

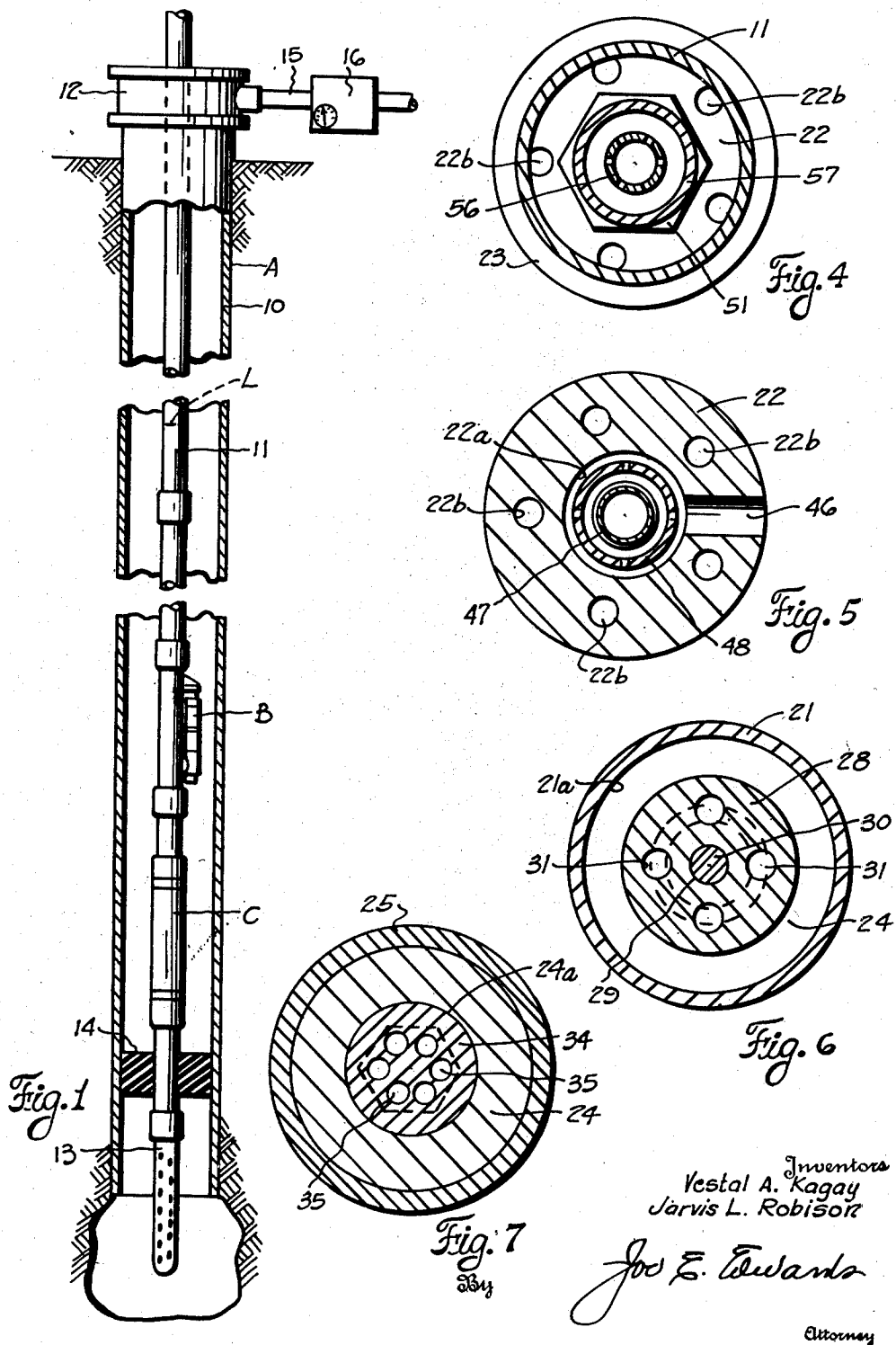
June 10, 1952

V. A. KAGAY ET AL
LIQUID LEVEL CONTROL DEVICE

2,599,713

Filed June 28, 1946

2 SHEETS—SHEET 1



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2 SHEETS—SHEET 2

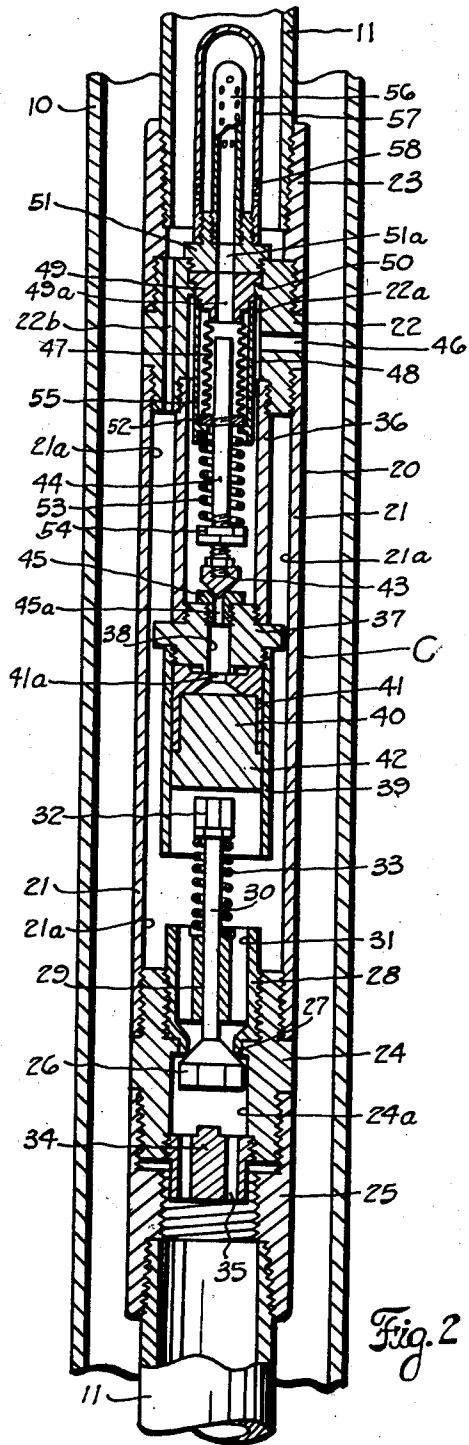


Fig. 2

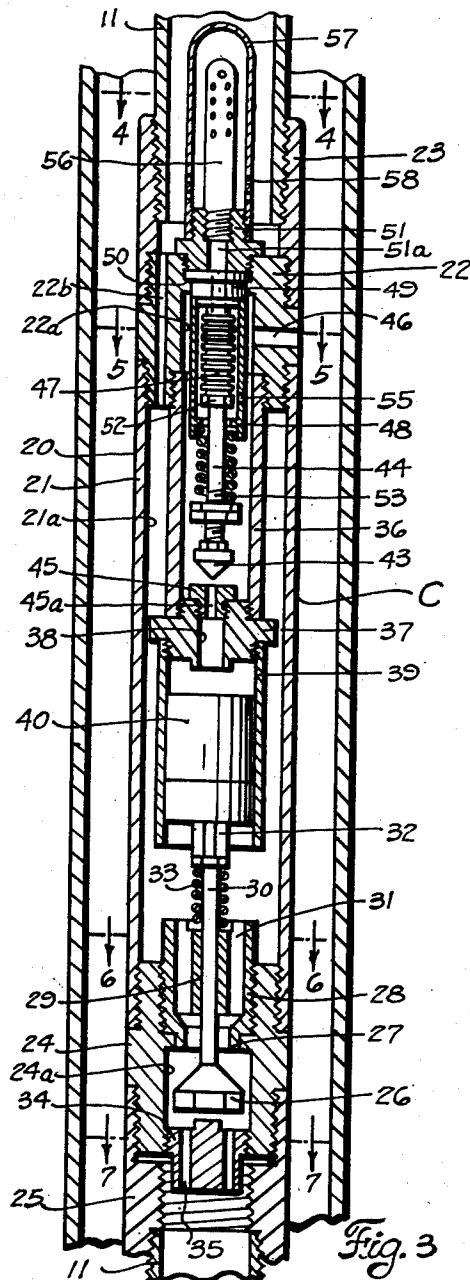


Fig. 3

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UNITED STATES PATENT OFFICE

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LIQUID LEVEL CONTROL DEVICE

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This invention relates to new and useful improvements in liquid level control devices.

In petroleum wells which are incapable of flowing the well liquids to the surface because of insufficient sub-surface formation pressure or for other reasons, it has become the general practice to utilize an auxiliary lifting fluid, such as gas or air, which fluid is introduced into the well liquid column below the upper level thereof to aerate and lift said column to the surface. The admission of the auxiliary lifting fluid is sometimes controlled by a series of "flow valves" which are located at various elevations in the well conductor or tubing and which are usually actuated by pressure differentials thereacross, whereby the lifting fluid is admitted as needed to the well liquid in said conductor or tubing; the use of a series of flow valves is commonly referred to as stage lift. Another type of flow device and one with which the present invention is adapted for use is the "intermitter" device which is simply a single valve mechanism for controlling, at predetermined intervals, the admission of a lifting fluid into a well liquid column within a well conductor or tubing. Ordinarily, the intermitter