

Aug. 16, 1966

G. R. GANDY
DIFFERENTIAL PRESSURE ADAPTER FOR AUTOMATIC
CYCLE WELL CONTROL

3,266,574

2 Sheets-Sheet 1

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Fig. 1

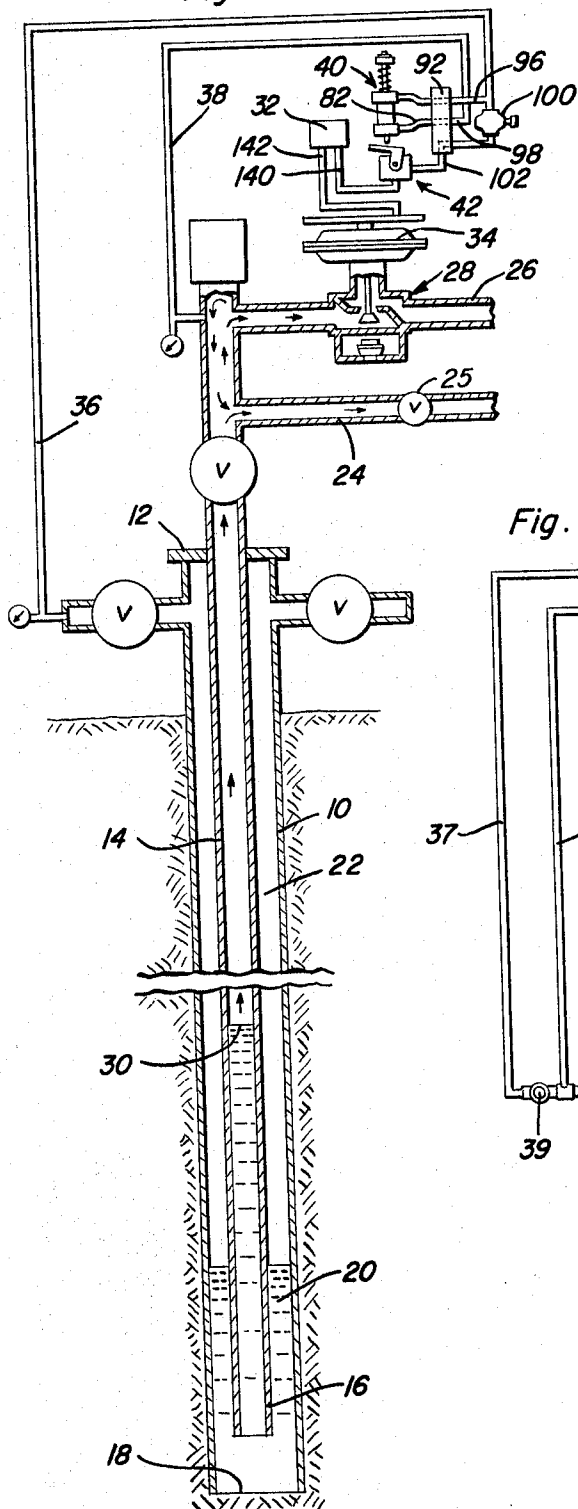


Fig. 2

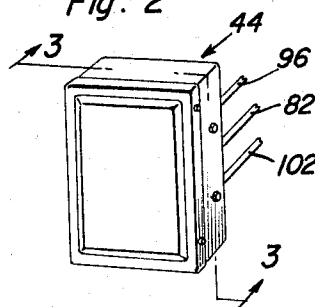
