Sept. 7, 1937. L. SPENCER 2,092,338

FORMATION TESTER

Filed May 1, 1935 2 Sheets-Sheet 1

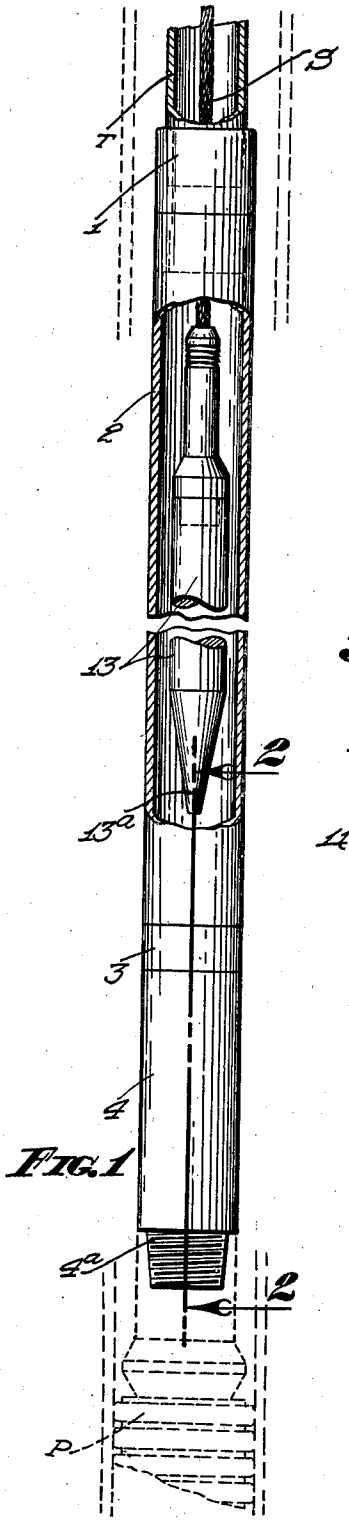


FIG. 1

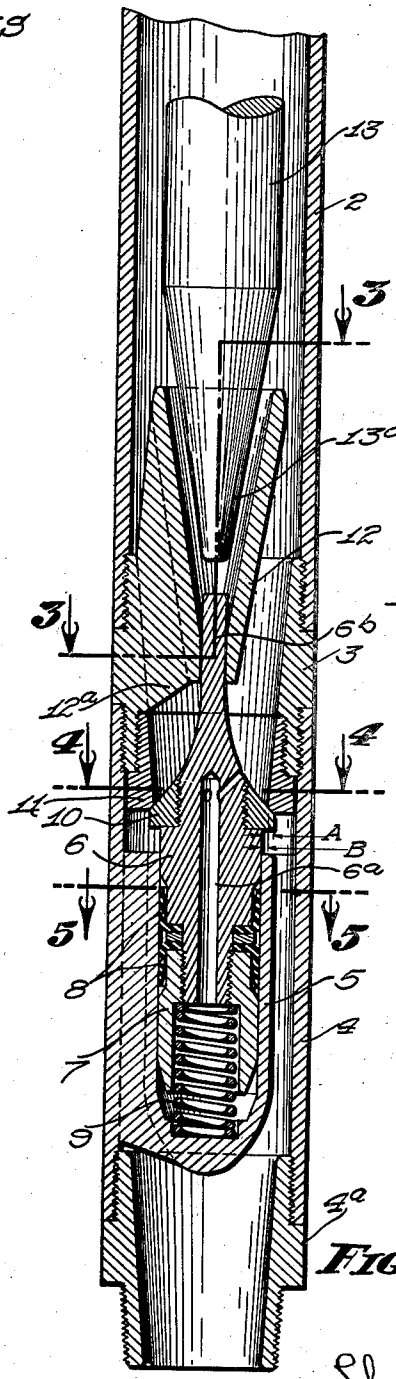


FIG. 2

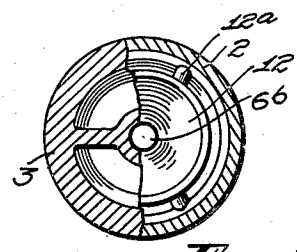


FIG. 3

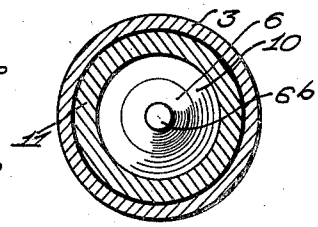


FIG. 4

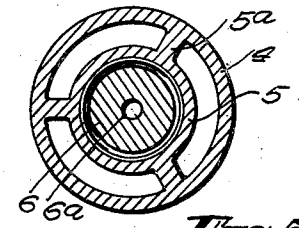


FIG. 5

INVENTOR