device is disposed at a predetermined elevation below the level to which the well liquids will normally rise in said conductor or tubing and said device is intermittently actuated from the surface either through a mechanically controlled means, such as shown in the patent to Staggs No. 1,683,930 or by the admission of a predetermined auxiliary pressure in the annular space outside said conductor or tubing as shown in the pending application of R. O. Walton, Serial No. 451,570, filed July 20, 1942, now abandoned. When the intermitter is actuated, a predetermined volume of lifting fluid under pressure is admitted to the liquid conductor or tubing and this admitted fluid is in accordance with the well liquid which will normally be present above the point of admission of said lifting fluid.

So long as the well liquids in the conductor or tubing rise to the normal standing level or do not quite reach such level, the lifting operation is satisfactorily accomplished by the admitted lifting fluid. However, it has been found that in many instances the well liquid level will rise higher than that normally expected and when this occurs, the lifting fluid admitted upon the subsequent operation of the intermitter is insufficient to lift or raise the liquids because the excessive load is greater than that for which the intermitter device was set.

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It is, therefore, one object of the present invention to provide an improved liquid level control device which may be readily connected in a well conductor or tubing and which will accurately control the level to which the well liquids will rise in said conductor or tubing, whereby efficient operation of an intermitter type of lifting fluid control device connected in said conductor above the device, is assured.

An important object of the invention is to provide an improved liquid level control device which is actuated by the differential between the pressure or load of the well liquids acting on one side and a known predetermined pressure on its opposite side, whereby the device is in a position permitting upflow through the well conductor until such time as the liquid reaches a desired level after which the device is actuated to shut off further upflow; the device again being operated to allow upflow when the liquid load thereabove is reduced by removal of liquids upwardly through the conductor.

Another object of the invention is to provide an improved device for controlling the level of the well liquids within a conductor or tubing wherein a main valve controls the upward flow of the well liquids and wherein the actuation of the main valve is, in turn, controlled by a pilot valve which when open admits pressure to the actuating parts of said main valve; the pilot valve being movable in accordance with the differential in the pressure of the liquid column above the assembly acting on one side thereof and a fixed or known pressure acting on the opposite side thereof, whereby the pilot is opened to open the main valve and permit upflow of well liquids only when the liquid above the assembly is below the desired predetermined level.

Still another object of the invention is to provide an improved liquid level control device wherein the fixed or known pressure, which acts upon one side of the pilot to open the same when the well liquid level is below the desired point, is utilized to open the main valve whereby positive actuation of the main valve is assured.