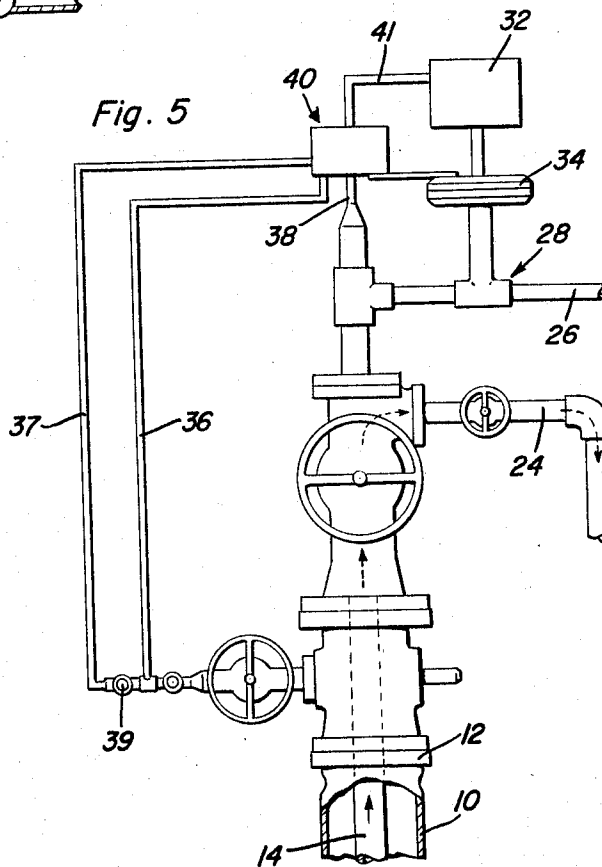


Fig. 5



Gary R. Gandy
INVENTOR.

BY *Alvanice A. O'Brien*
and Harvey B. Jacobson
Attorneys

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Fig. 3

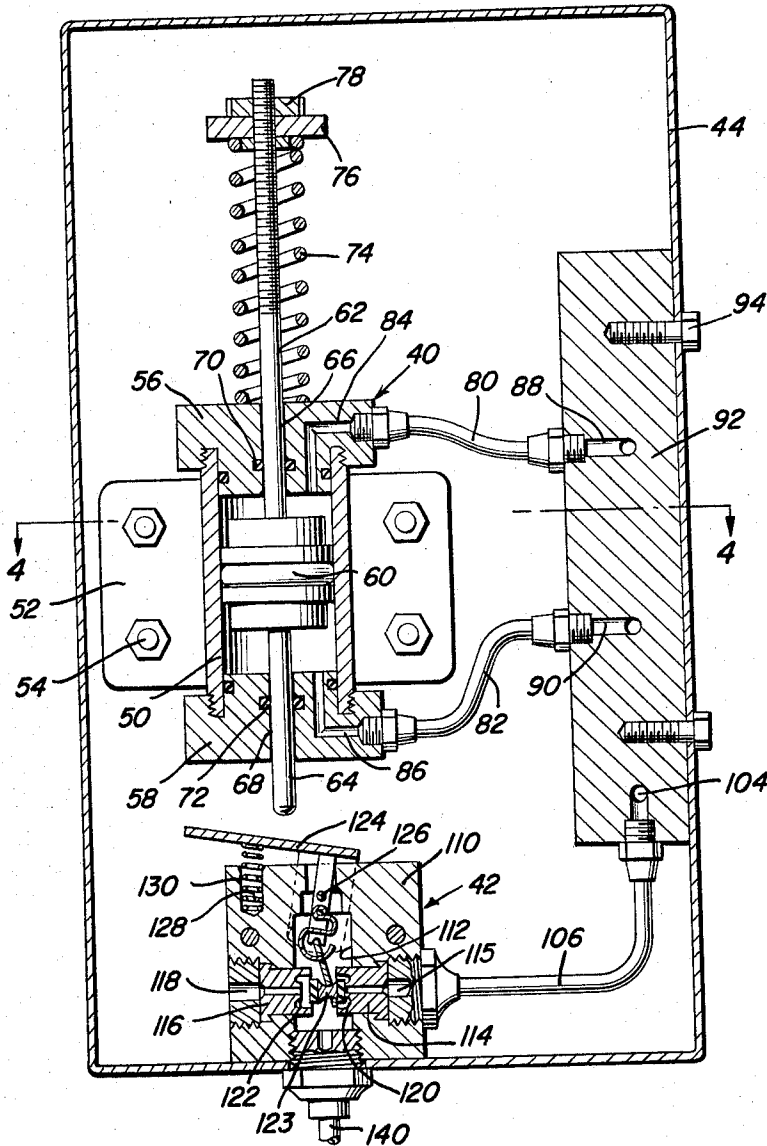
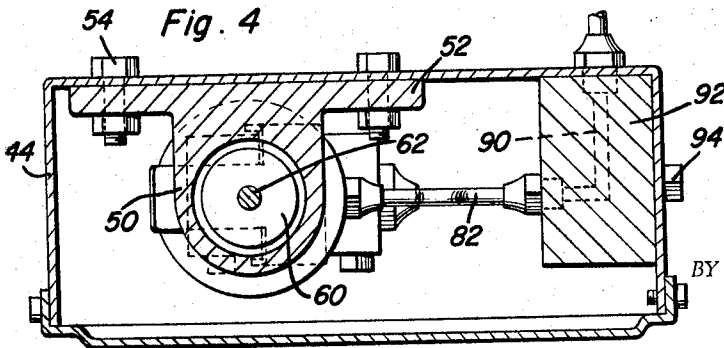


