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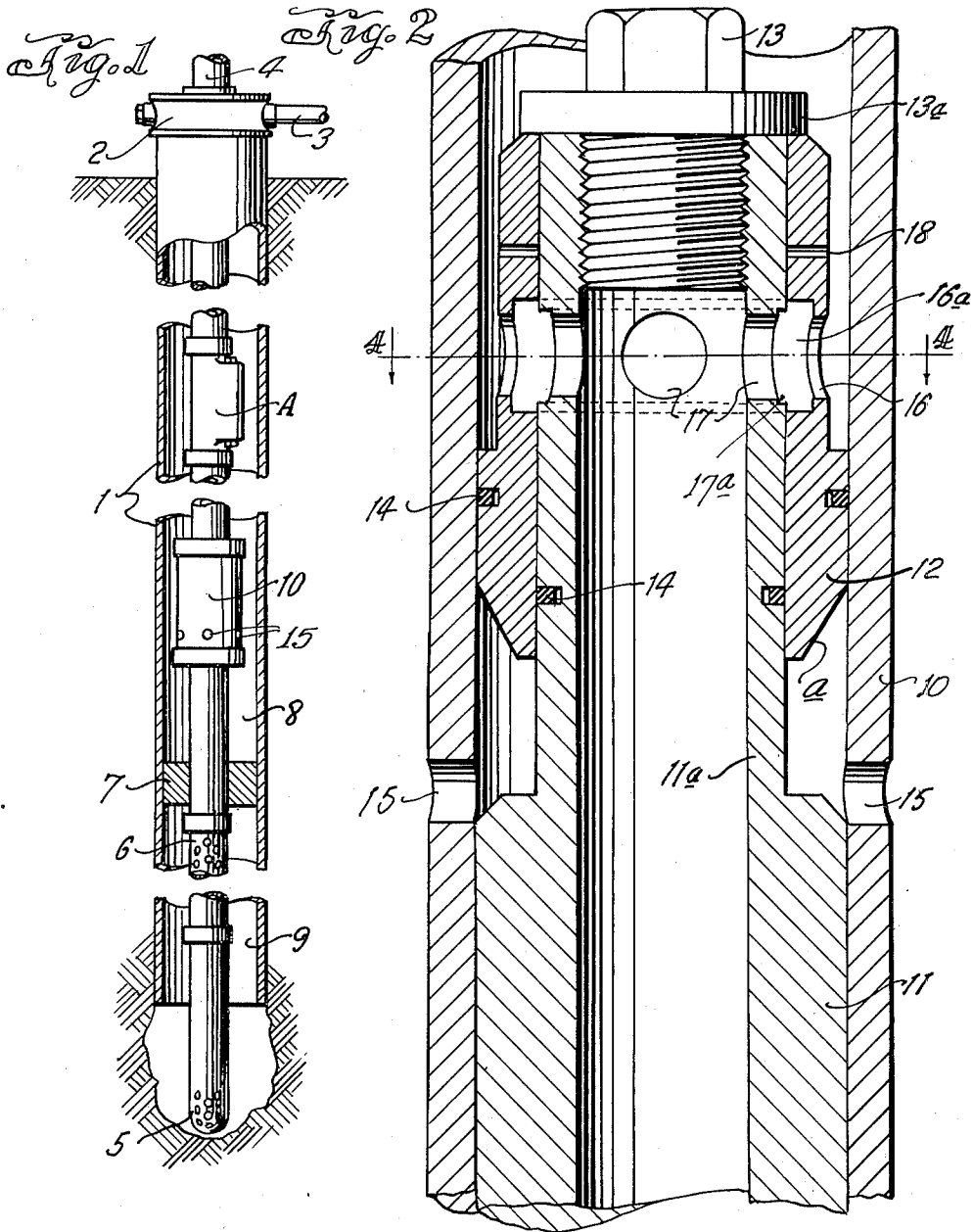
R. E. MILLICAN