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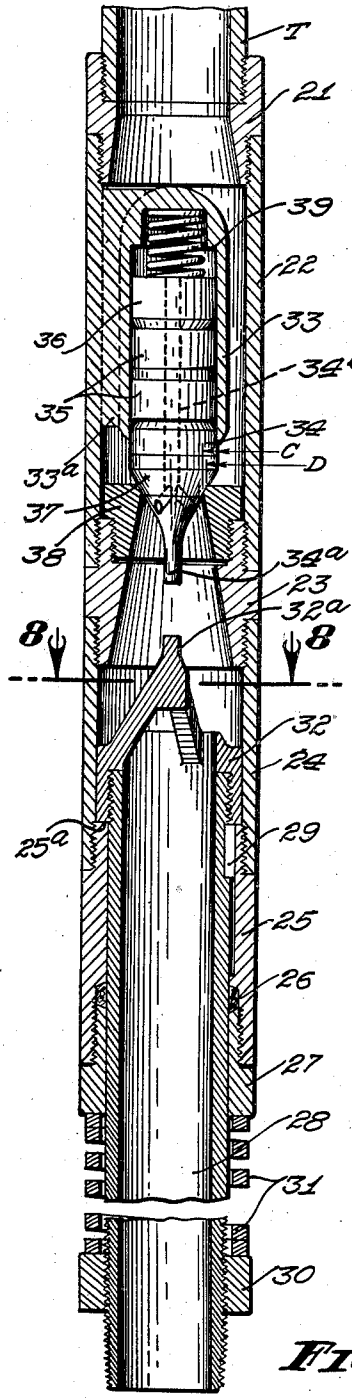


FIG. 7

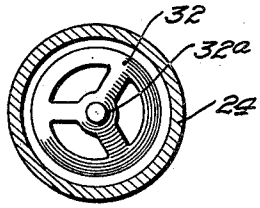


FIG. 8

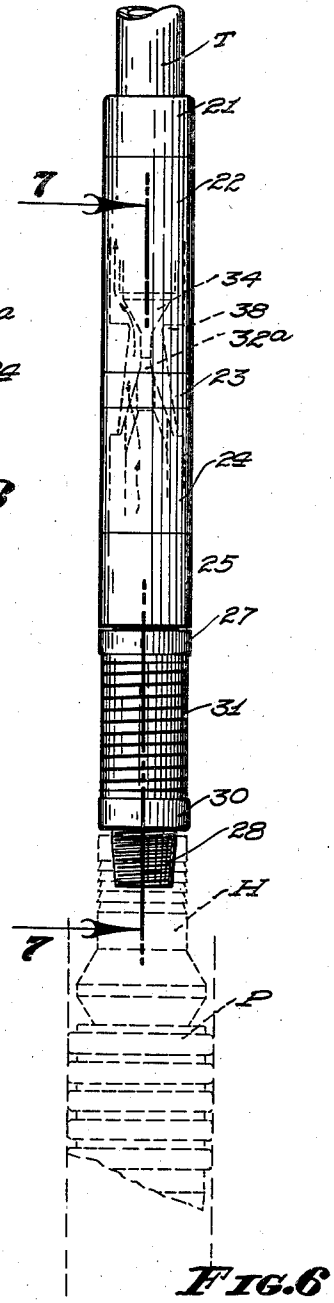


FIG. 6

INVENTOR

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2,092,338

FORMATION TESTER

Lloyd Spencer, Los Angeles, Calif., assignor to The Technicraft Engineering Corp., Los Angeles, Calif., a corporation of California