Fig. 4



Gary R. Gandy
INVENTOR.

BY *Alonzo A. Brown*
and *Harvey B. Jackson*
Attorneys

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DIFFERENTIAL PRESSURE ADAPTER FOR
AUTOMATIC CYCLE WELL CONTROL

Gary R. Gandy, 3518 Kayenta Drive,
Farmington, N. Mex.
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This invention comprises a novel and useful differential pressure adapter for automatic cycle well control and more particularly pertains to an attachment adapted to be applied to a conventional time cycle controller employed for the intermittent discharge of liquid accumulations in a gas well.

It is well known that flowing gas wells are from time-to-time adversely affected by the accumulations of liquid in the well bore during the flow of gas from the formation into the well bore. When the liquid accumulations reach a sufficient quantity, it adversely affects the production of gas from the well. It is therefore customary to provide an automatic cyclic operation of such gas wells whereby the gas pressure is then utilized to effect the forcible expulsion of the accumulated liquid from a tubing string in the well bore. After the liquid has been blown from the well, the motor valve through which the liquid was expelled is again closed and the gas is allowed to resume its normal flowing operation.

It has been customary to provide an automatic time controller for intermittently opening the motor valve and allowing the well pressure to expel the liquid from the well bore. Inasmuch as such mechanisms have heretofore operated upon a time cycle, it has been necessary to regulate the time or frequency of the intermittent operation or the "intermitting" of the gas well so as to periodically discharge liquid accumulations therefrom. However, in such operations, the automatic intermitting of the well occurs regularly at a predetermined and preset time interval regardless of whether an excessive amount of liquid has accumulated therein. When a small quantity of liquid has accumulated, the automatic intermitting of the well results in expelling this liquid and then in a considerable loss of gas from the well through the tubing until the intermitting period has ended.

It is therefore the principal object of this invention to provide an apparatus which will greatly reduce the wasting and loss of natural gas in a flowing well when the well is being cyclically "intermitted" for discharging accumulations of liquid entering the well bore.

A further object of the invention is to provide an attachment which may be applied to a conventional time-controlled automatic well cycling device to prevent the intermitting of the well until it has accumulated a sufficient quantity of liquid to require its expulsion from the well.

A still further and more specific object of the invention is to provide an attachment in accordance with the preceding objects which may be readily applied to conventional time-controlled cyclic well operators and which will prevent the actuation of the cyclic operator from intermitting the well at its normal preset time interval unless there is accumulated a quantity of liquid in the well bore.

A still further and more specific object of the invention is to provide an attachment in accordance with the preceding objects which shall sense the presence of liquid in the well bore, and which will respond to the difference in

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pressure between the gas in the annulus of the well and the pressure of the gas flowing in a well tubing when liquid accumulates in the well, will utilize this pressure differential to allow operation of the cycle control timer to intermit the well and will then preclude further operation of the cyclic timer when the accumulation of liquid has been expelled from the well.