2,591,087

HYDROPNEUMATIC GRADUATOR

Filed March 10, 1947

2 SHEETS—SHEET 1



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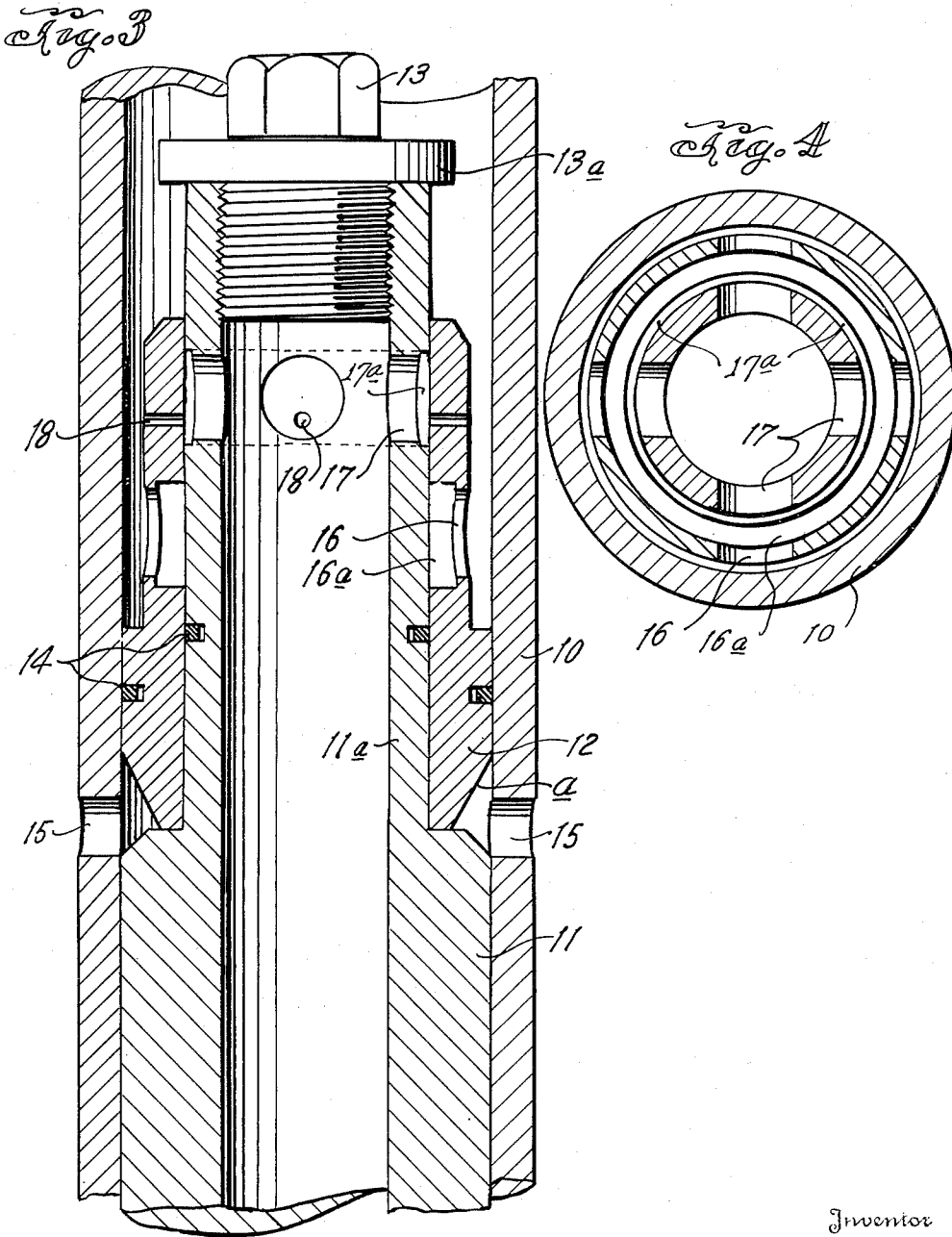
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HYDROPNEUMATIC GRADUATOR

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8 Claims. (Cl. 103—232)

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This invention relates to fluid control apparatus for oil producing wells and it has particular reference to fluid replacement gradulators for wells.

The principal object of the invention is to provide means for graduating replacement of fluid in the tubing of an oil well for gas lift.

Another object of the invention is to provide an apparatus whose fluid graduating replacement action tends to separate water from oil before fluid reaches the gas lift valves.

Another and important object of the invention is to provide, in an apparatus as set forth, a restricted passageway to permit oil which has been separated from water to pass upwardly through the tubing string preparatory to gas lift action.

Still another object of the invention is to provide a bottom hole hydro-pneumatic graduator whose graduator replacement action prevents fluid overrunning and drowning out the lowermost of the gas lift devices of the tubing string.

With the foregoing and other objects in view, the invention has further reference to certain features of accomplishment which will become apparent as the description proceeds, taken in connection with the accompanying drawings wherein:

Figure 1 is a view, partly in elevation and partly in section, of a tubing string in an oil well, having a gas lift valve and a graduating fluid replacement device constructed according to the present invention.

Figure 2 is a vertical cross-sectional view of the graduating device in full open position for passing fluid.

