thereof, the tamper proof manifold 10 is to be used in conjunction with a conventional cased well 11 having a flow line 12 extending above the wellhead 13 and a tubing string 14. A safety valve 15 is made up in the

2

tubing string below the wellhead. The manifold has three accessory conduits or outlets 16, 17 and 18, connecting it to the flow line 12, the safety valve 15, and the atmosphere, respectively. The pipe cross 19 is made up in accessory line 17, with one outlet of the pipe cross being attached to a pressure gage 21. The remaining outlet of the pipe cross is connected to a valve 22 by means of which the manifold 10, line 17 and safety valve 15 are charged with hydraulic fluid under pressure from a suitable source 23.

The subsurface safety valve 15 may be of any common type wherein the valve is operated to open position by sufficient fluid pressure in conduit 17 and wherein the valve will close when the fluid pressure within conduit 17 decreases below a predetermined minimum. An example of such a valve usable for the above purpose is that illustrated and described at page 4124 of the Composite Catalog of Oil Field Equipment and Services, 1957 edition, and which is schematically illustrated herein. When sufficient fluid pressure is exerted through conduit 17 into piston chamber 25, the fluid pressure piston actuator 26 will be forced downwardly, rotating the ball valve 27 by the interaction of the housing lugs 28 and ball valve grooves 29 so that the ball valve bore 30 becomes aligned with the bore of the tubing string. When the pressure in piston chamber 25 decreases, spring 31 forces piston 32 upwardly, rotating the ball valve to a position wherein the bore thereof is transverse to the bore of the tubing string to interrupt flow through the valve.

Referring now to the specific details of the manifold, as illustrated in FIGS. 2A and 2B, the manifold comprises an outer casing 35 formed from a tubular body member 36 sealed at its ends by unbolt scraper trap couplings 37 and 38, welded thereto as at 39.

Unbolt scraper trap couplings are commonly used in the oil well industry and will be described herein only in so far as is necessary for an understanding of the present invention. Such couplings are fully illustrated at page 5137 (FIGS. 13b and 15c) of the Composite Catalog of Oil Field Equipment and Services, 1957 edition. To seal the blanking plug 41 against the seal ring 42 (carried by the hub 43), the blanking plug 41 is rotated with respect to nut 44 and hub 43 by tightening nuts 45 on bolts 46 which join the arms 47 and 48 (mounted on the blanking plug 41 and nut 44, respectively). This causes the inclined lugs 49 and 50 (on the blanking plug 41 and nut 44, respectively), to move relative to one another so as to cam the blanking plug inwardly to compress the seal ring 42 against hub 43.

In the same way, the blanking plug 51 of the coupling 38 is sealed.

Connector 52 and fitting 53 are threadedly inserted in the blanking plug 41. Connector 52 is connected by conduit 17 to the pipe cross fitting 19, which in turn is connected to the valve 22, pressure gage 21, and safety valve 15, as described hereinabove with reference to FIG. 1. Nipple 54 is welded to the internal surface of the blanking plug 41 at 55. Fitting 53 communicates with the atmosphere through the opening 18 within nut 44.

The blanking plug 51 at the right end of the outer casing 35 has two ports 57 and 58 communicating its interior and exterior surfaces. Connector 59, having an orifice fitting 60 threadedly inserted therein, threadedly engages port 57 in the blanking plug and is connected to the conduit 16 of FIG. 1. Nipple 61 is welded at 62 to the plug and communicates with port 58 therein, and is also connected to a conventional gate valve 63. The purpose of this gate valve is discussed hereinafter.

The inner casing 65 is contained completely within the outer casing 35 to form an outer chamber A therebetween. An inner chamber B is formed within the inner casing 65. The left end of the inner casing is sealed by

engagement of end-sub 66 therewith and O-ring 67 therebetween. The left end of the inner casing is positioned within chamber A by connector 68 which at one end is threadedly inserted in the end-sub and maintained in this position by lock nut 69 and at its other end is positioned within nipple 54 by pin 70. Connector ports 71 provide communication between chamber A and the connector passageway 72. Fitting 73, threadedly inserted in end-sub passageway 74, and tubing 75, connected to fittings 73 and 53, provide communication between chamber B and the atmosphere.