A still further purpose of the invention is to provide an attachment in accordance with the foregoing objects where its entire operation will be pressure actuated and wherein the pressures required therefor are derived from the gases in the well bore.

These together with other objects and advantages which will become subsequently apparent reside in the details of construction and operation as more fully hereinafter described and claimed, reference being had to the accompanying drawings forming a part hereof, wherein like numerals refer to like parts throughout, and in which:

FIGURE 1 is a somewhat diagrammatic view showing a typical gas well installation having an automatic cycle control mechanism in accordance with prior practice applied thereto and the differential pressure adapter of this invention connected therewith;

FIGURE 2 is a perspective view of the actuating unit of the differential pressure adapter of this invention;

FIGURE 3 is a view taken upon an enlarged scale in vertical section substantially upon the plane indicated by the section line 3—3 of FIGURE 2 and showing the internal construction of the differential pressure adapter of this invention;

FIGURE 4 is a horizontal transverse sectional view taken substantially upon the plane indicated by the section line 4—4 of FIGURE 3; and,

FIGURE 5 is a fragmentary elevational view of a slightly modified arrangement of the upper portion of a casing head with a conventional cyclically operated well intermitting arrangement to which this adapter has been applied.

In FIGURES 1 and 5 the same numerals have been employed to designate the elements common to another well intermitting device and the intermitting system in accordance with this invention. Indicated at 10 is the casing of a well bore which casing has a head as at 12 and a tubing string 14 extends through this casing wellhead with its open or perforated lower end as at 16 in sufficient proximity to the bottom 18 of the well bore to enable the gas flowing into the well bore from the formation to be accessible to the lower end of the tubing string 14 until such time as liquid as at 20 has accumulated in the bottom of the well bore to a sufficient depth to outweigh the pressure of the well bore thus cut-off or slow down the delivery rate through the tubing string 14 to the flow line 24. Indicated by the numeral 22 is the well annulus which is the space lying between the tubing string 14 and the well casing 10. The gas accumulating in the well bore is communicated to this annulus and is drawn on as a reserve by the tubing 14 as the sales line or flow line 24 requires it and is delivered by said line 24 to any suitable destination. Thus, the gas from the formation flowing from the well rises through the tubing 14 and is discharged to any suitable destination by means of the gas flow line 24. The tubing string is communicated with a conduit 26 which constitutes a liquid discharge line, flow through which is controlled by a motor valve assembly 28 of any

suitable design and which is controlled by a cyclic control device of conventional design. The motor valve assembly 28 stops flow through the liquid discharge line.

When sufficient liquid 20, whether water, oil or any other liquid, accumulates in the bottom of the well to a sufficient depth to close the lower end 16 of the tubing string, the pressure of the gas will force this liquid to a height within the tubing string as indicated by the numeral 30.

When the open end 16 of the tubing string is free of liquid, the pressure of gas in the annulus 22 and in the tubing string will be substantially equal. However, upon accumulation of liquid that is pulled into the tubing on its way to the flow line 24, the tubing pressure is decreased in proportion to the quantity of the incoming liquid and will result in a considerable decrease in the pressure of the gas in the tubing string 14 as compared with the pressure prevailing in the annulus 22. It is this pressure difference which is utilized in the present invention as a means for sensing the presence of an accumulation of liquid which is detrimentally affecting the operation of the flowing gas well and which accumulation is to be ejected from the well in order to obviate the interference of the liquid with the flow of the well.

In the conventional system of operating flowing gas wells it is customary to periodically, at preselected intervals of time, open the normally closed motor valve 28 and to shut-off flow through the gas flow line 24 whereby the pressure within the annulus 22 will operate to eject the liquid accumulation 20 and 30 up through tubing 14 and through the liquid discharge line 26. Ordinarily, an automatic timing device such as that indicated at 32 is utilized to effect operation of the valve 28 at desired predetermined and preset time intervals so as to periodically automatically "intermit" the well. The operation of intermitting the well is thus a temporary cessation of its normal flow and a utilization of the gas pressure to effect a discharge of the accumulated liquid from the well.

