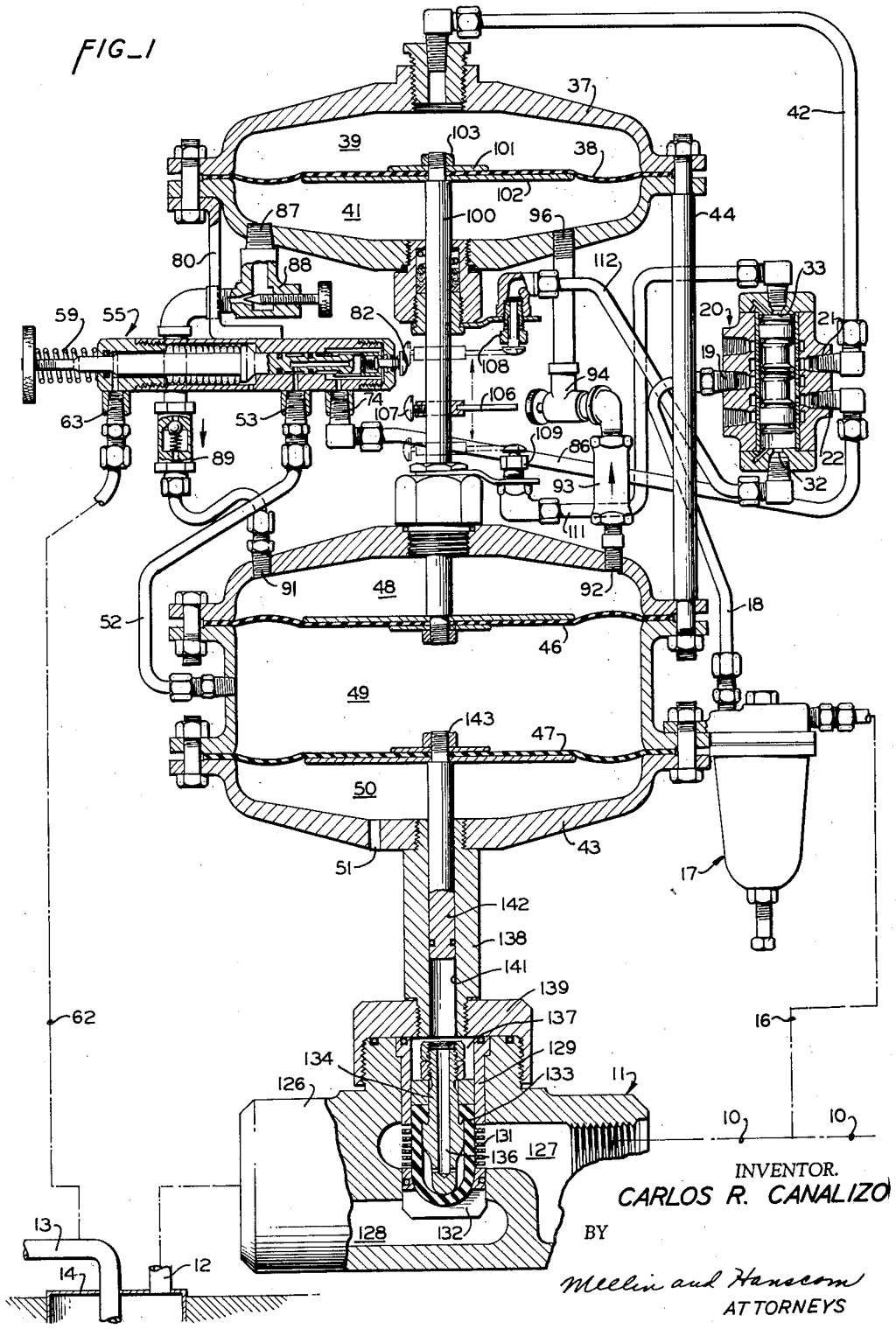
April 10, 1962 C. R. CANALIZO 3,028,815

AUTOMATIC INTERMITTING DEVICE

Filed Aug. 12, 1957 3 Sheets-Sheet 1

FIG_1



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AUTOMATIC INTERMITTING DEVICE

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FIG_2

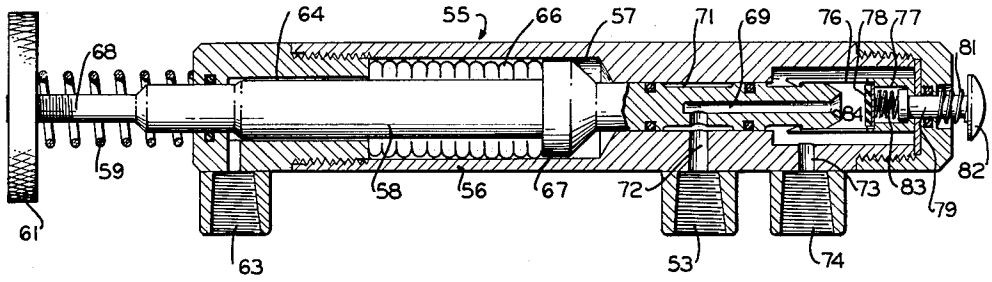


FIG_3

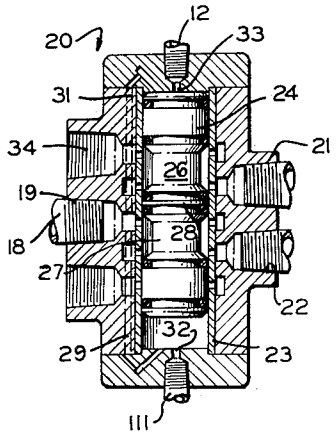


FIG_4

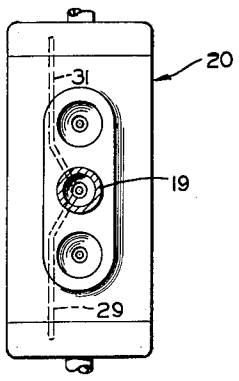
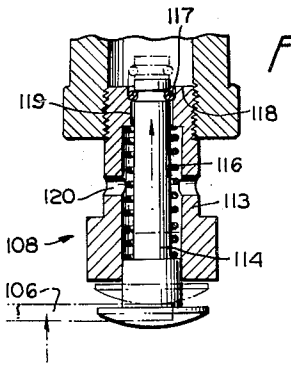