The right end of the inner casing 65 is supported within and spaced from the outer casing by a plurality of legs 76 welded thereto. This end of the inner casing is sealed by the engagement of the housing member 77 of pilot valve 78 therewith and the engagement of the piston cap 79 with the housing member 77. Fitting 80 is threadedly inserted in passageway 81 and by conduit 82 communicates with fitting 83.

Plunger guide 84 extends through the housing member 77 and is threadedly connected to seat retainer 85, the surface therebetween being sealed by O-ring 86. The seat assembly, comprised of seat 87, O-ring retainer 88, and O-ring 89 therebetween, is disposed within the plunger guide and is maintained in this position between shoulders 90 and 91. Nipple 92 is threadedly made up between seat retainer 85 and a pressure accumulator 93 to provide communication between passageway 94 in the seat retainer and a variable capacity reservoir 95 in the accumulator. Prior to being disposed in chamber B, the accumulator 93 is charged with gas through valve 96 to provide constant pressure on piston 97 therein, which in turn provides a constant pressure on the fluid in the reservoir 95 on the other side of the piston and in the passageway 94. Elbow 98 is threadedly inserted in the seat retainer 85 and communicates through conduit 99, fittings 100, conduit 101, and fitting 102 to connector 52. Thus communication is provided between passageway 94 in the seat retainer and the safety valve 15 made up in the well tubing string, as shown in FIG. 1.

Piston 103 is disposed within the pilot valve 78. A piston chamber C is thus formed between the piston and the plunger guide 84 and piston chamber D between the piston and piston cap 79. Chamber D communicates with passageways 104 and 81. Passageway 104 is sealed by piston hold down member 106, which extends through nipple 61 into gate valve 63. O-ring 107, disposed about the piston hold down, seals passageway 104. While the piston hold down can be forced to the left to engage piston 103 and thus enlarge chamber D, its displacement to the right is limited by shoulder 108.

Chamber C communicates with chamber B through passageways 109 and 110, and also through passageway 111. Plunger, or relief valve hold down member, 112 is disposed within passageway 109 and abuts at one end piston 103 and at its other end the relief ball valve 113. The ball is of the proper diameter to seat against the seat assembly 87, 88 and 89, thus disrupting communication between passageway 94 and passageway 110. If, however, fluid pressure in passageway 94 exerts a force on ball 113 greater than the pressure in chamber D exerts on piston 103, the ball will be displaced to the right, and the fluid pressure in passageway 94 will be relieved into chamber B through passageway 110.

It is to be noted that the area of ball 113 exposed open to passageway 94 is much less than the area of piston 103 facing chamber D. Therefore, a unit pressure within chamber D considerably smaller than that within chamber 94 will cause ball 113 to remain seated.

It is also to be noted that the ball 113 can be reseated by opening gate valve 63, forcing piston hold down 106 to the left, and thereby forcing piston 103 and plunger 112 to the left against the ball.

The device for performing this last function is shown in FIG. 4, and comprises a prong member 115 threadedly

engaged intermediate its ends to body member 116 and sealed thereto by O-ring 117. The body member 116 has external threads 118 thereon enabling it to be threadedly inserted into the gate valve 63. Rotation of the prong member 115 by handle 119 will cause the prong member to move to the left and force against the piston hold down 106.

Referring now to the details of FIG. 3, it is seen that diaphragm housing 120 and reset pilot housing 121 are securely connected to one another and are supported in chamber B by fitting 122, which is connected in passageway 123 of the end-sub 66, and in the diaphragm housing 120. Fitting 122 also provides communication between chamber F of the diaphragm housing and passageway 123 so that chambers A and F will be at the same fluid pressure. Diaphragm 124 provides a pressure-tight seal between chamber F and chamber E. Due to the passageway 125, chamber E is at the same pressure as that within reset pilot housing 121, which is maintained at atmospheric pressure by means of ports 126.