In the conventional system, a diaphragm 34 is connected to the valve 28 for operating the latter. This diaphragm is in turn connected operatively by a clock controlled pilot 32 that can be set periodically to transmit a fuel gas signal, such as 20 pounds pressure to the diaphragm 34 thereby operating the motor valve assembly 28.

The present invention makes use of the conventional cyclic operating mechanism of a gas well. However, a novel differential pressure-sensing unit indicated generally by the numeral 40 is connected in a novel manner with the time cycle pilot 32 to effect operation of the latter.

Referring now specifically to FIGURES 1 and 3, it will be observed that the sensing unit 40 is operatively connected with a block valve assembly 42. Both of these units as shown in FIGURE 3 may be received in a housing or casting 44 for convenience of assembly and mounting.

The differential pressure-sensing unit 40 includes a cylinder 50 having mounting flanges 52 which are secured as by fastening bolts 54 to any suitable support within the housing 44. The two ends of the cylinder 50 are closed as by screw-threaded end plates or heads 56 and 58. Reciprocable within the cylinder is a piston 60 having a fluid-tight engagement with the wall of the cylinder and from which piston extend upper and lower piston rods 62 and 64 respectively. These rods are slidably received through corresponding bores as at 66 and 68 respectively in the cylinder head members with suitable O-rings or other packing means as indicated at 70 and 72 being provided to ensure the establishing of a fluid-tight seal for the piston and its piston rods. The upper rod 62 is surrounded by a compression spring 74 whose force is adjusted by a spring retainer 76 under the action of an adjusting nut 78 threaded upon the extremity of the stem 62. The spring yieldingly urges the piston upward-

ly in the cylinder 50 with a force which is readily adjustable by proper manipulation of the adjusting nut 78.

A pair of conduits 80 and 82 which may be of a flexible nature communicate with the upper and lower ends of the cylinder 50 above and below the piston as by passage means at 84 and 86 respectively. It will be observed that fluid pressures applied by the conduit 80 will tend to move the piston 60 downwardly against the resistance of the spring 74 and the pressure applied to the underside of the piston 60 by the conduit 82.

The two conduits communicate with passages 88 and 90 respectively disposed in a block or manifold member 92 secured to the housing as by fastening bolts 94.

Referring now specifically to FIGURE 1 it will be observed that the well casing pressure conduit 36 has a branch conduit 96 which communicates with the block or manifold body 92 and with the passage 88 therein. In a similar manner, the tubing pressure conduit 38 communicates by a branch conduit 98 with the passage means 90 in the block 92 and thus with the conduit 82. Thus, pressures existing in the casing and in the tubing are simultaneously applied to opposite sides of the piston 60. In normal operation of the well, these two pressures will be substantially equal and therefore the spring 74 will be effective to urge the piston to its raised position. However, when the tubing pressure drops a sufficient extent below the casing pressure, the casing pressure communicated by the conduit 80 will be sufficient to move the piston 60 downwardly against the spring. The spring will be adjusted to respond to a predetermined differential between these two pressures.

It will be further noted from FIGURE 1 that the casing pressure conduit 36 extends downwardly below its connection with the branch conduit 96 to a pressure reduction valve assembly 100 of any suitable and conventional design, which reduces the casing pressure to a predetermined value as for example 20 pounds per square inch. This reduced casing pressure is communicated by a branch conduit 102 to a passage 104 disposed within the lower portion of the block 92 and is then led by a conduit 106 to the block valve assembly 42. It is this reduced pressure of 20 pounds which is utilized as the pressure which actuates the diaphragm 34 and thus opens the valve 28 when the time cycle pilot 32 actuates.