A further object of the invention is to provide an improved liquid level control device, of the character described, which is adapted to be employed in combination with an intermitter valve and which is so constructed that the lifting fluid under pressure which is normally admitted to the well liquid column by the intermitter for lifting the well liquids may be utilized to control actuation of said liquid level control device.

The construction designed to carry out the in-

vention will be hereinafter described together with other features of the invention.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawing, wherein an example of the invention is shown, and wherein:

Figure 1 is a view, partly in section and partly in elevation of a well conductor extending through a well bore and having a liquid level control device, constructed in accordance with the invention, connected therein,

Figure 2 is a transverse, vertical, sectional view of the liquid level control device, with the pilot valve as well as the main valve in closed or seated position,

Figure 3 is a view, similar to Figure 2 with both pilot valve and main valve in open position,

Figure 4 is an enlarged, horizontal, cross-sectional view, taken on line 4—4 of Figure 3,

Figure 5 is an enlarged, horizontal, cross-sectional view, taken on the line 5—5 of Figure 2,

Figure 6 is an enlarged, horizontal, cross-sectional view, taken on the line 6—6 of Figure 2, and

Figure 7 is an enlarged, horizontal, cross-sectional view, taken on the line 7—7 of Figure 2.

In the drawings, the letter A designates a well bore having a well casing 10 therein. A well tubing 11 extends downwardly through the casing 10 and has its upper end supported in the usual casing head 12 which is mounted on the upper end of the well casing. The lower end of the well tubing has the conventional well screen 13 through which the well fluids are admitted into said tubing attached thereto. A suitable well packed 14, which is schematically illustrated, packs off between the tubing and casing above the perforated screen, whereby the well liquids from the formation flow upwardly through the well tubing 11.

Because of the lack of sub-surface formation pressure or for other reasons, the well liquids do not flow to the surface but rather rise to a normal standing level L within the well tubing 11. It has become the practice in this type of well to employ an auxiliary lifting fluid, such as gas, which lifting fluid is introduced into the annular space between the well casing and well tubing through an inlet pipe 15. The admission of the auxiliary lifting fluid into this annular space may be controlled by a suitable intermitter control mechanism 16.

The admission of the auxiliary lifting fluid from the annular space into the well liquid column within the tubing is ordinarily controlled by an intermitter valve B which is connected in the well tubing at some point below the normal standing level, indicated by the dotted line L in Figure 1. The particular construction of the intermitter valve is subject to variation and any of the well known devices of this character may be employed. The particular valve illustrated in Figure 1 is that shown in the hereinbefore referred to Walton application, Serial No. 451,570. However, it is pointed out that a mechanically controlled intermitter valve, such as shown in the patent to Staggs 1,683,930 could be substituted for the valve.

In order for the valve B to function properly upon each actuation to efficiently lift the well liquids in the tubing above said valve, it is desirable that the liquid level L be controlled for obviously if the liquid level rises to a height greater than that which the admitting auxiliary

lifting fluid is capable of raising, inefficient operation is had.

The present invention is directed to controlling the liquid level of the well liquids as they rise within the well tubing and to maintain this level at a desired or predetermined point so that efficient functioning of a suitable intermitter valve which admits the auxiliary lifting fluid may be assured. In accomplishing the control of this liquid level, the device C, which constitutes the present invention, is connected in the well tubing 11 at a point below the intermitter valve B. This device C comprises an outer tubular housing 20 which is constructed of a main tubular body 21 having a bushing 22 threaded into its upper end. A coupling collar 23 connects the upper end of the bushing 22 with the well tubing 11. A somewhat similar bushing 24 is threaded into the lower end of the tubular body 21 and has its lower portion coupled by a coupling collar 25 with the well tubing and thus it is obvious that the assembly forms a part of the tubing string.