Reset pilot valve 130 is fixedly secured to the reset pilot housing in the position shown in FIG. 3. Conduit 131 leading from fittings 132, end-sub passage 133 and fitting 83, communicates through fitting 134 with passageway 135 in pilot valve 130. Also, end-sub passage 136 and conduit 137 place chamber A in fluid communication with passage 138 of pilot valve 130. Plunger seat 139 is disposed within and threadedly connected to reset pilot valve 130. Plunger 140 is slidably disposed within the plunger seat. With the surfaces between the plunger seat 139 and the reset pilot valve sealed by O-rings 141, 142 and 143, and those between the plunger and plunger seat sealed by O-rings 144, 145 and 146, passageways 135 and 138 are sealed from one another when the plunger is in the position shown in FIG. 3. In this position passageway 135 communicates with passageway 147, which in turn is open to chamber E and chamber B. Plunger 140 can be forced downwardly within the plunger seat to provide communication between passageways 135 and 138, and by means of O-ring 144 cut off communication between passageways 135 and 147.

The portion of plunger 140 extending from reset pilot valve 130 extends through a bifurcated yoke 148 of a rod 149, which yoke can engage shoulders 150 and 151 of the plunger. The rod 149 is pivotally secured to the reset pilot housing at its lower end 152. An arm 153 of the rod is connected to the upper end of a spring 154, the lower end of which is connected to a lever 155. The upper end of the lever 155 is pivotally connected at 156 to the wall of the reset pilot housing. The lower portion of the lever 155 is constantly urged toward diaphragm housing 120 by spring 157, the opposite end of which abuts adjustable spring plate 158 within spring housing 159 secured to reset pilot housing 121.

Plunger 160 is fixedly secured to diaphragm 124, extends through passageway 125 and can engage lever 155 in the groove 161, which prevents slippage between the plunger and the lever.

The automatic reset pilot 130 operates entirely as a function of the pressure of flow line 12, which is the same pressure as that within chamber A and conduit 137. Now, with the plunger of the reset pilot 130 in the position shown in FIG. 3, should the flow line pressure in chamber A increase sufficiently, diaphragm 124 will flex to the right, forcing plunger 160 against lever 155. Lever 155 now pivots about 156 and against spring 157, and moves the lower end of spring 154 to the right of the upper end thereof. When the line between the ends of spring 154 intersects the longitudinal axis of the rod 149 (i.e., when the lower end of spring 154 is to the right of point 152), yoke 148 will engage shoulder 151 and force plunger 140 downwardly to the right, and the passageways 135 and 138 of pilot valve 130 will be placed in communication with one another.

Should the flow line pressure in diaphragm chamber

5

F decrease sufficiently, spring 157 will force the lower end of the lever 155 to the left, thus repositioning the lower end of spring 154 to the left of the longitudinal axis of the rod 149, thus forcing yoke 148 against shoulder 150 of the plunger and moving it back to the position illustrated in FIG. 3. This is due, of course, to the moment created on lever 155 by spring 157 being larger than that created thereon by diaphragm 124 through the plunger 160.

Prior to placing the manifold 10 into operation, there is no flow in flow line 12, due to the fact that safety valve 15 has closed the tubing string 14. To place the manifold in operation, the following operations are effected. First, after the pronged member 115 is threadedly connected to gate valve 63 and sealed thereto to prevent a decrease in pressure through nipple 61, the gate valve is opened. Then, the pronged member 115 is forced against the piston hold down 106 sufficiently to force piston 103 and plunger 112 inwardly to seat ball 113 against the seat assembly 87, 88 and 89. This arrangement is maintained. Secondly, the hydraulic system is charged to the desired operating pressure through the valve 22 from the pressure source 23. The hydraulic system consists of safety valve 15 and conduit 17, the four-way fitting 19, connector 52, conduits 101 and 99, passageway 94, and the accumulator 93. When the safety valve 15 has been opened by this hydraulic fluid, and the hydraulic system is charged to the desired pressure, valve 22 is closed and the pressure source may be disconnected therefrom. The fluid within the hydraulic system is now the fluid source for the actuation of valve 15 to open position. Now that the safety valve 15 is open, fluid in the flow line 12 enters chamber A through connector 59, and pressure builds up in end-sub passageway 123 and chamber F in the diaphragm housing 120 (FIG. 3). When the pressure in chamber F reaches the desired magnitude, as previously determined when spring 157 was set, the automatic reset pilot operates, as previously explained, to provide communication between passageways 135 and 138. Now, flow line pressure in chamber A builds up in piston chamber D (through conduits 137, 131 and 82) to the point where the force exerted on ball 113 through plunger 112 and piston 103 is greater than the force exerted on the ball by the hydraulic fluid within passageway 94. When such is the case, the plunger 115 is retracted, the gate valve is closed, the pronged tool is removed from the gate valve, and the piston hold down 106 is forced by pressure in chamber D to the position shown in FIG. 2B. The manifold 10 is now in operation.

