

April 20, 1954

J. R. BAKER
SUBSURFACE WELL APPARATUS WITH
GAS EXPANSION RETARDING DEVICE

Original Filed Jan. 12, 1948

2,675,877

2 Sheets-Sheet 1

Fig. 1.

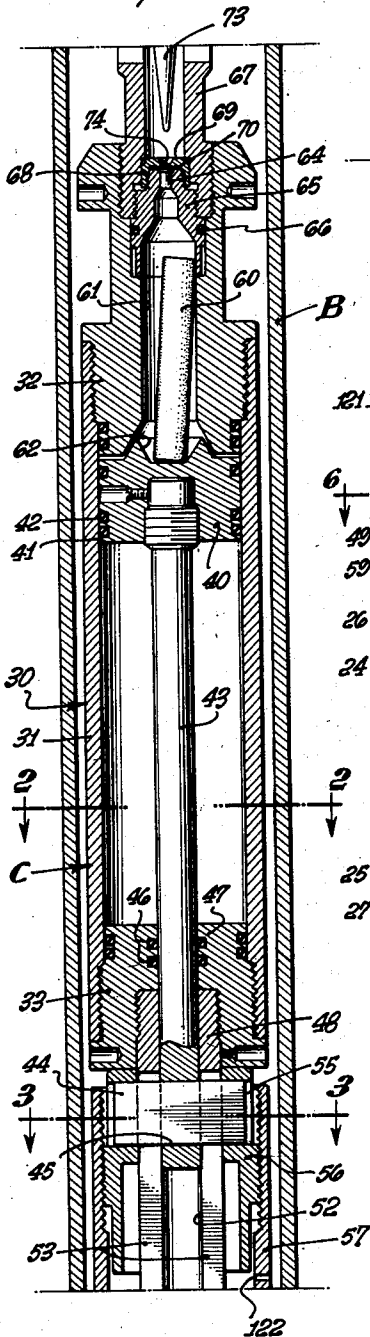


Fig. 1a.

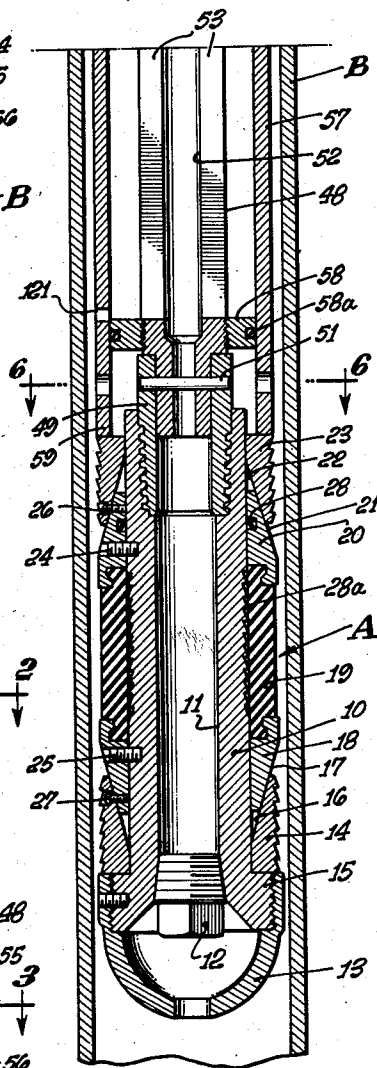


Fig. 2.

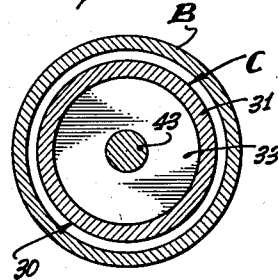
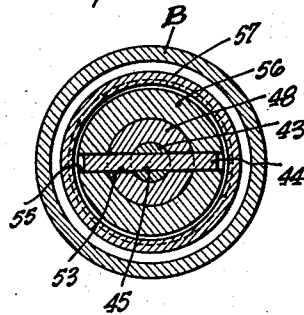


Fig. 3.