As explained, the well liquids rise upwardly in the well tubing to the "normal" standing level L and for controlling the flow through the tubing, the device C is provided with a main control valve 26. This valve is movable within the bore 24a of the bushing 24 and is adapted to move upwardly into engagement with a valve seat 27 which is formed in the lower end of a valve seat member 28. As is clearly shown in Figure 2 the member 28 which is threaded into the upper end of the bushing 24 has an axial bore 29 through which the valve rod 30 of the valve 26 extends. In addition the member has flow ports or passages 31 which extend vertically therethrough. The upper end of the valve rod projects above the member 28 and has nuts 32 threaded thereon. The valve is normally moved upwardly toward a seated position as shown in Figure 2 by a coil spring 33 which surrounds the valve rod and is confined between the nuts 32 and the upper end of the member 28. A stop collar 34 having vertical passages 35 therein is threaded into the lower end of the bushing 24 and limits the downward movement of the main valve 26.

It will be obvious that when the main valve 26 is open a flow upwardly through the tubing past the valve into the bore 21a of the tubular body of the device, then upwardly through vertical passages 22b formed in the bushing 22 and finally into the tubing above the device, may occur; however, when the valve is in its seated position as shown in Figure 2, upward flow of well liquids through the tubing is prevented. In order to control the liquid level it is necessary that the valve 26 be open to allow upflow through the tubing when the level is below the line L. Whenever the level L is reached by the well liquids the valve 26 closes to halt further flow of well liquids upwardly in the tubing 11 to thereby maintain said level.

For controlling the opening and closing of the main valve, a pilot valve assembly is mounted within the device C and as shown in Figures 2 and 3 this assembly includes a tubular sleeve 36 which has its upper end threaded into the lower end of the bushing 22. A coupling 37 threads into the lower end of the sleeve and has an axial bore 38. A cylinder 39 has its upper end connected to the coupling 37 and a duplex piston 40 is slidable within the cylinder. The piston comprises an outer sleeve member 41 and an inner plug member 42 which are capable of

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telescoping movement with respect to each other. When pressure is applied to the upper end of the piston through the bore 38 of the coupling, the piston 40 is moved downwardly to engage the upper end of the valve rod or stem and thereby force the main valve off of its seat to an open position. The use of the duplex piston, that is, a piston in two parts is merely for the purpose of preventing said piston from sticking to the wall of the cylinder. If the upper section 41 of the piston should become stuck within the cylinder, the pressure may pass through a port 41a in the upper end of said section and may act against the plug portion 42 of the piston to move this portion downwardly separately of the upper section and thus operation of the main valve could still be effected. If the lower section 42 of the piston becomes stuck, pressure applied to both this portion, as well as the upper section 41, will affect release thereof. However, it is noted that any desired type of piston could be employed, and it is desirable that the piston have a relatively "sloppy" or loose fit within its cylinder to allow a pressure leakage between the outer surface of the piston and the bore of the cylinder.

For controlling the admission of pressure to the piston 40, a pilot valve 43 is secured to the lower end of a valve rod 44, which rod is disposed axially within the tubular sleeve 36. The valve 43 is adapted to engage a valve seat 45 to close an orifice 45a which extends through the valve seat member and which communicates with the bore 38 of the coupling and thence with the cylinder 39 above the piston 40. When the pilot valve 43 is in its raised or unseated position the pressure of the lifting fluid in the annular space may flow through a radial port 46 formed in the upper bushing 22, then downwardly through the bore 22a of said bushing, through the sleeve 36, past the pilot valve 43 and into the cylinder 39 to exert its pressure on the piston. This results in a downward movement of the piston which engages the valve rod or stem 30 of the main valve to move said main valve to an open or unseated position. Obviously, when the pilot valve 43 is closed, the coil spring 33 will return the main valve and piston to their upper positions which closes said main valve, any pressure above the piston escaping through the leakage space between the outer surface of the piston and the wall of the cylinder. It is noted that the pressure of the spring 33 acting against the lower end of the piston is sufficient to force any fluid above the piston outwardly around said piston.