Figure 3 is a view similar to Figure 2 but showing the device in retarding position, and

Figure 4 is a view in transverse section, taken on line 4—4 on Figure 2.

Continuing with a more detailed description of the drawings, reference numeral 1 denotes a conventional well casing which extends vertically through the well bore. A casing head 2 of any suitable construction is mounted on the upper end of the casing at the surface and is provided with the usual conductor 3 whereby communication with the interior of the well casing may be established. Well tubing 4 extends axially through the well casing to the lower end of the well bore and has the conventional well screen or perforated pipe section 5 at its lower end.

At a fixed distance above the lower end of the well casing is a second perforated section of pipe 6. Immediately above the perforated section 6, a well packer 7 is adapted to be set, whereby the

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annular space 8 between the well tubing and casing may be sealed off. The packer 7 may be of any suitable construction.

In carrying out the invention, a plurality of flow devices A is connected in the tubing string of the well at various elevations therein. The construction and function of flow devices being generally well known, it is considered herein sufficient simply to relate their presence and purpose in the assembly.

A lifting fluid, such as gas under pressure, is introduced through the pipe 3 into the casing and fills the annular space between the tubing and casing above the packer 7. The flow devices A control the admittance of this lifting gas into the interior or bore of the well tubing 4 whereby the well liquids within the tubing may be lifted to the surface.

Immediately above the wall packer 7, the graduating fluid control device is connected in the well tubing string 4, numeral 10 denoting a tubular housing for this control device. A tubular insert 11 is fitted suitably in the housing 10 and has a reduced portion 11a on its upper end to receive slidably a sleeve 12. The upper end of the bore of the tubular insert 11 is threaded to receive a cap screw plug 13 which has a flanged portion 13a. Piston rings 14 in the exterior walls of the reduced portion 11a and sleeve 12 prevent leakage of gas.

The lifting gas under a suitable pressure is introduced through pipe 3 into the bore of the well casing. The pressure of this gas within the casing 1 is provided contact with the lower end of sleeve 12 through orifices 15 and, bearing against the beveled face a of the sleeve 12, tends to move sleeve 12 upwardly and against the cap flange 13a. With the sleeve 12 in this uppermost position, the orifices 16 of the sleeve above the midsection thereof are brought to align with orifices 17 in the tubular extension 11a of insert 11. An annular recess 18a is provided in the sleeve to insure passage of fluids through orifices 17, continuing through orifices 16, regardless of radial position. An annular reduction 17a is provided on tubular extension 11a of insert 11 to insure passage of fluids through orifices 17, continuing through orifices 13, regardless of radial position.

With the sleeve 12 in raised position, fluid will be allowed to flow freely from the bottom of the well upward in the casing or filtration reservoir 9, which is immediately below the well casing packer 7, and pass through the orifices 6, into the well tubing 4 which passes upwardly through the well packer 7 and is suitably connected to the

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housing 10. When sufficient fluid has entered the tubing 4 to cause the gas lift device A to begin lifting fluid to the surface, gas that is under the same pressure will tend to force sleeve 12 to its raised position, as described, and shown in Figure 2. This same gas pressure, being admitted to the fluid column in the tubing 4 through the gas lift device A, will register equally on both ends of the sleeve 12. This equal gas pressure registration on the top end of sleeve 12, plus the weight of the liquids contained in the tubing 4 between the gas lift device A downward to the upper end of sleeve 12 will obviously move said sleeve downwardly to the position shown in Figure 3, thereby retarding the passage of fluid through the small orifice 18 in the sleeve 12.

Since water is heavier than oil, retarding or restricting the passage of liquids up the tubing string, as set forth, provides time for a substantial amount of oil which may be trapped with water in the reservoir 9 to rise to the top of the water, pass through the orifices 6 into the bore of the tubing 4 and upwardly. Water will siphon downwardly and through the orifices 5 into the lower portion of the producing formation of the oil well.

When the gas lift device A has delivered the fluids in tubing 4 to the surface exhaust, then the pressure on the upper end of sleeve 12 will have become less than the pressure on the lower end thereof, causing the sleeve 12 to again move upward, repeating the cycle, as described.

Manifestly, the construction as shown and described is capable of some modification and such modification as may be construed to fall within the scope and meaning of the appended claims is also considered to be within the spirit and intent of the invention.

What is claimed is:

1. In a bottom hole hydro-pneumatic graduator for oil wells, a tubing string having gas actuated lift devices therein, a housing incorporated in said tubing string below said gas lift devices having gas pressure inlet orifices therein, an insert in said housing having a tubular extension provided with fluid outlet openings, a sleeve reciprocally mounted on said extension having openings alignable with those of said extension and elevated by gas pressure through said inlet orifices to align the sleeve and extension openings for increased upward passage of fluid through said tubing and housing to said gas lift devices, said sleeve being retracted upon equalization of gas pressures above and below the same to disalign said openings to retard the flow of fluid therethrough.