Application May 1, 1935, Serial No. 19,248

17 Claims. (Cl. 166—1)

My invention relates to formation testers and the objects of my invention are:

First, to provide a formation tester which may be used in conjunction with any type of packer including both casing and open-hole packers, whereby the formation tester may be used for casing shoe or water shut-off tests as well as formation tests;

Second, to provide a formation tester which may be so arranged that its operation is independent of movement of the tubing string from which it is suspended, the elements of the formation tester being mounted with rigidly connected sections so that the packer, usually mounted below the formation tester, may be manipulated for setting and releasing as if supported from a conventional tubing string;

Third, to provide a formation tester which incorporates a novel valve arrangement which may be opened either mechanically or hydrostatically, the valve being readily responsive to mechanical force but comparatively resistant to hydrostatic force so that the valve may support a predetermined liquid column within the tubing string, but is capable of opening in response to additional hydrostatic pressure so that circulation may be established down the tubing string and upwardly outside of the tubing string in the event that the tubing string should become stuck;

Fourth, to provide a novel valve arrangement for formation testers which is relatively unaffected by the hydrostatic pressure outside of the tubing string on which it is carried;

Fifth, to provide a novel means of mechanically opening the valve for the purpose of making a formation or water shut-off test;

Sixth, to provide a formation tester which, while having large passages therethrough, may be made particularly compact and with a small cross-section to permit its use in well casing of small diameter; and

Seventh, to provide on the whole a novelly arranged formation tester which is durable, efficient in its action, and economical of manufacture proportional to its functions.

With the above and other objects in view as may appear hereinafter, reference is made to the accompanying drawings, in which:

Figure 1 is an elevational view of my formation tester in one form with portions thereof in section, and showing a packer and a surrounding casing fragmentarily and by dotted lines.

Figure 2 is an enlarged longitudinal sectional view thereof taken through 2—2 of Figure 1 showing the valve arrangement in its closed position.

Figures 3, 4, and 5 are transverse sectional views thereof taken through 3—3, 4—4, and 5—5 respectively of Figure 2.

Figure 6 is an elevational view, similar to Figure 1 showing a modified form of my formation tester with the well casing and packer shown by dotted lines and fragmentarily, and also indicating by dotted lines the open position of the tester valve.

Figure 7 is an enlarged fragmentary sectional view through 7—7 of Figure 6 with the tester valve in its normal or closed position.

Figure 8 is a transverse sectional view thereof taken through 8—8 of Figure 7.

In the structure disclosed in Figures 1 through 5, the character T denotes a tubing string at the lower end of which is secured an adapter 1 which connects the tubing string with a tube section 2, preferably slightly larger than the tubing string. The lower end of the tube section 2 is adapted to be screwthreadedly secured to the upper end of a nipple 3, the lower end of which is in turn secured to a valve shell or housing 4 of cylindrical form and equal in cross-section to the tube section 2. The lower end of the housing 4 is secured to an adapting nipple 4a which is arranged for connection to any suitable packer, designated P in Figure 1.

The valve housing 4 is provided with a concentrically disposed cylinder 5 which may be integrally connected therewith by webs 5a. Said cylinder 5 is closed at its lower end and open at its upper end and arranged to receive a valve body 6. The lower end of the valve body is reduced in section and threaded to receive a collar 7. Clamped between the valve body and collar is a pair of cup-shaped sealing members 8 which face in opposite directions and form sealing fits with the walls of the cylinder 5. The collar 7 is recessed on its under side to receive a spring 9 the lower end of which bears against the closed end of the cylinder 5.

The protruding end of the valve body receives a ring valve 10 having its face on its upper outer margin. The ring valve 10 is adapted to engage a valve seat member 11 which is secured to the lower end of the nipple 3.

The valve body 6 is provided with a passage 6a extending from a point above the ring valve 10 to a point within the cylinder 5 below the packing or sealing members 8 so that the pressure between the lower end of the valve body and the cylinder is equal to the pressure above the ring

valve. The internal diameter of the valve seat member 11 is slightly larger than the diameter of the valve body and cylinder 5, as indicated by B in Figure 2 so that the valve is not quite balanced and any hydrostatic force against the circular area indicated by B is in opposition to the spring 9.