The pilot valve is controlled in its actuation by a depressible bellows 47 which is mounted within a tubular casing 48. The casing 48 has its upper end connected to a plug member 49 which is supported on an annular shoulder 50 within the upper portion of the bushing 22, said plug being retained in position by a coupling member 51 threaded into the top of said bushing. The upper end of the bellows 47 is connected to the plug 49, while its lower end is connected to a nut 52 which is secured on the stem 44 of the pilot valve. The pilot valve is constantly urged toward a lowered or seated position by a coil spring 53 which is confined between the lower end of the casing 48 and an adjusting nut 54 threaded on the lower portion of the pilot valve stem 44.

It will be evident that when the operating bellows 47 is in its extended position (Figure 2), the pilot valve is closed. However, when the bel-

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lows 47 is collapsed or retracted, as shown in Figure 3, the pilot valve 43 is raised or in an unseated position to admit pressure to the actuating piston 40 for the main valve 26. The exterior of the operating bellows is exposed to the pressure of the auxiliary lifting fluid which is in the annular space between the well casing and the well tubing, such pressure acting through the inlet port 46 in the bushing 22, then through the bore 22a of said bushing and through ports 55 formed in the wall of the casing 48. Thus, the pressure of the auxiliary lifting fluid is constantly tending to collapse or retract the operating bellows and is therefore tending to unseat the pilot valve. The interior of the bellows 47 is acted upon by the well liquids in the well tubing 11 above the device, such liquids acting downwardly through the axial bore 49a of the plug 49 and the axial bore 51a of the coupling 51. A suitable perforated pipe or screen 56 is threaded into the coupling 51 and this screen may be covered by a suitable protective shield 57 which has inlets 58 in its lower portion. Thus, the well liquids in the tubing above the device may enter the inlets 58, then pass through the screen 56, bores 51a and 49a and into the interior of the bellows. The well liquids which flow upwardly through the tubular housing 21 of the device may by-pass the bushing through the vertical passages 22b which are provided in said bushing.

From the foregoing it will be obvious that the operating bellows 47 of the pilot valve is operated by the differential in the pressure of the well liquids acting on the interior of the bellows and the pressure of the auxiliary lifting fluid in the annular space between the well tubing and casing, acting upon the exterior of said bellows. The particular differential at which the bellows is collapsed may be set by adjusting the coil spring 53 which obviously adds its pressure to the pressure of the well liquids tending to hold the valve closed.

In the operation of the device, said device C is connected in the well tubing 11 below the intermitter valve B and above the packer 14. With the desired auxiliary fluid pressure in the annular space outside of the tubing, the pressure of this tubing acts upon the bellows 47 to collapse said bellows and unseat the pilot valve 43, thereby admitting this pressure to the operating piston 40, whereby said piston is moved downwardly to engage the valve stem 30 and unseat the main valve 26. When this occurs well liquids may flow upwardly through the tubing, thence through the device C, passing through the tubular housing 21 and vertical passages 22b of the bushing 22 into the well tubing above the device C and also above the intermitter valve B. The fluid load above the device C may act through the inlets 58 in the protective shield 57, through the screen 56, coupling 51 and plug 49 into the interior of the bellows. Whenever the liquid level rises to the point L, the load which is acting on the interior of the bellows, plus the force of the spring 53, is sufficient to overcome the pressure of the auxiliary lifting fluid which is acting exteriorly of the bellows. When this condition is reached, the bellows is expanded to close the pilot valve 43 and shut off the pressure acting against the operating piston 40. As soon as this pressure is relieved, the coil spring 33 associated with the main valve 26 may move said main valve upwardly to its closed position and prevent the further upflow of well liquids within

the tubing. Therefore, the level L can never rise any higher until the fluid load above the device C is removed.