2. In a fluid replacement graduator for oil wells, a surface pressurized casing and tubing string, gas actuated fluid lift devices incorporated in said tubing string, a cylindrical perforated housing in said tubing string below said lift devices open to upward passage of well fluid, a packer below said housing closing the space between said tubing and casing, a sleeve reciprocable in said housing having perforations therein and actuated by surface pressure entering said housing to align the perforations thereof with those of said housing for opening the latter to provide increased upward passage of well fluid to said lift devices and adapted upon equalization of gas pressures above and below the housing to move to a position to disalign said perforations to close said housing for retarding the upward flow of fluid.

3. In a fluid replacement graduator for an oil well, a casing in said well, a tubing string in said casing, gas lift devices incorporated in said tub-

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ing string, a housing incorporated in said tubing string below said gas lift devices having orifices open to surface gas pressure introduced into said casing from the surface, a reciprocable sleeve in said housing influenced by gas pressure entering said housing to open the orifice of latter and said tubing string to increase upward flow therein of well fluid and effective, upon equalization of gas pressure above and below said housing to resume a position closing the orifice of said housing to retard said upward flow of well fluid.

4. In a fluid replacement graduator for an oil well, a casing in said well, a tubing string in said casing, gas lift devices incorporated in said tubing string, a perforated housing incorporated in said tubing string below said gas lift devices and open to surface gas pressure in said casing, means prohibiting upward passage of well fluid except through said tubing, a perforated sleeve reciprocable in said housing and actuated by said surface gas pressure entering said housing to align the perforations of said sleeve and housing and open said tubing and housing to increase upward passage of well fluid, said reciprocable sleeve being effective upon equalization of gas pressures above and below the same to disalign the perforations of said housing and sleeve and close said housing and tubing to said gas pressure to retard said upward passage of well fluid.

5. Apparatus of the character described, comprising a well casing and a tubing string therein, gas lift devices incorporated in said tubing string, a perforated housing incorporated in said tubing string below said gas lift devices through which well fluid is elevated by gas pressure from said casing, a perforated and reciprocable sleeve elevated by gas pressure entering said housing from the casing to align the perforations of said sleeve and housing and open said tubing and housing to increased upward passage of well fluid to said gas lift devices and effective upon equalization of gas pressures above and below the same to disalign said perforations and close said tubing and housing and retard said passage of well fluid.

6. Apparatus of the character described including a well casing, a tubing string in said casing, gas lift devices incorporated in said tubing string, a housing incorporated in said tubing string and having orifices open to gas pressure in said casing, perforated means normally restricting upward passage of well fluid through said tubing and housing and actuated by surface gas pressure entering said housing from said casing to align its perforations with the orifices of said housing to open the housing and said tubing to increase upward flow of well fluid through said tubing and housing to said gas lift devices, said perforated means being returned to normal position upon equalization of gas pressures above and below the same to disalign said perforations and orifices and retard said upward flow of fluid.

7. A device of the character described, comprising an oil well flow tubing, gas lift apparatus incorporated in said tubing, an oil well casing embracing said tubing having a compartment providing a reservoir for pressurized gas to actuate said gas lift apparatus, a compartment in said casing providing a filtering reservoir for fluids, a perforated housing in said tubing below said gas lift apparatus and a perforated sleeve reciprocable therein which in one position is effective to align its perforations with those of said housing to provide rapid replacement of fluid to said well tubing after gas lift action, and

in another position, to disalign said perforations

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for instantly retarding said replacement action to the extent of constraining upward passage of oil preparatory to renewed gas lift action.

8. A fluid replacement graduator for oil wells including a casing and tubing string in an oil well, a packer in said well closing the space between said tubing and casing, defining an upper reservoir for gas under pressure and a lower filtration reservoir, gas actuated lift devices incorporated in said tubing string, a housing in said tubing string intermediate said gas lift devices and said packer having gas pressure inlet orifices therein, an insert in said housing having a tubular extension provided with fluid outlet openings, a sleeve reciprocally mounted on said extension having openings alignable with those of said extension and elevated by gas pressure through said inlet orifices to align said sleeve and extension

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openings for increased upward passage of fluid through said tubing and housing to said gas lift devices, said sleeve being retracted upon equalization of gas pressure above and below said sleeve to disalign said openings to retard the flow of fluid therethrough.

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