INVENTOR.
JOHN R. BAKER,
BY
Mellin and Hanscom
ATTORNEYS

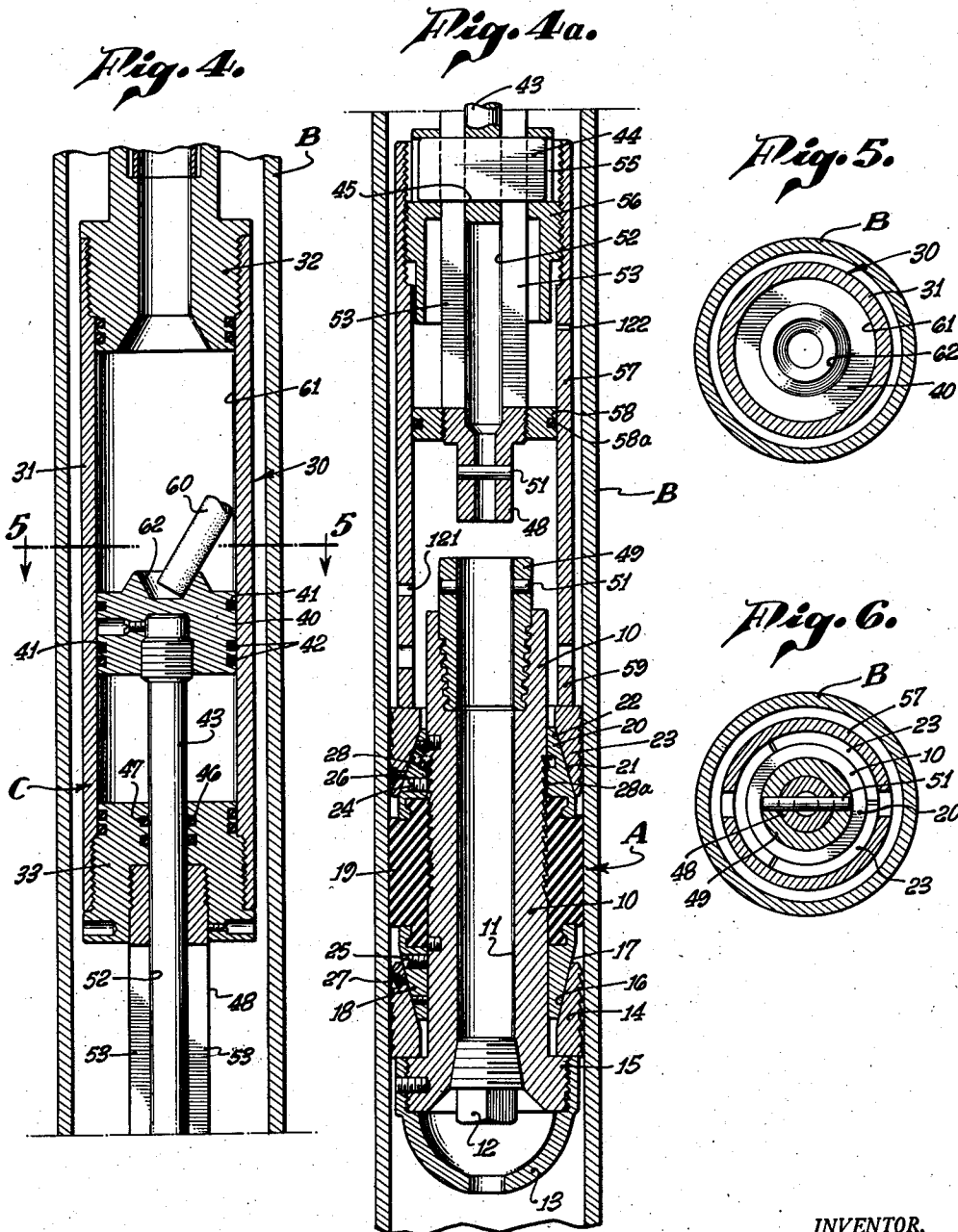
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JOHN R. BAKER,
BY
Mellin and Haxcom
ATTORNEYS

UNITED STATES PATENT OFFICE

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SUBSURFACE WELL APPARATUS WITH GAS
EXPANSION RETARDING DEVICEJohn R. Baker, Pasadena, Calif., assignor to
Baker Oil Tools, Inc., Vernon, Calif., a corpo-
ration of CaliforniaOriginal application January 12, 1948, Serial No.
1,845. Divided and this application April 12,
1951, Serial No. 220,661

12 Claims. (Cl. 166—12)

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The present invention relates to well devices, and more particularly to subsurface devices for performing desirable operations in oil, gas and similar wells.