The removal of the fluid load is effected by actuation of the intermitter valve B which opens to admit auxiliary lifting fluid into the well liquid column. This admission of the lifting fluid into the liquid column will raise the well liquids to the surface and this will unload the tubing above the device C. As soon as this occurs, the pressure acting interiorly of the actuating bellows 47 is reduced, with the result that the lifting fluid pressure acting exteriorly of said bellows collapses the bellows to again open the pilot valve 43 and admit pressure to the operating piston. This again moves the piston 49 downwardly to unseat the main valve 26 and allow upflow of well liquids through the tubing. The main valve 26 will remain open until such time as the liquid load above the device again expands the actuating bellows to reseat the pilot valve.

It will be evident that the device will accurately control the level to which the well liquids in the tubing may rise. Such control assures that there will never be a greater liquid load than the intermitter valve B can handle and in this manner efficient lifting or raising of the liquids to the surface upon each operation of the intermitter is assured. It is again noted that any suitable type of intermitter valve B may be employed either a pressure actuated type or a mechanically controlled arrangement. Since the device C is actuated by a differential in the pressure of the liquid load on one side and the auxiliary fluid pressure on the other side, the level to which the liquid may rise can be accurately controlled.

The foregoing description of the invention is explanatory thereof and various changes in the size, shape and materials, as well as in the details of the illustrated construction may be made, within the scope of the appended claims, without departing from the spirit of the invention.

What we claim and desire to secure by Letters Patent is:

1. A liquid level control device including, a well conductor, a housing adapted to be connected in said conductor, a main valve within the housing for controlling the flow of well liquids through the housing and upwardly through the well conductor, and a pilot valve within the housing for controlling actuation of said main valve, said pilot valve being operated by the differential in pressure between the well liquid load within the conductor above the housing and a fixed fluid pressure which is present exteriorly of the conductor, whereby said pilot is opened to open the main valve when the pressure of the liquid load above the housing falls below a predetermined point.

2. A liquid level control device including, a well conductor, a housing adapted to be connected in said conductor, a main valve within the housing for controlling the flow of well liquids through the housing and upwardly through the well conductor, a pilot valve within the housing for controlling actuation of said main valve, an actuator connected to the pilot valve having one side exposed to a fixed predetermined pressure exteriorly of the housing and its opposite side exposed to the pressure of the well liquids in the conductor above the housing, whereby said actuator and the pilot valve are operated by the differential in such pressures.

3. A liquid level control device including, a

well conductor, a housing adapted to be connected in said conductor, a main valve within the housing for controlling the flow of well liquids through the housing and upwardly through the well conductor, a pilot valve within the housing for controlling actuation of said main valve, an actuator connected to the pilot valve having one side exposed to a fixed predetermined pressure exteriorly of the housing and its opposite side exposed to the pressure of the well liquids in the conductor above the housing, whereby said actuator and the pilot valve are operated by the differential in such pressures, said pilot valve remaining closed to maintain the main valve closed so long as a predetermined well liquid level is present in the conductor and being automatically opened to open the main valve and admit additional well liquids to the conductor when said level drops below the predetermined point.

4. A liquid level control device as set forth in claim 2, with a resilient means associated with the pilot valve for normally urging said valve toward its closed position, the force of said resilient means being added to the pressure of the well liquid pressure, whereby the differential at which said valve operates may be predetermined.

5. A liquid level control device including, a well conductor, a housing adapted to be connected with said conductor and having a flow passage communicating with said conductor whereby well fluids flowing from the formation flow upwardly through said passage and conductor, a main valve in said passage movable to open and closed position for controlling upward flow of the liquids in said conductor, and means including a pilot valve actuated in accordance with the level of the well liquids in the conductor for controlling the operation of the main valve, whereby the latter is opened only when the liquid level falls below a predetermined point.

6. A liquid level control device as set forth in claim 5, wherein the pilot valve of the main valve control means is operated by the differential in the pressure of the well liquid and a predetermined known pressure exteriorly of the housing and conductor.