FIG_5



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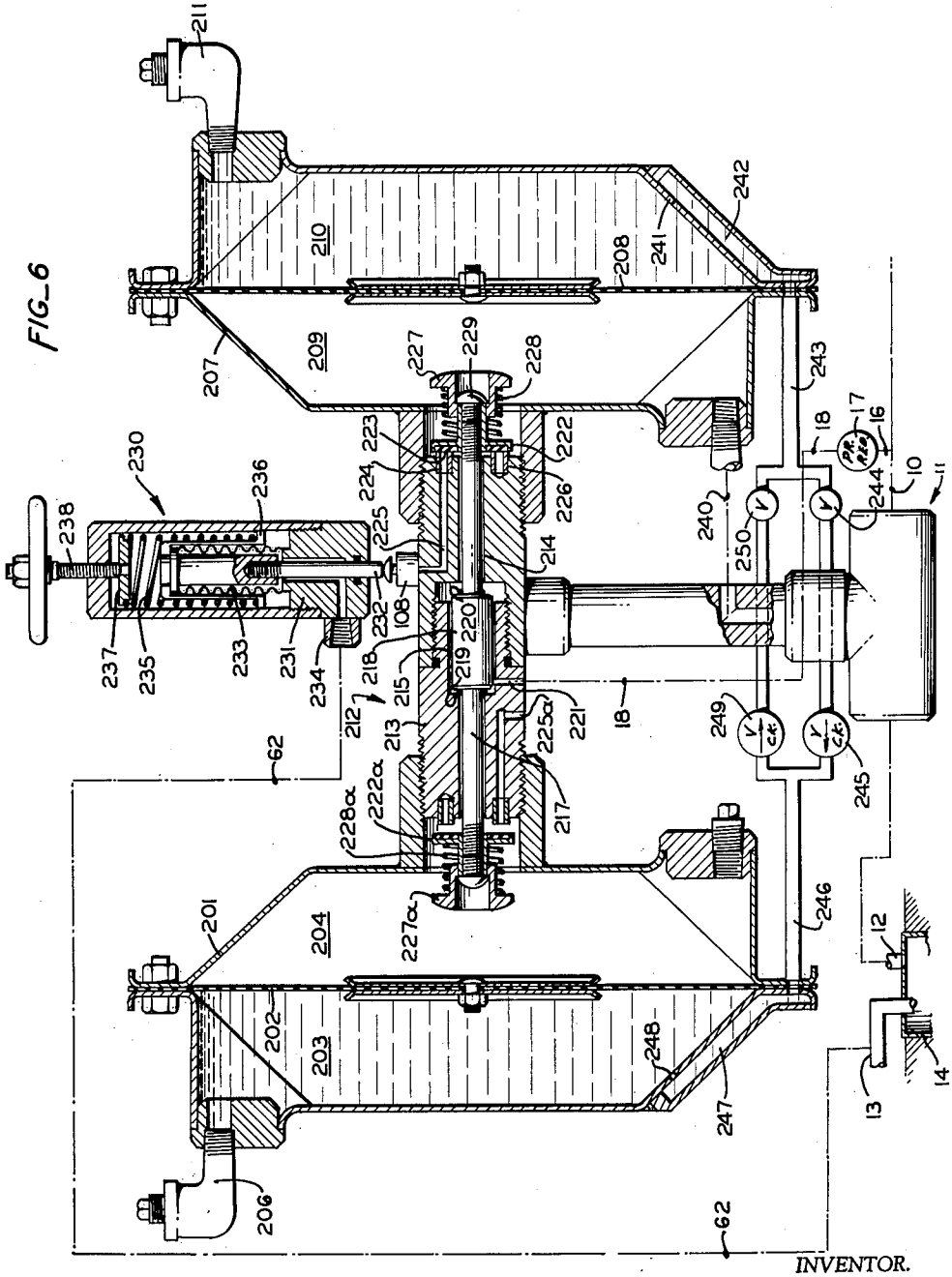
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AUTOMATIC INTERMITTING DEVICE

Filed Aug. 12, 1957 3 Sheets-Sheet 3

FIG_6



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United States Patent Office 3,028,815 Patented Apr. 10, 1962

3,028,815

AUTOMATIC INTERMITTING DEVICE

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Filed Aug. 12, 1957, Ser. No. 678,757
16 Claims. (Cl. 103—232)

This invention relates to device for automatically intermittently injecting gas into an oil well for gas lifting the oil out of such wells, and is a continuation-in-part of my co-pending application, Serial No. 543,992, filed March 5, 1957, and now abandoned.

In the production of oil wells by gas lift, it is often desirable to intermittently inject the gas which is used as power fluid into the well. Intermittent injection of power fluid is desirable from an economic standpoint, as it enables the operator to use less gas per unit of well fluids lifted. It is true that many wells produce large quantities of oil and water and thus require continuous injection of power fluid. In less prolific wells, continuous gas injection is wasteful, and it is desirable to inject gas or power fluid at predetermined intervals to permit the well fluids to rise within the tubing of the well prior to each period of gas injection.

The practice of intermittent gas injection is not new, and there are a number of devices which are designed to provide intermittent gas injection. Most of these devices are operated by a clock mechanism which opens and closes a valve controlling the gas injection line at intervals which can be predetermined by proper adjustment of the clock mechanism. Such intermitting devices have many disadvantages, among which is the necessity for winding the clock mechanism. Failure to wind the clock mechanism may result in the waste of large quantities of gas, as experience has shown that the clock mechanism will usually stop with the gas injection control valve in the open position. This is due to the fact that as the clock approaches the run-down state, there is not sufficient energy to close the control valve. Even if the clock mechanism should stop with the valve closed, production from the well is interrupted. Clock mechanisms are necessarily complicated and delicate, and exposure to weather, salt air and dust seriously affects the accuracy of such an intricate device. Repair of clock mechanisms requires a skilled mechanic, and such repairs cannot be performed by the switcher or pumper who operates the wells. Such intricate mechanisms are also subject to damage by shock which is likely to occur in the rough handling which normally occurs in the installation of oil field equipment.

Electrical timing devices have also been employed for intermittently opening and closing the gas injection line valves. However, such devices require an auxiliary source of power for their operation, either from power lines strung to the well site or from motor-generator sets.

The present device has been designed so that the power to operate the intermitter is provided by the power fluid, preferably gas, used to lift the oil from the well, thus assuring a reliable and uninterrupted source of power for the intermitting device whenever a gas lifting operation is in progress. The only time that the intermitter would be inoperative due to a lack of power would be when there is a failure of the power fluid which automatically insures that so long as there is gas for gas lifting purposes, there will be power for the intermitting device. In general, the invention operates by the displacement of a fluid having a high viscosity index through metering valves which can be adjusted to provide a variable cycle of displacement. In addition, the invention provides a cut-off device which will shut down the flow of lifting gas to the well in the event that the pressures in the well

tubing exceed a safe amount, and which will cause the lifting gas to be immediately re-applied to the well when the tubing pressure falls back to the safe amount.