The valve body 6 extends upwardly beyond the ring valve 10 and tapers to form a stem 6b. Said stem forms a loose sliding fit within the lower or apex end of a frusto-conical guide member 12 which may be formed integrally with the nipple 3 and is held in concentric relation therewith by radial webs 12a.

The guide member 12 is adapted to receive the pointed lower end 13a of a weight bar 13 which is adapted to be lowered down the tubing string T by a wire rope or "sand line" S as it is termed in well drilling industry. The tube section 2 is made long enough to encompass the weight bar so that ample passage is provided there around.

Operation of the formation tester is as follows:

The valve body and valve member normally occupy the position shown in Figure 2. The formation tester is made up with a packer at its lower end and the tubing string above and is then lowered by the tubing string to the desired level. The tubing string is then turned or otherwise manipulated in any conventional manner to set the packer. This is done of course without disturbing the valve which remains closed.

After the packer has been set the weight bar 13 is lowered on the sand line down the tubing string until it engages the upper end 6a of the valve body and opens the valve. The only resistance to opening of the valve is the spring 9 and the area, designated A in Figure 2 which is subjected to the hydrostatic pressure existing outside the tubing string. The weight bar may be caused to hammer somewhat on the valve to aid in opening the valve against the hydrostatic pressure existing below the valve and once the valve is opened, the pressures tend to equalize so that the mere weight of the bar is sufficient to maintain the valve open. After the valve has been opened the desired interval, the weight bar is withdrawn, but first, may be used again to hammer the valve or vibrate it to dislodge any particles that may hold it open.

The tubing string is then manipulated to release the packer and withdrawn. Should the tubing string become stuck for any reason, sufficient pressure may be applied within the tubing string to increase the pressure on area B until greater than the tension of the spring 9 whereupon fluid may be circulated down the tubing string and upwardly around the exterior thereof.

In the structure disclosed in Figures 6 through 8, the tester valve is opened mechanically by telescoping movement of two sections of tubing.

In this construction an adapter 21 is joined to the lower end of a tubing string T and is in turn connected to a valve housing 22, which is cylindrical in form. The lower end of the housing 22 is internally threaded for connection to a valve seat supporting nipple 23. Said nipple is in turn connected to a short tube section 24.

The tube section is secured to a collar 25 of equal outside diameter but of smaller inside diameter to form a shoulder 25a. The collar 25 is recessed internally at its lower portion to receive packing material 26 and a packing nut 27.

The collar 25 slidably receives a hollow body member 28 which is held in non-rotatable relation therewith by a key 29. The lower extremity of the body member 28 is adapted to be secured to the head H of a packer P. Above its lower extremity the body member 28 receives a screw-threaded collar 30. Between the collar 30 and packing nut 27 is mounted a strong spring 31. The upper end of the body member 28 receives an end member or apertured cap 32 which fits within the tube section 24 and engages the shoulder 25a to limit the outward movement of the body member.

The valve housing 22 is provided with a concentrically disposed cylinder 33 closed at its upper end and which may be integrally connected therewith by webs 33a. The cylinder 33 receives a valve body 34 which supports a pair of oppositely facing cup-shaped sealing members 35 secured by a nut 36. The valve body 34 protrudes below the cylinder 33 and is provided with a removable valve face 37 which engages a valve seat member 38 secured to the supporting nipple 23.

The valve seat member and its nipple 23 form the throat of the valve and the valve body 34 is provided with a depending stem 34a which extends into the throat and is engageable by a pin member 32a extending upwardly from the cap 32 after the spring 31 has been compressed a predetermined amount.

The valve body 34 is provided with a passage 34b communicating between the throat of the valve and the chamber formed by the valve body nut 36 and closed end of the cylinder 33.

The above described valve structure is generally similar to that of the first described structure, however the present valve is operated mechanically from below rather than from within the tubing string. Also, the area of the cylinder 33 is greater than the aperture through the valve seat 38 so that pressure from below the valve acts on an area indicated by C in Figure 7 to close the valve, while hydrostatic pressure from above acts on area indicated by D, to raise the valve.