With the tamper proof manifold in the operating position as just described, the safety valve will be closed upon the occurrence of either of two conditions: first, the reduction of hydraulic fluid pressure below a predetermined magnitude; and, secondly, the reduction of flow line pressure in chamber A in the manifold below a predetermined magnitude proportional to the hydraulic fluid pressure. The results of the occurrence of either of these two conditions is next described.

Should the hydraulic pressure within the valve 15 or the conduit 17 be reduced below the predetermined magnitude, either by its being bled off at valve 22 or by rupture of the line 17, the valve 15 will be closed by the spring 31 therein. The same result will be obtained in the event that either the conduit 99 or accumulator 93 develops a leak, due to the fact that these elements are contained within chamber B, which is maintained at atmospheric pressure by conduit 75.

When the manifold is operating, the pressure in piston chamber D is the same as that in chamber A due to the communication provided by conduits 136 and 137, reset valve passages 135 and 138, and conduits 131 and 82; the plunger 140 of the pilot valve 130 being in a position to the right opposite to that shown in FIG. 3. Thus with the force exerted on ball 113 by plunger 112 (which

6

is the pressure in chamber D acting on the relatively large area of piston 103) being greater than the force exerted by the hydraulic fluid pressure on the exposed surface of the ball 113, the ball prevents the loss of hydraulic fluid into the chamber B (at atmospheric pressure), and thus prevents the safety valve 15 from closing. However, should either the outer casing 35, flow line 12, or conduit 16 be ruptured or opened in any manner, or should gate valve 63 be opened, the pressure in chamber A will thereby be reduced to a predetermined level, and the safety valve 15 will be closed as a result of the following. First, the pressure in diaphragm chamber F will be reduced to the same pressure as in chamber A and spring 157 will move plunger 140 to the position shown in FIG. 3. Secondly, the pressure in piston chamber D will be bled to atmosphere through the now fluidly connected conduits 82 and 131, and passages 135 and 147 of the pilot valve 130. Thirdly, the hydraulic pressure in passageway 94, being greater than that now in piston chamber D, will force ball 113, plunger 112, and piston 103 to the right, thus permitting the hydraulic fluid pressure to bleed into chamber B which is at atmospheric pressure. Without the hydraulic fluid pressure's maintaining it open, the safety valve 15 closes.

Although this invention has been described for a well having a single tubing string, it is apparent that a system such as that shown in FIG. 1 can be provided for each tubing string of a multiple tubing string well, which systems can be made to operate singly, or in any combination desired.

It should be noted that chambers D and A are not directly connected to one another, but rather that the pilot valve 130 is connected therebetween. If chambers D and A were directly connected, the closing of passage 94 by ball 113 would be governed by two variables: the hydraulic pressure in passageway 94, and the line pressure in chamber D. This, of course, precludes designing piston 103 so that it will release ball 113 at any specific chamber D pressure. However, by the use of the pilot valve 130, the closing of the ball valve will depend upon only one variable; namely, the pressure in chamber A, and upon one fixed constant, the spring force of spring 157.