It is a principal object of this invention to provide a device for intermittent injection of lifting gas to a well in which the device is powered by the pressure of the lifting gas.

It is a further object to provide an intermitting device comprising a gas line adapted to be connected to a source of pressurized gas, a control valve in said gas line, a means for intermittently opening and closing said valve, and means to operate said intermitting means by the gas pressure in said gas line.

A further object of the invention is to provide an intermitting device for intermittently injecting pressurized gas into the well casing of an oil well in which the intermitting device is powered by the pressurized gas, and including means for interrupting the action of the intermitting device whenever the tubing pressure of the well exceeds a desired degree, and in which the interrupting means allows the pressurized gas to be immediately injected in the well casing as soon as the tubing pressure falls to a desired degree.

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

In the drawings, forming a part of this specification and in which like reference numerals are used to indicate like parts throughout the same,

FIG. 1 is an elevational view of a preferred embodiment of the invention, with portions being shown in cross section and other portions being shown schematically.

FIG. 2 is an enlarged cross-sectional view of the cut-off device illustrated in FIG. 1.

FIG. 3 is an enlarged cross-sectional view of the four-way valve illustrated in FIG. 1.

FIG. 4 is an elevational view of the four-way valve of FIG. 3, viewing it from the left of that figure.

FIG. 5 is an enlarged cross-sectional view of one of the relief valves illustrated in FIG. 1.

FIG. 6 is a view similar to FIG. 1 of a modification of the invention, with portions shown in section and portions shown schematically.

Referring now to FIGS. 1, 2 and 3, a supply conduit represented by the line **10** supplies gas under pressure from a pressurized gas source (not shown) to and through the main valve **11**, to the conduit **12**, to admit the pressurized gas to the casing of an oil well. Conduit **13** is connected at the well top **14** to the interior of the well tubing to receive the oil flowing therefrom.

A branch conduit **16** is connected to the supply conduit **10** upstream of the main valve **11**, to deliver a portion of the pressurized gas to a conventional pressure reducer **17**, which releases the pressure of the gas passing therethrough from approximately 500 p.s.i. main line pressure to preferably about 25 p.s.i. The ratio of these pressures, or the reduced pressure, is not of importance in this invention, it being desired only to reduce the lifting gas pressure to a degree whereby the intermitting apparatus may function at a conveniently low pressure.

The gas passing through the pressure reducer **17** leaves through conduit **18** to enter the inlet connection **19** of a four-way control valve **20**. This valve, best shown in FIGS. 3 and 4, is adapted to place the inlet **19** into communication selectively with either of the outlets **21** or **22**, while connecting the other of the outlets **21** or **22** to atmosphere. The valve **20** has a hollow cylinder **23** therethrough, with a valve piston **24** axially movable in the cylinder. The valve piston is provided with two areas **26** and **27** of reduced diameter, these reduced diameter areas being separated by a portion **28** of the valve piston in contact with the walls of the cylinder **23**.

An internal passage **29** connects the valve inlet **19** to

the lower end of the cylinder 23, while a similar passage 31 connects the valve inlet 19 to the upper end of the cylinder 23. The lower end of the cylinder 23 is provided with an outlet orifice 32, while a similar outlet orifice 33 is provided in the upper end of the cylinder 23.

In the position of the valve member 24 as shown in FIG. 3, and with gas being supplied to the valve 20 through conduit 18, the gas will enter the inlet 19, pass around the reduced diameter portion 27 of the valve piston 24, and out the outlet 22. The other outlet 21 will be in communication with the atmosphere around the reduced diameter portion 26 of the valve member 24 and out through the atmosphere orifice 34, and the passages 29 and 31 will admit the inlet gas under pressure to the top and bottom of the valve piston 24. In operation, both of the orifices 32 and 33 will be closed so that no gas can pass from the ends of the cylinder 23.

If it is desired to reverse the valve 20 from the position of FIG. 3, the orifice 32 is opened to atmosphere by a suitable valve (to be later described). This will reduce the pressure in the lower end of cylinder 24, so that the pressure existing in the upper end of cylinder 23 will force the valve piston 24 downwardly. In this second position (not illustrated), the inlet 19 will now be in communication with the reduced portion 26 of valve piston 24 and the outlet 21, while the outlet 22 will be in communication with the atmosphere around the reduced portion 27 of the valve piston and the atmosphere orifice 36.

The valve 20 may then be returned to its original position by the closing of orifice 32 and the opening of orifice 33, to force the valve piston upwardly to the position shown in FIG. 3. Thus, by alternately opening and closing the orifices 32 and 33, the inlet 19 may be alternately connected to one of the outlets 21 or 22, while the other of those outlets is bled to atmosphere.

Returning to FIG. 1, a casing, or housing, 37, having a flexible diaphragm 38 therein dividing the chamber within the casing into upper and lower compartments 39 and 41, has the upper compartment 39 thereof connected by conduit 42 to the outlet 21 of valve 20.

A second casing, or housing, 43, spaced below casing 37 and rigidly connected thereto by tie rods 44, has two flexible diaphragms 46 and 47 therein, dividing the chamber within the casing into an upper, middle and lower compartment 48, 49 and 50, respectively. A bleed orifice 51 in the lower part of casing 43 places the lower compartment at atmospheric pressure. The middle compartment 49 is connected by conduit 52 to the threaded connection 53 of the pressure responsive cut-off device 55.

The cut-off device, shown in larger detail in FIG. 2, is of the type disclosed in my copending application, Serial No. 643,973, filed March 5, 1957, now Patent Number 2,896,903, and has an axial bore 57 therethrough to slidably receive piston 58. Compression spring 59 seats on housing 56 and adjustment nut 61 to urge the piston leftwardly to the position as shown in FIG. 2. Tubing pressure from the well tubing 13 is admitted through conduit 62 to the inlet opening 63 of housing 56 and to the bore 57 thereof and passes through the annular space 64 between the piston 58 to the interior of bellows 66. Since bellows 66 is welded at its left end to housing 56 and at its right end to the piston shoulder 67, the pressure from the well tubing will tend to elongate the bellows and move the piston 58 to the right. This movement is opposed by spring 59, the compression of which may be adjusted to any desired amount by the rotation of adjustment nut 61 on the threaded end 68 of piston 58.

The right end of piston 58 fits snugly in bore 57, and has an axial passage 69 therethrough. The passage 69 communicates with a reduced diameter portion 71 of piston 58 which, in turn, communicates with orifice 72 formed through the housing 56 and threaded connection 53. The reduced diameter portion 71 of piston 58 is sufficiently elongated so that orifice 72 will always be in communication with passage 69 regardless of the axial position of piston 58 in bore 57 of the cut-off device. The right end of passage 69 is in fluid communication with orifice 73 and threaded connection 74.