Operation of the formation tester shown in Figures 6 through 8 is as follows:

When the packer and the formation tester are lowered on the tubing string, the tester valve is closed as shown in Figure 7. The weight of the valve, backed by a spring 39, and the hydrostatic pressure of the fluid in the well bore against area C hold the valve closed. When the desired level is reached, the tubing string is manipulated to release the packer, whereupon application of the weight of the tubing string first applies pressure through the spring 31 to seat the packer. Additional weight of the tubing string further compresses the spring causing the pin member 32a to engage the stem 34a and raise or open the valve.

After the fluid from below the packer has risen to its hydrostatic level above the valve, the tubing string is raised causing the valve to close by its weight, spring 39, and hydrostatic pressure against area C, and in opposition to the hydrostatic pressure against area D.

Should it be necessary to establish circulation for any reason, the pressure within the tubing string is increased until its value against area D is in sufficient excess of that against area C to lift the valve. The negative pressure that may exist in the throat of the valve tending to pull the valve down cannot effect the valve for this pressure value also exists within the cylinder 33.

I claim:

1. In a formation tester for wells; a partially balanced valve structure having pressure areas on opposite sides, the pressure area on one side

being greater than on the other to provide a predetermined differential pressure area responsive to fluid pressure tending to open the valve structure; and yieldable means tending to maintain said valve structure closed to fluid pressures below a predetermined value.

2. In a formation tester for wells; a partially balanced valve structure having pressure areas on opposite sides, the pressure area on one side being greater than on the other to provide a predetermined differential pressure area responsive to fluid pressure tending to open the valve structure; yieldable means tending to maintain said valve structure closed to fluid pressures below a predetermined value; and means independent of said fluid pressure for opening said valve structure.

3. The combination with a tubing string and packer, of a formation tester comprising: a partially balanced valve structure having opposed major and minor pressure areas both exposed to the same side of said valve structure, and a predetermined differential pressure area responsive to fluid pressure within the tubing string; and yieldable means tending to maintain said valve structure closed to fluid pressure below a predetermined value.

4. The combination with a tubing string and packer, of a formation tester comprising: a partially balanced valve structure having opposed major and minor pressure areas both exposed to the same side of said valve structure, and a predetermined differential pressure area responsive to fluid pressure within the tubing string; yieldable means tending to maintain said valve structure closed to fluid pressures below a predetermined value; and means independent of said fluid pressure for opening said valve structure.

5. The combination with a tubing string and packer, of a formation tester comprising: a partially balanced valve structure arranged to provide a predetermined area responsive to fluid pressure within the tubing string; yieldable means tending to maintain said valve structure closed to fluid pressures below a predetermined value; and means, insertable through the tubing string, for actuating said valve structure independently of the fluid pressure therein.

6. In a formation tester for wells; a partially balanced valve structure arranged to provide a predetermined area responsive to fluid pressure tending to open the valve structure; yieldable means tending to maintain said valve structure closed to fluid pressures below a predetermined value; and weight means for actuating said valve structure independently of said fluid pressure.

7. In a formation tester, the combination with a tubing string, of a hollow body member continuing therefrom and having a constricted portion defining a valve port; a valve member engageable with one side of said valve port and having a pressure area exposed to the other side thereof tending to open the valve member; a piston and cylinder means incorporating said valve member, said means having a pressure area communicating with said other side of the valve port and adapted to urge said valve member in opposition to the first mentioned pressure area, said pressure areas having a predetermined difference and the excess or differential area of the larger pressure area being exposed to the interior of the tubing string and tending to open said valve member in response to pressures therein; and yieldable means restraining said valve member against the urge of said differential area until the pressure in said tubing string exceeds a predetermined value.

8. In a formation tester, the combination with a tubing string, of a hollow body member continuing therefrom and having a constricted portion defining a valve port; a valve member engageable with one side of said valve port and having a pressure area exposed to the other side thereof tending to open the valve member; a piston and cylinder means incorporating said valve member, said means having a pressure area communicating with said other side of the valve port and adapted to urge said valve member in opposition to the first mentioned pressure area, said pressure areas having a predetermined difference and the excess or differential area of the larger pressure area being exposed to the interior of the tubing string and tending to open said valve member in response to pressures therein; yieldable means restraining said valve member against the urge of said differential area until the pressure in said tubing string exceeds a predetermined value; and mechanical means for opening said valve member.