Referring now specifically to FIGURE 3 it will be seen that the block valve 42 includes a valve body 110 having therein a valve chamber 112. A pair of tubular nipples 114 and 116 are threadedly engaged in this chamber in diametrically opposed relation, the nipple 116 having an opening 118 vented to the interior of the housing 44 and thus to the atmosphere and the nipple 114 having an inlet opening 115 which communicates the actuating pressure conduit 106 with the valve chamber 112.

Each of the two nipples has a valve seat shown at 120 and 122 respectively and a control valve 123 is disposed between these seats and is selectively movable to seat upon and close either of these seats. The control valve is connected to and operated by a lever 124 which is pivoted as at 126 and is urged as by a spring 128 seated in a recess 130 in the open upper surface of the valve body 110. The arrangement is such that the lever 124 is disposed closely adjacent the under end of the valve stem 64. The spring normally urges the lever and thus the connected valve 123 to a position which will seat the valve upon the seat 120 and thus prevent flow of the 20 pound gas pressure from the conduit 106 into the valve chamber 112. However, if the sensing device 40 is subjected to a pressure differential between the casing and tubing gas through the conduits 80 and 82 of a predetermined difference greater than that for which the spring 74 is set, the casing pressure will move the piston downwardly and cause the piston stem 64 to depress the lever 124 and thus shift the valve to the other position and cause it to close the seat 122. At that time, the 20 pound gas pressure from the line 106 will enter the chamber 112

and then pass downward through the conduit 140 to the timer control 32 and from thence by the conduit 142 will enter the diaphragm 34 and thus effect actuation of the latter as previously described.

When the valve is closed upon its seat 120 which is the normal position during normal operation of the well, the vent 118 will vent any pressure within the chamber 112 to the atmosphere.

From the foregoing, it will now be apparent that during normal flowing of the well and when there is no appreciable or undesirable accumulation of liquid therein, the block valve 42 will be in its closed position as shown in FIGURE 3. Consequently, the 20 pounds of gas pressure supplied by the casing pressure line 36 and the pressure reducer 100 to the line 106 will be precluded from energizing the diaphragm actuator 34. During this time the pressure in the annulus of the casing and in the tubing 14 thereof is substantially equal and therefore the pressure of the spring 74 will maintain the piston 60 in its raised position so that the piston lock valve actuating stem 64 will not engage the actuating lever 124 and thus the latter will remain in valve closing position.

Therefore, despite the presence of the time controller 32 of the intermitting mechanism of the cyclic operator for the well, the timer will be unable to initiate the intermitting operation. The well will thus continue to flow for as long a time as there is no accumulation of liquid therein despite the presence of the cyclically operating well intermitter assembly and the time control mechanism therefor.

However, when liquid does accumulate as at 20 and 30 within the casing and tubing string 14, to a sufficient degree so as to produce a pressure differential between the casing and tubing which is greater than the force exerted by the spring 74, the piston 60 will be moved downwardly and will actuate the valve lever 124 thereby closing the escape vent 118 by seating the valve upon the seat 122, and opening the valve seat 120 and permitting the 20 pound pressure to pass through the conduit 106 to the time controller 32. However, this pressure still will not actuate the valve 34 until the time controller again in its normal operation opens flow between or connects the conduits 140 and 142. Accordingly, with the block valve being thus opened, upon the next actuation of the time controller, the diaphragm valve 34 will be operated to open the intermitting valve 28 thus permitting flow through the liquid discharge line 26. At the same time the flow through the gas flow line 24 will be interrupted by the closing of a valve 25 such as a spring biased check valve or the like, for example. Accordingly, the gas pressure within the casing will force the liquid therefrom up through the flow tubing and eject this liquid through the liquid discharge line thereby conditioning the well for renewed efficient operation. As soon as the liquid has been ejected, the pressures within the tubing and the annulus of the casing will be equal and the spring 74 will then be enabled to operate in view of the balanced pressures on both sides of the piston, to lift the stem 64 and release the lever 124 so that its spring 128 will again shut off the block valve and the flow of 20 pound gas therefrom.