Supported on the right end of piston 58, by spring fingers 76, is a cage 77 holding valve member 78 therein. A plunger 79 extends from the cage 78 through the housing 56 and is outwardly biased by spring 81 acting on the button head 82 of plunger 79.

In the position of the piston 58 in the bore 57 as shown in FIG. 2, the button 82 may be pressed inwardly against the bias of spring 81, but such movement of the plunger 79 through take-up spring 83 to the valve member 78, will be insufficient to seat the valve member 78 on the valve seat 84 of piston 58, and thus the fluid communication between the housing connections 53 and 74 will not be interrupted.

However, if sufficient tubing pressure is introduced into the bellows 66 to overcome the compression spring 59 so that the piston 58 moves to the right, then a depression of button 82 will cause the valve member 78 to come into engagement with the valve seat 84, and the fluid communication between the housing connections 53 and 74 will be interrupted. The take-up spring 83 will maintain a sealing engagement between valve 78 and valve seat 84 while allowing some relative movement between plunger 79 and piston 58.

The valve 78 may be opened with respect to valve seat 84 by either a retraction of piston 58 or by outward movement of plunger 79.

Returning again to FIG. 1, the cut-off device 55 is secured to bracket 80, which is bolted to casing 37, and a conduit 86 extends from the cut-off device connection 74 to the outlet 22 of valve 20.

The casing compartments 41 and 48 are designed to be filled with a fluid, preferably a liquid having a high viscosity index such as oil, and are fluidly interconnected in the following manner. An outlet opening 87 is provided in the upper casing 37, enabling the liquid to flow from compartment 41, through metering valve 88, and a downwardly opening check valve 89 to inlet opening 91 through casing 43 into compartment 48. Similarly, the liquid may flow from compartment 48 through casing opening 92, the upwardly opening check valve 93, the metering valve 94, and through casing opening 96 into compartment 41. As is obvious, liquid can only flow from compartment 41 through metering valve 88, and can only flow from compartment 48 through metering valve 94. The rates of flow from one compartment to the other can be easily regulated by adjusting the adjusting screws of the metering valves 88 and 94.

A piston 100 is connected at its upper end to diaphragm 38, and at its lower end to diaphragm 46, so that as the connected diaphragms move upwardly or downwardly, the piston 100 will move therewith. Suitable rigid plates 101 and 102 are provided on either side of diaphragm 38 and are held in engagement therewith by the threading of nut 103 on the threaded end of piston 100. Similar plates are provided on the lower end of piston 100 to lend support to diaphragm 46.

A valve actuator plate 106 is secured to the middle of piston 100 by means of a setscrew 107 having a button head, so that as the piston 100 reciprocates, the plate 106 will be carried between the dotted limit positions shown in FIG. 1. Situated in positions to be engaged by the actuator plate 106 are two relief valves, 108 and 109, the valve 108 being mechanically secured to the upper casing 37 and the valve 109 being mechanically secured to the lower casing 43. Valve 108 is connected by conduit 112 to orifice 32 of the four-way valve 20, and valve 109 is connected by conduit 111 to orifice 33 of the four-way valve 20.

Valve 108, shown in greater detail in FIG. 5, comprises a tubular housing 113, with a plunger 114 axially mounted

therein, the plunger being urged downwardly by spring 116 so that the O-ring 117 carried by plunger 114 seats on the annular valve seat 118 of housing 113. When the plunger is pushed upwardly by the actuator plate 106 to the dotted position, the O-ring will be unseated from seat 118 to allow fluid to flow from above downwardly through the annular space 119 between the housing 113 and plunger 114 and out through the housing orifice 120 to atmosphere. When the actuator plate 106 moves downwardly out of engagement with the plunger 114, the spring 116 will close the valve.

The main valve 11, controlling the flow of pressurized gas to the well casing, is of the type disclosed in my copending application, Serial No. 643,964, filed March 5, 1957, now Patent Number 2,886,281. For the purposes of this application, it should be sufficient to state that valve 11 comprises a body member 126, having an inlet chamber 127 and an outlet chamber 128 with a cage member 129 disposed therebetween. The cage member 129 has a series of horizontal slots 131 therethrough allowing the passage of gas from the inlet chamber 127 into the interior of the cage member 129, and a series of vertical slots 132 therethrough allowing gaseous communication from the interior of the cage member 129 to the outlet chamber. A resilient cup member 133 is disposed within the cage member and held in place around a depending hub 134. The latter has an axial passage 136 therethrough, enabling a fluid, preferably oil, to pass from a reservoir 137 in the upper portion of the body member 126 downwardly through the hub 134 into the interior of the cup member 133. A cylindrical member 138 is threaded into the cap 139 of valve 11 so that the bore 141 of the cylindrical member 138 is in fluid communication with reservoir 137, and a valve-actuating piston 142 is slidably received in cylindrical member 138. In operation of valve 11, the reservoir 137 and the bore 141 of cylindrical member 138 are filled with oil and the piston 142 is inserted in the bore 141. A downward pressure on piston 142 forces oil through hub passage 136 outwardly into the interior of cup member 133, causing the cup to tightly seal against the interior of the cage member 129 to prevent any passage of gas through the slots 131 or 132. If the downward force on the piston 142 is relieved, the gas pressure in the inlet chamber 127 will collapse the cup member 133 inwardly around hub 134, with the oil in the cup member 133 being forced back into the reservoir 137 and bore 141, and gas may flow freely through the slotted cage member 129.

The upper end of piston 142 is secured at 143 to the diaphragm 47 in casing 43, the diaphragm 47 being sufficiently large in size so that a relatively small gas pressure in compartment 49 will exert a sufficiently great total downward force through piston 142 to overcome the total force in the inlet chamber 127 which tends to collapse the cup member 133 around the hub 134 and thus will seal the cup member 133 against the cage member 129. Or, that is, whenever there is pressure in compartment 49, as a result of low pressure gas being directed to that compartment from the four-way valve 20, the main valve 11 will be closed, preventing any gas flow therethrough into the well casing.

The operation of the device is as follows. The supply conduit 10 is connected to a source of high pressure gas, and a portion of such high pressure gas is bled off through conduit 16, through the pressure reducer 17 to the four-way valve 20. In the position as shown in FIG. 1, this gas passes through the four-way valve, conduit 86, cut-off device 55, conduit 52 to compartment 49. At the same time, compartment 39 is vented to atmosphere through conduit 42 and the four-way valve 20.