7. A liquid level control device including, a well conductor, a housing adapted to be connected with conductor and having a flow passage communicating with said conductor whereby well fluids flowing from the formation flow upwardly through said passage and conductor, a main valve in said passage movable to open and closed position for controlling upward flow of the liquids in said conductor, said main valve being normally in a closed position closing flow through the passage, pressure-actuated means for moving the valve to its open position, and means operated when the level of the well liquids in the conductor above the main valve falls below a predetermined point for admitting pressure to the pressure-actuated means whereby the main valve is opened to permit upflow of the well liquid to restore said liquid level.

8. A liquid level control device including, a well conductor, a housing adapted to be connected with said conductor and having a flow passage communicating with said conductor whereby well fluids flowing from the formation flow upwardly through said passage and tubing, a main valve in said passage movable to open and closed position for controlling upward flow of the liquids in said conductor, said main valve being normally in a closed position closing flow through the passage, pressure-actuated means for moving the

valve to its open position, and a pilot valve in said housing for controlling the admission of pressure fluid to the pressure-actuated means.

9. A liquid level control device as set forth in claim 8, wherein the pilot valve is moved to an open position to admit pressure fluid to the pressure-actuated means to open the main valve only when the level of the well liquid in the conductor above the passage falls below a predetermined point.

10. A liquid level control device as set forth in claim 8, wherein a pressure responsive actuator is connected to the pilot valve and also wherein said actuator has one side exposed to a fluid pressure exteriorly of the tubing and its opposite side exposed to the pressure of the well liquids in the conductor above the passage, whereby said actuator is operated by the differential in such pressures.

11. An apparatus for flowing wells comprising, a well conductor, an intermitter control valve connected in the conductor and operable independently of the liquid level in said conductor for controlling the admission of a pressure lifting fluid into the conductor at predetermined time intervals, a liquid level control device connected in the conductor below said intermitter valve and having valve means for shutting off the admission of well liquid into the conductor when the level of said liquid rises to a predetermined point in the conductor, said valve means of the liquid level control device being normally urged toward a closed position, means for conducting the pressure from exteriorly of the conductor to the valve means to hold said valve means in an open position, and means actuated by the liquid within the conductor rising to a predetermined level for shutting off the application of pressure to the valve means to effect a closing of said valve means.

12. An apparatus for flowing wells comprising, a well conductor, an intermitter control valve connected in the conductor and operable independently of the liquid level in said conductor for controlling the admission of a pressure lifting fluid into the conductor at predetermined time intervals, a liquid level control device connected in the conductor below said intermitter valve and having valve means for shutting off the admission of well liquid into the conductor when the level of said liquid rises to a predetermined point in the conductor, said intermitter control valve being actuated solely by the pressure exteriorly of

the conductor and irrespective of the liquid present in the conductor.

13. The combination with a well conductor having an intermitter control valve connected therein and operable independently of the liquid level in the conductor for controlling the admission of a lifting fluid under pressure into said well conductor, of a liquid level control device connected in said well conductor below said intermitter valve and having means for maintaining the level of the well liquids at a desired point in said conductor, said liquid level device including a main valve, pressure-actuated means for opening the valve, and a pilot valve for controlling the admission of pressure to the pressure-actuated means, said pilot valve being opened only when the level of the well liquid in the conductor falls below a predetermined point.

14. The combination with a well conductor having an intermitter control valve connected therein and operable independently of the liquid level in the conductor for controlling the admission of a lifting fluid under pressure into said well conductor, of a liquid level control device connected in said well conductor below said intermitter valve and having means for maintaining the level of the well liquids at a desired point in said conductor, said liquid level device including a main valve, pressure-actuated means for opening the valve, a pilot valve for controlling the admission of pressure to the pressure-actuated means, and pressure responsive means connected to the pilot valve for operating the same, said pressure responsive means having one side exposed to the well liquid in the conductor above the control device and its opposite side exposed to the pressure exteriorly of the conductor, whereby the pilot valve is actuated by the differential in such pressures.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,803,683	Taylor	May 5, 1931
1,834,369	Archer	Dec. 1, 1931
2,006,909	Boynton	July 2, 1935
2,132,738	Knox	Oct. 11, 1938