In normal practice, the hydraulic system is over-charged to compensate for normal leakage and to extend maintenance intervals. For example, if the safety valve 15 is set to close when the hydraulic pressure is below 500 p.s.i., the hydraulic system may be charged to 1000 or even 2000 p.s.i. Now, if piston 103 is designed to keep the safety valve 15 open when the chamber D and hydraulic pressures are 200 and 2000 p.s.i., respectively, and if over a period of time the hydraulic pressure drops to 500 p.s.i., the chamber D pressure can drop considerably (say, to 120 p.s.i.) without closing valve 15; this situation (where line pressure drops due to a partial rupture of line 12) could occur in wells which have a very high producing rate. This will not occur when the automatic reset pilot is used because spring 157 is designed to release the hydraulic pressure when line pressure (chambers A and D) drops to a predetermined desired level; hence, ball 113 is controlled independently of hydraulic pressure, and the manifold is made sensitive to any desired change in flow line pressure.

Another example of the use of the pilot valve 130 is to assume that the hydraulic system and chamber D (flow line) pressures are 2000 and 200 p.s.i., respectively, and that valve 15 will close when the hydraulic pressure drops below 500 p.s.i. and the chambers A and D were directly connected. A hole might be made in flow line 12, which would be sufficient to lower the pressure therein to 175 p.s.i. This would permit ball 113 to become unseated and the hydraulic fluid pressure to drop to, say, 1500 p.s.i., whereupon ball 113 would be resealed. In this case, the safety valve 15 would not close and a large quantity of oil could be lost. This would not occur with

the reset pilot in use because it could be set to detect very small flow line pressure changes. It is important to observe that chamber D is vented to atmospheric pressure as soon as the reset pilot detects a change in flow line pressure. This completely vents the hydraulic system and allows the safety valve 15 to close completely.

It is to be realized that the embodiment of the invention, herewith shown and described, is to be taken as a preferred embodiment of the same, and that various changes in the shape, size and arrangement of parts may be resorted to without departing from the spirit of the invention or the scope of the attached claims.

Having thus described our invention, what we claim and desire to secure by Letters Patent is:

1. Apparatus of the character described for use in a system having a well tubing string with a subsurface safety shut off valve made up therein, a fluid pressure operated actuator for holding said safety shut off valve open, a source of fluid under pressure connected to said actuator and a surface flow line connected to said tubing, said apparatus comprising: an outer casing, an inner casing disposed completely within said outer casing so as to form an outer chamber between said casings and an inner chamber within said inner casing, passage means communicating said inner chamber through said outer casing to atmosphere, a first conduit communicating with said outer chamber and adapted to be connected to said flow line, a second conduit communicating with said inner chamber and adapted to be connected to said source of fluid under pressure, a relief valve connected in said second conduit, and means responsive to pressure within said outer chamber for opening said relief valve upon the presence of a predetermined low pressure in said outer chamber.

2. Apparatus of the character described for use in a system having a well tubing string with a subsurface safety shut off valve made up therein, a fluid pressure operated actuator for holding said safety shut off valve open, a source of fluid under pressure connected to said actuator and a surface flow line connected to said tubing, said apparatus comprising: an outer casing, an inner casing disposed completely within said outer casing so as to form an outer chamber between said casings and an inner chamber within said inner casing, passage means communicating said inner chamber through said outer casing to atmosphere, a first conduit communicating with said outer chamber and adapted to be connected to said flow line, a second conduit having one end thereof communicating with said inner chamber and adapted to have its other end connected to said source of fluid under pressure, a relief valve disposed within said inner chamber and connected to said second conduit, and means responsive to pressure within said outer chamber for opening said relief valve upon the presence of a predetermined low pressure in said outer chamber.

3. Apparatus as set forth in claim 2 further including a variable capacity enclosed fluid pressure reservoir disposed within said inner chamber, means fluidly connecting said reservoir to said second conduit between said relief valve therein and said other end thereof.

4. Apparatus of the character described for use in a system having a well tubing string with a subsurface safety shut off valve made up therein, a fluid pressure operated actuator for holding said safety shut off valve open, a source of fluid under pressure connected to said actuator and a surface flow line connected to said tubing, said apparatus comprising: an outer casing, an inner casing disposed completely within said outer casing so as to form an outer chamber between said casings and an inner chamber within said inner casing, passage means communicating said inner chamber through said outer casing to atmosphere, a first conduit communicating with said outer chamber and adapted to be connected to said flow line, a second conduit communicating with said inner chamber and adapted to be connected to said source of fluid under pressure, a relief valve in said second conduit for

venting said second conduit to said inner chamber, a fluid pressure operated valve actuator means operatively associated with said relief valve for holding said relief valve closed upon the existence of a predetermined high fluid pressure acting upon said actuator means and for opening said relief valve when the fluid pressure acting thereon drops below said predetermined high pressure, means communicating the pressure in said outer chamber with said fluid pressure operated valve actuated means, and means fluidly connecting said actuator means with said outer chamber.