The presence in compartment 49 of the gas pressure will exert a downward force on diaphragm 47 and piston 142 so as to close the main valve 11. At the same time, the difference in pressures between compartments 49 and 39 will cause the oil in compartment 48 to be forced upwardly through check valve 93 and metering valve 94 into compartment 41, the rate of flow being regulated to a desired amount by proper adjustment of metering valve 94. The decrease of oil in compartment 48 and the increase in oil in compartment 41 will cause the diaphragms 46 and 38 to move upwardly, carrying with them their interconnected piston 100.

After the desired length of time has passed, the valve actuator 106 will have been carried to the upper dotted position, where it actuates the plunger of relief valve 108. As has been explained, this will cause the four-way valve 20 to reverse its position, to pass gas therethrough to conduit 42 and compartment 39, and, at the same time, the valve 20 will vent compartment 49 to atmosphere.

The venting of compartment 49 to atmosphere removes the downward pressure on diaphragm 47 and piston 142, and allows the valve 11 to open, passing gas therethrough to the well casing. At the same time, the greater pressure in compartment 39 will cause the diaphragm 38 to be forced downwardly, and the oil in compartment 41 will pass downwardly through metering valve 88 and check valve 89 to compartment 48. Again, the rate of flow of the oil may be regulated by the proper adjustment of metering valve 88.

The diaphragms 38 and 46 will be forced downwardly, carrying the piston 100 and valve actuator 106 downwardly, until finally the valve actuator 106 comes into engagement with the plunger of relief valve 109, again causing the four-way valve to reverse its position so that the gas will again be sent to compartment 49, thereby closing the main valve 11 and again starting the piston 100 on its upward travel. Thus, the device will continue to reciprocate as long as gas pressure is supplied to the conduit 16, with the valve 11 being alternately opened and closed.

In the discussion of operation thus far, every time the piston 100 moves upwardly, the head of the setscrew 107 will come into contact with, and depress, the button 82 of the cut-off device. However, if the tubing pressure in the well is sufficiently low so as not to overcome the compression spring 59 of the cutoff device, the depression of the button 82 will not interrupt the flow of gas through the cut-off device.

In the event that the tubing pressure should build up to a greater amount than desired, i.e., above the pressure for which the cut-off device has been set, the intermitter operates in the following manner. The excessive tubing pressure will cause the bellows 66 to expand against the force of the compression spring 59 and will move the piston 58 to the right. This does not yet act to cut off gas flow through the cut-off device 55, although gas flow through the main valve 11 will be shut off if there is gas pressure in compartment 49. The piston 100 will be moved upwardly, as before, until the setscrew 107 comes into engagement with button 82 so as to move the cut-off device valve member 73 against the valve seat 84 to prevent gas flow therethrough. The pressure of the gas now trapped in compartment 49 will continue to exert an upward force on diaphragm 46, causing the piston 100 to move slightly further upwardly into engagement with the button of the relief valve 108, again causing the four-way valve 20 to reverse its position, thus applying gas under pressure to compartment 39. However, compartment 49 is prevented by the cut-off device from venting to atmosphere and the gas pressure remains in that compartment. The pressure in compartment 39 is slightly higher than that in compartment 49 and the piston 100 will be forced downwardly a slight amount until the pressures in compartments 39 and 49 are equalized and further piston travel ceases. The slight amount of downward movement of piston 100 will be insufficient to allow the setscrew 107 to be removed from button 82 of the cut-off device 55, and the system comes to rest.

When the tubing pressure falls below the setting of the

cut-off device 55, the bellows 66 will contract and the spring 59 will move the piston 58 to the left, thus removing the valve seat 84 from the valve member 78, and the compartment 49 will immediately vent through the cut-off device 55 and four-way valve 26 to atmosphere, allowing the main valve 11 to open to admit gas into the well. The gas pressure in compartment 39 will again move the piston 100 downwardly and the automatic intermitting operation will continue as long as desired, or until the tubing pressure again reaches an undesired high level, so as to again actuate the cut-off device, as described above.

From this it is apparent that the intermitter will set itself upon an over pressure situation so that as soon as the tubing pressure falls back within the desired range of operation, the intermitter will immediately open the main valve 11, to allow gas to pass into the well.

It is obvious that the intermitter could be used to supply pressurized gas to the well tubing to cause an upward flow through the casing, with the cut-off device then being responsive to casing pressure, if desired.

Referring now to FIG. 6, wherein is illustrated another embodiment of the invention, a first casing, or housing, 201 is provided with a vertically disposed flexible diaphragm 202 therein, dividing the chamber within the casing into two compartments, 203 and 204. A plugged street el fitting 206 enables compartment 203 to be easily filled with non-compressible fluid. Similarly, a second casing, or housing, 207 has a vertically disposed flexible diaphragm 208 therein, dividing the chamber within the casing into two compartments 209 and 210. A plugged street el fitting 211 is also utilized for filling purposes.

A four-way control valve, generally designated at 212, has a body member 213 rigidly connected at one end thereof to casing 201, and rigidly connected at the other end thereof to casing 207. The valve 212 is provided with an axial bore 214 therethrough, the bore being radially enlarged at 215, and a reciprocally movable valve stem 217 is received within the bore 214, the stem being slightly smaller in diameter than the bore 214 so as to enable gas to pass through the annular space therebetween.

The stem is radially enlarged at 218, with O-rings 219 and 220 carried by stem 217 at the shoulders formed by the radial enlargement to serve as valve members, when carried against the shoulders of the bore 214 formed by the radial enlargement thereof.

As shown in FIG. 6, gas entering the inlet 221 cannot pass along the stem to the left into compartment 204, because the O-ring 219 is compressed between the stem and bore shoulders. However, the gas may pass to the right, through the annular space between the stem and bore and into compartment 209. If the valve stem 217 is moved to the right so as to confine the O-ring 220 between the stem and bore shoulders, the flow of gas from the inlet 221 will be reversed, to flow into compartment 204.

Mounted near the right end of valve stem 217 for movement therewith is a valve member 222 having a resilient insert 223 adapted to engage seat member 224 extending outwardly from the body member 213. A discharge passage 225 extends through the seat member 224 to a button valve 108 mounted on the valve body. As shown in FIG. 5, if the button valve is depressed, a passage therethrough will be establihsed, with a release of the button valve serving to close the discharge passage 225.

A similar seat member 226 is spaced 180° from seat member 224 to engage and balance valve member 222 when the latter is seated on seat member 224. It will be noted that the seat members 224 and 226 extend outwardly from body member 213 to form a flow passage at all times between the body member and valve member 222, thus placing compartment 209 in fluid communication with the annular space between the valve stem 217 and bore 214.