Accordingly, with the above attachment applied to a conventional time control cyclic operator for well intermitting action, it is evident that it is impossible for the motor valve 28 to be opened until the time cycle control pilot is energized by the above mentioned adapter. It requires therefore both the energizing of the time cycle controller and the existence of a pressure differential in the casing and tubing as detected by the sensing device 40 to open the valve 28 thus avoiding the escape of gas from the well when there is no liquid to be expelled thereby.

FIGURE 5 shows a slightly modified arrangement of applying the differential pressure adapter 40 of this invention to a conventional gas well intermitting system. Corresponding elements of this system are identified with the same numerals employed in the preceding arrangement.

However, the adapter 40 is mounted directly upon the tubing 14 and is in communication with the latter to receive tubing pressure with the conduit 36 supply casing pressure for the same operation and to the same structure described and illustrated in FIGURE 3. The 20 pound signal to the automatic timing device or clock controlled pilot 32 is now supplied by the conduit 37 which receives gaseous pressure through the pressure reduction valve 39.

In response to the 20 pound pressure or signal applied from the adapter 40 by the conduit 41, and the automatic timer controlled actuation of the pilot 32, the motor valve 28 is operated and the well is intermitted as previously described.

The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly all suitable modifications and equivalents may be resorted to, falling within the scope of the invention as claimed.

What is claimed as new is as follows:

1. In combination with a flowing gas well having a casing, a tubing string therein having its lower end opening at the bottom of the casing and a gas flow annulus between said tubing string and casing; a normally open gas flow line communicating with said tubing, a normally closed liquid discharge line connected to said tubing for the intermittent discharge by casing gas pressure of liquids accumulating in said casing and tubing, an intermittently operable cyclic flow control device including an intermitter to open said liquid discharge line, an adapter including a differential pressure sensing unit connected to said casing and tubing, means connecting said sensing unit to said cyclic flow control device and preventing operation of said intermitter until a predetermined pressure differential is detected between the casing and tubing pressures.

2. The combination of claim 1 wherein said intermitter includes a timer connected to said intermitter and actuating the latter at predetermined time intervals.

3. In combination with a flowing gas well having a casing, a tubing therein having its lower end opening at the bottom of the casing and an annulus between said tubing string and casing; a normally open gas flow line communicating with said tubing, a normally closed liquid discharge line connected to said tubing for the intermittent discharge by casing gas pressure of liquids accumulating in said casing and tubing, a normally closed valve controlling flow through said liquid discharge line, a pressure actuator connected to said valve, means supplying an actuating pressure to said actuator, a normally closed block valve controlling flow to said pressure actuator, a differential pressure sensing unit interposed in said actuating pressure supply means, said differential pressure sensing unit being connected to both said casing and said tubing and responsive to a predetermined pressure differential between said casing and said tubing to open said block valve.

4. The combination of claim 3 including a timer control disposed in said actuating pressure supply means and receiving actuating pressure from said sensing unit and delivering actuating pressure from the latter to said pressure actuator.

5. The combination of claim 4 wherein said block valve includes a valve body having a valve chamber therein, an inlet nipple adapted to direct the flow of actuating pressure into said valve chamber, a vent nipple adapted to vent said valve chamber to the atmosphere, a control valve movable alternately to control the flow through said inlet nipple and said venting nipple, means operated by said sensing unit for actuating said control valve.

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6. The combination of claim 5 wherein said sensing unit comprises a cylinder with a piston reciprocable therein, means connecting said cylinder at the opposite sides of said piston to said casing and said tubing, and an adjustable spring connected to said piston and opposing movement of said piston by said casing pressure.

7. The combination of claim 6 wherein said piston has a pair of oppositely disposed stems, one stem being engaged by said spring and the other stem comprising said means operable by said sensing unit.

8. The combination of claim 7 wherein said means for supplying an actuating pressure comprises a conduit con-

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necting said casing annulus to said block valve, and a pressure reduction valve in said last-mentioned conduit.

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CHARLES E. O'CONNELL, *Primary Examiner.*
D. H. BROWN, *Assistant Examiner.*