5. Apparatus of the character described for use in a system having a well tubing string with a subsurface safety shut off valve made up therein, a fluid pressure operated actuator for holding said safety shut off valve open, a source of fluid under pressure connected to said actuator and a surface flow line connected to said tubing, said apparatus comprising: an outer casing, an inner casing disposed completely within said outer casing so as to form an outer chamber between said casings and an inner chamber within said inner casing, passage means communicating said inner chamber through said outer casing to atmosphere, a first conduit communicating with said outer chamber and adapted to be connected to said flow line, a second conduit having one end thereof communicating with said inner chamber and adapted to have its other end connected to said source of fluid under pressure, a relief valve in said second conduit for venting said second conduit to said inner chamber, a pressure operated relief valve actuator operatively associated with said relief valve for holding said relief valve closed, a pilot valve having a movable valve member therein, a first fluid connection from said pilot valve to said relief valve actuator, second and third connections from said pilot valve to said outer and inner chambers respectively, said pilot valve member having a first position wherein said first and second connections are in fluid communication and a second position wherein said first and third connections are in fluid communication, and means responsive to pressure within said outer chamber for holding said pilot valve member in its first position when the outer chamber pressure is above a predetermined value and for moving said pilot valve member to its second position when said outer chamber pressure is below said predetermined value.

6. Apparatus as set forth in claim 5 further including a variable capacity enclosed fluid pressure reservoir disposed within said inner chamber, means fluidly connecting said reservoir to said second conduit between said relief valve therein and said other end thereof.

7. Apparatus of the character described for use in a system having a well tubing string with a subsurface safety shut off valve made up therein, a fluid pressure operated actuator for holding said safety shut off valve open, a source of fluid under pressure connected to said actuator and a surface flow line connected to said tubing, said apparatus comprising: an outer casing, an inner casing disposed completely within said outer casing so as to form an outer chamber between said casings and an inner chamber within said inner casing, passage means communicating said inner chamber through said outer casing to atmosphere, a first conduit communicating with said outer chamber and adapted to be connected to said flow line, a second conduit having one end thereof communicating with said inner chamber and adapted to have its other end connected to said source of fluid under pressure, said second conduit having a valve seat therein facing downstream into said inner chamber, a relief valve member seatable upon said valve seat to prevent fluid flow therepast, a hold down member engageable with said valve member, a pressure operated valve actuator operatively associated with said hold down member and operable to force said hold down member against said relief valve member to hold said valve member against said valve seat, means fluidly communicating

9

said valve operator with said outer chamber, a pilot valve having a movable valve member therein, a first fluid connection from said pilot valve to said relief valve actuator, second and third connections from said pilot valve to said outer and inner chambers respectively, said pilot valve member having a first position wherein said first and second connections are in fluid communication and a second position wherein said first and third connections are in fluid communication, and means responsive to pressure within said outer chamber for holding said pilot valve member in its first position when the outer chamber pressure is above a predetermined value and for moving said pilot valve member to its second position when said outer chamber pressure is below said predetermined value.

8. Apparatus as set forth in claim 7 further including a variable capacity enclosed fluid pressure reservoir disposed within said inner chamber, means fluidly connecting said reservoir to said second conduit between said valve seat therein and said other end thereof.

10

9. Apparatus as set forth in claim 7 wherein said pressure operated valve actuator comprises a piston chamber and a piston axially movable therein, said hold down member being movable by said piston towards said valve seat upon admission of fluid under pressure into said piston chamber.

10. Apparatus as set forth in claim 9 further including means forming a closable opening through said outer casing, and means including a pronged member sealably insertable through said opening to force said relief valve member against said valve seat.

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