A cap member 227 is slidably mounted on the outer end of valve stem 217, and is outwardly biased by spring 228. Screw 229 limits outward movement of cap member 227.

The other end of the valve stem 217 is provided with a similar valve member, spring biased cap member and discharge passage, with identical parts being designated by the same reference numerals with the letter "*a*" appended thereto. The discharge passage 225*a* communicates directly to atmosphere.

The button valve 108 is operated by means of the cut-off valve 230 mounted in fixed relation to the four-way valve 212. The cut-off valve 230 has a body member 231 with a stem member 232 axially slidable therein and projecting therefrom. A bellows member 233 surrounds a portion of the stem 232 and is secured at one end thereof to the stem and is secured at the other end thereof to the body member 231, so that a fluid under pressure entering the inlet 234 will act on the bellows to force the stem member inwardly into the body member. Such movement is opposed by a compression spring 235 confined between spring retainer 236 and spring guide 237. The amount of compressive force of the spring may be varied by the manually operable screw member 238.

The cut-off valve 230 is mounted with respect to the four-way valve 212 so that the cut-off stem member 232 is normally held by spring 235 against the button valve 108 to open that valve and allow the discharge passage 225 to communicate to atmosphere. If the pressure of the fluid entering the inlet 234 exceeds the compressive force of the spring 235, the bellows will expand, drawing the stem member 232 inwardly into the valve to allow the button valve 108 to close, thus preventing the four-way valve passage 225 from venting compartment 209 to atmosphere.

The operation of the embodiment of FIG. 6 is as follows: A portion of the supply gas from conduit 10 is bled off through conduit 16, pressure reducer 17, and conduit 18 to the inlet 221 of valve 212. As shown in FIG. 6, this gas cannot pass the O-ring 219, and passes into compartment 209. A portion of the gas passes from this compartment through conduit 240 to the valve actuator of the main valve 11 to close this valve against flow therethrough, in a manner as before described.

The pressure of the gas within compartment 209 moves diaphragm 208 to the right and forces the oil within compartment 210 to flow therefrom through a first flow path comprising port 241, passage 242, conduit 243, metering valve 244, check valve 245, conduit 246, passage 247 and port 248 into compartment 203. This increase of oil within compartment 203 will force the diaphragm 202 to the right, until it engages the cap member 227*a*. Further movement of the diaphragm 202 will move the cap member 227*a* rightwardly on the stem 217, compressing spring 228*a*, until the right end of the cap member 227*a* engages the valve member 222*a*. Further rightward travel of diaphragm 202 then acts directly on stem 217 to move it rightwardly, which movement unseats O-ring 219 and valve 223, to equalize the pressure acting on the valve stem 217. The pent-up energy in spring 228*a* then snaps the valve stem 217 rightwardly, seating O-ring 220 to prevent flow into compartment 209, and seating valve member 223*a* on seat member 224*a* to close the discharge passage 225*a*.

The compartment 204 is now pressurized by the gas passing through the four-way valve, and the compartment 209 is vented to atmosphere through the discharge passage 225 and button valve 108. With compartment 209 now at atmospheric pressure, the main valve 11 will be opened for flow therethrough. The fluid within compartment 203 is now forced outwardly therefrom, through a second flow path comprising port 248, passage 247, conduit 246, check valve 249, metering valve 250, con-

duit 243, passage 242, and port 241 back into compartment 210.

In a manner similar to that previously described, the filling of compartment 210 will cause diaphragm 208 to flex leftwardly, first engaging cap member 227, then compressing spring 228, and then moving the stem 217 to the left so that it may be snapped by spring 228 back to the operative position shown in FIG. 4. The gas then flows again through the four-way valve 212 into compartment 209 to pressurize this compartment, again acting through conduit 240 to close the main valve against flow therethrough; and the intermitting device begins another cycle of operation.

The lengths of time required for the timing fluid to flow from compartment 210 to compartment 203 and vice versa are controlled by the setting of the metering valves 244 and 250, respectively. Since it is normally required that the period of gas injection into the well 14 be of short time duration as compared to the intervals between injections, the metering valve 244 is adjusted to give a greater flow therethrough than that allowed by metering valve 250. This gives a short period of gas injection, when the timing fluid passes from compartment 203 through check valve 249 and metering valve 250 into compartment 210, and a long period between injections, when the timing fluid passes from compartment 210 through metering valve 244, and check valve 245 into compartment 203.

As stated above, the cut-off device 230 is positioned so as to normally hold the button valve 108 in open position. If the tubing pressure in the well tubing 13 increases beyond the safe amount for which the cut-off device is set, this pressure will be communicated through conduit 62 into the cut-off device, to move the stem member 232 inwardly thereof, which movement releases the button valve 108 to its closed position, closing the discharge passage 225.

If the cut-off device 230 operates as a result of excessive well tubing pressure while the intermitting device is in its long portion of its cycle of operation; i.e., when the compartment 209 is pressurized and the main valve 11 is closed, the intermitter will continue in operation, since the discharge passage 225 is already closed by valve member 222, until the diaphragm 202 moves rightwardly to move the stem 217 to the right, as under normal operation. However, if the excessive tubing pressure still exists, the movement of the stem 217 and valve member 222 will not allow compartment 209 to vent to atmosphere, and the pressures within compartments 204 and 209 will be equal. This equality in pressures will stop any further exchange of fluid between the compartments 203 and 210 and the intermitting device will cease its cycling operation. When the well tubing pressure drops below the unsafe amount, the cut-off device 230 will open the button valve 108, enabling the compartment 209 to vent to atmosphere, the main valve 11 to open, and the short, or injection, portion of the cycle to begin immediately.

If the cut-off device 230 is actuated during the short, or injection, portion of the cycle; i.e., when compartment 204 is pressurized and compartment 209 is vented to atmosphere, the button valve 108 will close the discharge passage 225. Since compartment 209 is at atmospheric pressure, the diaphragm 202 will continue to move leftwardly, forcing the timing fluid from compartment 203 into compartment 210, to flex diaphragm 208 leftwardly, either until the end of the short cycle, or until the trapped air in compartment 209 is compressed so as to build up a pressure therein equal to that of the gas in compartment 204.

If the short cycle is completed, the stem 217 will be moved leftwardly to start the long period of the cycle which then continues until the end thereof, at which time the intermitting device stops operation as explained above, with the main valve 11 held closed and the device readied to begin an injection period as soon as the tubing pressure drops to a safe amount.

If the short cycle is not completed, because of the equalization of pressures within compartments 209 and 204, the pressure of the compressed air in compartment 209 will be sufficiently high as to close off the main valve 11. As soon as the tubing pressure drops to a safe amount, the button valve 108 will again be opened, venting compartment 209 to open the main valve 11 and complete the injection period.