9. The combination with a tubing string and packer, of a formation tester comprising: a valve element incorporating means for hydraulically counterbalancing said valve element, the effective areas of said valve element and counterbalancing means being different to define an unbalanced differential area exposed to the interior of said tubing string and responsive to fluid pressure therein for opening said valve element.

10. The combination with a tubing string and packer, of a formation tester comprising: a valve element incorporating means for hydraulically counterbalancing said valve element, the effective areas of said valve element and counterbalancing means being different to define an unbalanced differential area exposed to the interior of said tubing string and responsive to fluid pressure therein for opening said valve element; and yieldable means for maintaining said valve element closed against fluid pressure in said tubing below a predetermined value.

11. The combination with a tubing string and packer, of a formation tester comprising: a valve element incorporating means for hydraulically counterbalancing said valve element, the effective areas of said valve element and counterbalancing means being different to define an unbalanced differential area exposed to the interior of said tubing string and responsive to fluid pressure therein for opening said valve element; yieldable means for maintaining said valve element closed against fluid pressure in said tubing below a predetermined value; and mechanical means for opening said valve element irrespective of the pressures thereagainst.

12. The combination with a tubing string and packer, of a formation tester comprising: a partially hydraulically balanced control valve disposed at the lower portion of said tubing string and having an effective surface exposed to the interior of the tubing string and responsive to fluid pressures therein to open said valve, said effective surface being materially less in area than the port area of said valve; and yieldable means restraining action of said valve until the fluid pressure in said tubing string exceeds a predetermined amount.

13. The combination with a tubing string and packer, of a formation tester comprising: a partially hydraulically balanced control valve disposed at the lower portion of said tubing string

and having an effective surface exposed to the interior of the tubing string and responsive to fluid pressures therein to open said valve, said effective surface being materially less in area than the port area of said valve; yieldable means restraining action of said valve until the fluid pressure in said tubing string exceeds a predetermined amount; and mechanical means for opening said valve irrespective of the fluid pressures thereagainst.

14. The combination with a tubing string and packer, of a formation tester comprising: a valve structure having a relatively large port area for controlling flow of fluid into and out of said tubing string, said valve structure being partially balanced hydraulically and having an unbalanced pressure surface responsive to fluid pressure within the tubing string for discharging fluid therefrom; and yieldable means tending to close said valve structure in opposition to said pressure surface, the area of said unbalanced pressure surface being relatively nominal whereby a nominal resistance by said yieldable means necessitates a relatively high fluid pressure in said tubing string to open said valve structure.

15. The combination with a tubing string and packer, of a formation tester comprising: a valve structure having a relatively large port area for controlling flow of fluid into and out of said tubing string, said valve structure being partially balanced hydraulically and having an unbalanced pressure surface responsive to fluid pressure within the tubing string for discharging fluid therefrom; yieldable means tending to close said valve structure in opposition to said pressure surface, the area of said unbalanced pressure surface being relatively nominal whereby a nominal resistance by said yieldable means necessitates a relatively high fluid pressure in said tubing string to open said valve structure; and mechanical means for opening said valve structure irrespective of the fluid pressure thereagainst.

16. The combination with a tubing string and a packer at its lower end, of a formation tester comprising: a control valve, said control valve being hydraulically balanced except for a predetermined pressure surface of nominal area responsive to fluid pressures within the tubing string to open said control valve; and yieldable means tending to close said valve in opposition to the force against said pressure surface.

17. The combination with a tubing string and a packer at its lower end, of a formation tester comprising: a control valve; means hydraulically balancing said control valve except for opposed pressure surfaces bearing a minor relation to the port area of said control valve, one of said pressure surfaces being responsive to fluid pressures within said tubing string to open said control valve and the other to fluid pressures externally of said tubing string to close said control valve; yieldable means tending to close said control valve; and mechanical means for opening said control valve irrespective of the fluid pressure against said pressure surfaces.

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