Thus, the cut-off device 230 will serve to discontinue the operation of the intermitting device whenever the tubing pressure increases beyond a desired maximum amount, and the intermitting device sets itself to open the main valve 11 to inject gas into the well as soon as the over pressure situation is alleviated.

It is to be understood that the forms of the invention, herewith shown and described, are to be taken as preferred examples 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 my invention, or the scope of the attached claims.

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

1. An intermitting gas system for use with an oil well having a tubing disposed within a casing comprising a first housing having a first diaphragm therein forming a first and a second compartment, a second housing having a second and third diaphragm therein forming a third, a fourth and a fifth compartment, said fourth compartment including as the walls thereof said second and third diaphragms, a fluid-filling said second and said third compartments, a first conduit connecting said second and third compartments, a first check valve in said first conduit allowing fluid flow from said second to said third compartment, a second conduit connecting said second and third compartments, a second check valve in said second conduit allowing fluid flow from said third to said second compartment, a four-way valve means having an inlet adapted to be connected to a source of fluid under pressure and having a first operative position connecting said first compartment to said inlet and venting said fourth compartment to atmosphere and a second operative position connecting said fourth compartment to said inlet and venting said first compartment to atmosphere, a rod fixed at one end thereof to said first diaphragm and at the other end thereof to said second diaphragm, means responsive to a predetermined amount of movement of said rod to alternatively move said four-way valve means from one operative position to its other operative position, a gas line adapted to be connected to said casing, a valve in said gas line, means responsive to movement of said third diaphragm for operating said gas line valve between open and closed positions.

2. In a system as set forth in claim 1 including a conduit means communicating said four-way valve means inlet with said gas line upstream from said gas line valve.

3. In a system as set forth in claim 2 further including means adapted to be responsive to a predetermined pressure within said tubing, said last named means being operable to prevent venting of said fourth compartment to atmosphere by said four-way valve means upon the presence of said predtermined tubing pressure.

4. An intermitting gas system for use with an oil well having a tubing disposed within a casing comprising a gas line adapted to be connected at its downstream end to said casing, a valve in said gas line, a first housing having a diaphragm therein forming a first and second compartment, a second housing having a diaphragm therein forming a third and a fourth compartment, said second and third compartments being filled with a fluid, a first conduit connecting said second and third compartments, a first check valve in said first conduit allowing fluid flow from said second to said third compartment, a second conduit connecting said second and third com-

partments, a second check valve in said second conduit allowing fluid flow from said third to said second compartment, a four-way valve means having an inlet adapted to be connected to a source of fluid under pressure and having a first operative position connecting said first compartment to said inlet and venting said fourth compartment to atmosphere and a second operative position connecting said fourth compartment to said inlet and venting said first compartment to atmosphere, a rod fixed at each end to one of said diaphragms, means responsive to movement of said rod to alternatively move said four-way valve means from one operative position to its other operative position, means adapted to be responsive to a predetermined pressure in said tubing, said last named means being operable to prevent venting of said fourth compartment to atmosphere by said four-way valve means upon the presence of said predetermined tubing pressure, and means responsive to fluid pressure in said fourth compartment to close said gas line valve.

5. In a device as set forth in claim 4 including a conduit means communicating said four-way valve inlet with said gas line upstream from said gas line valve.

6. An intermitter device comprising a first housing having a flexible diaphragm therein dividing said first housing into a first and second compartment, a second housing having a flexible diaphragm therein dividing said housing into a third and fourth compartment, an incompressible fluid filling said second and third compartments, each of said diaphragms being adapted to flex between a first and second position, means to allow a one-way fluid flow from said second to said third compartment, means to allow a one-way fluid flow from said third to said second compartment, a source of fluid under pressure, means including a valve having a first and second operative position to connect said first compartment to said pressure fluid source and to vent said fourth compartment to atmosphere when said valve is in its first operative position, and to connect said fourth compartment to said pressure fluid source and to vent said first compartment to atmosphere when said valve is in its second operative position, means responsive to the flexing of one of said diaphragms to its first position to move said valve to its first operative position, and means responsive to the flexing of said one diaphragm to its second position to move said valve to its second operative position, and condition responsive means operable upon the presence of a condition to prevent said fourth compartment from venting to atmosphere when said one diaphragm moves to its first position and actuates said control valve to its first position.

7. An intermitting system comprising a conduit adapted to be connected to a source of fluid under pressure, a valve in said conduit having open and closed positions, a first housing having a flexible diaphragm therein dividing said first housing into a first and second compartment, a second housing having a flexible diaphragm therein dividing said second housing into a third and fourth compartment, an incompressible fluid filling said second and third compartment, each of said diaphragms being adapted to flex between a first and second position, means to allow a one-way fluid flow from said second to said third compartment, means to allow a one way fluid flow from said third to said second compartment, means including a control valve having a first and second operative position to connect said first compartment to said conduit upstream from said conduit valve and to vent said fourth compartment to atmosphere when said control valve is in its first operative position, and to connect said fourth compartment to said conduit upstream from said conduit valve and to vent said first compartment to atmosphere when said control valve is in its second operative position, means responsive to the flexing of one of said diaphragms to its first position to move said control valve to its first operative position, means responsive to the flexing of said one diaphragm to its second position to move said control valve to its second operative position, means responsive to the presence of pressure fluid in said fourth compartment to operate said conduit valve from one of its positions to the other, and condition responsive means operable upon the presence of a condition to prevent said fourth compartment from venting to atmosphere when said one diaphragm moves to its first position and actuates said control valve to its first position.

8. An intermitting gas system for use with an oil well having a tubing disposed within a casing comprising a gas line adapted to be connected at its downstream end to said casing, a valve in said gas line, a first housing having a diaphragm therein forming a first and second compartment, a second housing having a diaphragm therein forming a third and a fourth compartment, said second and third compartments being filled with a fluid, a first conduit connecting said second and third compartments, a first check valve in said first conduit allowing fluid flow from said second to said third compartment, a second conduit connecting said second and third compartments, a second check valve in said second conduit allowing fluid flow from said third to said second compartment, a four-way valve means having an inlet adapted to be connected to a source of fluid under pressure and having a first operative position connecting said first compartment to said inlet and venting said fourth compartment to atmosphere and a second operative position connecting said fourth compartment to said inlet and venting said first compartment to atmosphere, said four-way valve having a reciprocating valve stem therethrough to move said valve between its first and second operative positions, said valve stem extending into said first and fourth compartments for alternating engagement therewith by said diaphragms, means adapted to be responsive to a predetermined pressure in said tubing, said last named means being operable to prevent venting of said fourth compartment to atmosphere by said four-way valve means upon the presence of said predetermined tubing pressure, and means responsive to fluid pressure in said fourth compartment to close said gas line valve.

9. In a device as set forth in claim 8 including a conduit means communicating said four-way valve inlet with said gas line upstream from said gas line valve.

10. An intermitter device comprising a first housing, a first flexible diaphragm in said first housing forming a first and second compartment therein, a second housing, a second flexible diaphragm in said second housing forming a third and fourth compartment therein, an incompressible fluid in said second and third compartments, a first conduit connecting said second and third compartments, a first check valve in said first conduit allowing one-way fluid flow from said second to said third compartment, a second conduit connecting said second and third compartments, a second check valve in said second conduit allowing a one-way fluid flow from said third to said second compartment, a four-way valve having an inlet and a first operative position connecting said inlet to said first compartment and venting said fourth compartment to atmosphere and a second operative position connecting said inlet to said fourth compartment and venting said first compartment to atmosphere, and a valve operator extending through said four-way valve and having one end thereof projecting into said first compartment for engagement by said first diaphragm, said engagement causing said four-way valve to move to its first operative position, said valve operator having its other end projecting into said fourth compartment for engagement by said second diaphragm, said last engagement causing said fourway valve to move to its second operative position.

11. In a device as set forth in claim 10 further including pressure responsive valve means to prevent venting of said fourth compartment when said four-way valve is in its first operative position.

12. An intermitting gas system for use with an oil well

having a tubing disposed within a casing, comprising a gas supply line adapted to be connected at its downstream end to the tubing-casing annulus and to be connected at its upstream end to a source of gas under pressure, a valve in said gas line, valve actuating means responsive to the pressure of the gas in said gas line upstream of said valve to operate said valve, timing means operated by the gas pressure in said gas line upstream of said valve to intermittently supply said gas pressure to said valve actuating means adapted to be at predetermined intervals, and means responsive to a predetermined high pressure in said tubing, said last named means being operable to maintain said valve in closed position as long as said predetermined high tubing pressure exists and to discontinue the operation of said timing means when said timing means is in a position which would otherwise allow said valve to open so that said valve will open immediately when the tubing pressure falls below said predetermined high pressure.

13. An intermitting gas system comprising an oil well having a tubing disposed within a casing to form a tubing-casing annulus, a gas supply line connected at its downstream end to the tubing-casing annulus and adapted to be connected at its upstream end to a source of gas under pressure, a valve in said gas line, valve actuating means operable by to the pressure of the gas in said gas line upstream of said valve to operate said valve, timing means operated solely by the gas pressure in said gas line upstream of said valve to intermittently supply said gas pressure to and relieve said gas pressure from said valve actuating means at predetermined intervals, and means responsive to a predetermined high pressure in said tubing to maintain said valve closed as long as said predetermined high tubing pressure exists and to discontinue the operation of said timing means when said timing means is in a position which would otherwse allow said valve to open so that said valve will open immediately when the tubing pressure falls below said predetermined high pressure.

14. An intermitting gas system comprising a gas line, a main valve in said gas line, means forming first and second chambers, said chambers both being filled with a quantity of hydraulic fluid and a quantity of gas, passage forming means connecting said first and second chambers for reversible liquid flow therebetween, a conduit connecting said first chamber to said gas line upstream of said main valve, a control valve in said conduit, means operable when the amount of hydraulic liquid in said first chamber is at a predetermined maximum amount to actuate said control valve to a first position wherein pressure gas may pass through said conduit into said first chamber and operable when the amount of hydraulic fluid in said first chamber is at a predetermined minimum amount to actuate said control valve to a second position to shut off flow of said pressure gas through said conduit into said first chamber, means to vent said first chamber to atmosphere when said control valve is in its second position, main valve operator means including a fluid actuated member for operating said main valve between open and closed positions, and means disposing said fluid actuated member in direct exposure to and for direct actuation by said pressure gas which passes through the control valve in said conduit.

15. An intermitting gas system comprising a gas line, a main valve in said gas line, means forming first and second chambers, said chambers both being filled with a quantity of hydraulic fluid and a quantity of gas, means forming a first passage for one-way flow of hydraulic fluid from said first chamber to said second chamber, means forming a second passage for one-way flow of hydraulic fluid from said second chamber to said first chamber, first and second metering valves in said first and second passage respectively, a source of gas under pressure, a conduit connecting said first chamber to said pressure gas, a control valve in said conduit, means operable when the amount of hydraulic liquid in said first chamber is at a predetermined maximum amount to actuate said control valve to a first position wherein pressure gas may pass through said conduit into said first chamber and operable when the amount of hydraulic fluid in said first chamber is at a predetermined minimum amount to actuate said control valve to a second position to shut off flow of said pressure gas through said conduit into said first chamber, means to vent said first chamber to atmosphere when said control valve is in its second position, main valve operator means including a fluid actuated member for operating said main valve between open and closed positions, and means disposing said fluid actuated member in direct exposure to and for direct actuation by said pressure gas which passes through the control valve in said conduit.

16. An intermitting gas system comprising a gas line, a main valve in said gas line, means forming first and second chambers, said chambers both being filled with a quantity of hydraulic fluid and a quantity of gas, means forming a first passage for one-way flow of hydraulic fluid from said first chamber to said second chamber, means forming a second passage for one-way flow of hydraulic fluid from said second chamber to said first chamber, first and second metering valves in said first and second passage respectively, a conduit connecting said first chamber to said gas line upstream of said main valve, a control valve in said conduit, means operable when the amount of hydraulic liquid in said first chamber is at a predetermined maximum amount to actuate said control valve to a first position wherein pressure gas may pass through said conduit into said first chamber and operable when the amount of hydraulic fluid in said first chamber is at a predetermined minimum amount to actuate said control valve to a second position to shut off flow of said pressure gas through said conduit into said first chamber, means to vent said first chamber to atmosphere when said control valve is in its second position, main valve operator means including a fluid actuated member for operating said main valve between open and closed positions, and means disposing said fluid actuated member in direct exposure to and for direct actuation by said pressure gas which passes through the control valve in said conduit.

References Cited in the file of this patent

UNITED STATES PATENTS

862,867	Eggleston	Aug. 6, 1907
1,828,206	Simmons	Oct. 20, 1931
2,042,300	Forsberg	May 26, 1936
2,245,005	Nixon	June 10, 1941
2,251,323	Burke	Aug. 5, 1941
2,328,841	O'Leary	Sept. 7, 1943
2,501,294	Sigvard	Mar. 21, 1950
2,904,011	Miley	Sept. 15, 1959