This application is a division of the application of Reuben C. Baker, Thomas M. Ragan, John R. Baker and Martin B. Conrad, Serial No. 1,845, filed January 12, 1948, for "Gas Operated Well Apparatus," now Patent No. 2,640,547.

An object of the present invention is to provide gas pressure operated subsurface well apparatus, in which the expansion of the motivating gaseous medium used in the apparatus is retarded, without adversely affecting operation of the apparatus. In this manner, sufficient time is caused to elapse during which a certain desired sequence of operations in the apparatus can be performed properly.

Another object of the invention is to provide subsurface well apparatus operated by gas under pressure in which expansion of the gas is retarded following release of the load on the apparatus, thereby preventing or largely minimizing shock loads that would otherwise be imposed on the equipment as a result of allowing sudden expansion of the gas.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail, for the purpose of illustrating the general principles of the invention; but it is to be understood that such detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

Figures 1 and 1a together constitute a longitudinal section through the apparatus, with the parts in position for moving the apparatus lengthwise through well casing, Fig. 1a forming a lower continuation of Fig. 1;

Fig. 2 is a cross-section along the line 2—2 on Fig. 1;

Fig. 3 is a cross-section taken along the line 3—3 on Fig. 1;

Figs. 4 and 4a are similar to Figs. 1 and 1a, with the well packer anchored in packed-off condition in the well casing and the setting tool released from such packer;

Fig. 5 is a cross-section taken along the line 5—5 on Fig. 4;

Fig. 6 is a cross-section taken along the line 6—6 on Fig. 1a.

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As disclosed in the drawings, it is desired to run a well packer A to a desired location in a well casing B disposed within a bore hole. The packer is then anchored in packed-off condition against the well casing through use of a setting tool C connected to it, which is attached to the lower end of a running-in string, such as a wire line (not shown) extending to the top of the well bore.

The well packer A may assume any desired form. As disclosed in the drawings, it includes a tubular main body 10 whose central passage 11 may be closed by a plug 12. A guide 13 is secured to the lower end of the body to prevent hanging up of the tool in the casing joints, or coupling spaces, during its lowering through the well casing B.

The well packer can be anchored against downward movement in the well casing by a plurality of lower segmental slips 14 whose lower end engages the guide 13 and a lower abutment or flange 15 on the body. The inner surfaces 16 of these slips are tapered in a downward and inward direction for slidable engagement with a corresponding externally tapered surface 17 on a frusto-conical expander 18 slidable on the body. This expander is connected to the lower end of a packing sleeve 19, of rubber or similar material, disposed around the body 10, the upper end of this packing sleeve being connected to an upper expander 20 having an upward and inwardly inclined externally tapered surface 21 engageable with corresponding tapered surfaces 22 on a plurality of upper segmental slips 23.

Initially, the slips 14, 23 and packing element 19 are retained in retracted positions with respect to the packer body 10. Shear screws 24, 25, or other suitable frangible connecting elements, secure the upper and lower conical expanders 20, 18 to the body, with the intervening packing sleeve 19 held in retracted position. The upper and lower slips 23, 14 are also held in retracted positions by shear screws 26, 27 attaching them to their associated upper and lower expanders 20, 18. The shear screws 26, attaching the upper slips 23 to the upper expander 20, have a combined shearing strength which is substantially less than the shear value of the screws 24 holding the upper expander to the body 10. These latter screws have a lesser shear value than the screws 25, 27 securing the lower expander 18 to the body and the lower slips 14 to the lower expander. These relative shear values are selected to secure detachment at first of the upper slips 23 from the upper expander 20, and movement of the upper slips downwardly along the upper expander and radially outward into anchoring engagement with

the casing wall. Subsequent upward strain or pull on the packer body 10 shears the screws 24 holding the upper expander 20 to the body 10 and moves the lower expander 18 and slips 14 with the body toward the upper expander 20 and slips 23, effecting compression of the packing 19 between the expanders and its outward expansion into firm sealing engagement with the wall of the casing. Thereafter, an increase in the upward pull or force on the packer body 10 substantially simultaneously shears the screws 25, 27 holding the lower expander 18 to the body and the lower slips 14 to the lower expander, to cause the lower flange 15 and guide 13 on the body to shift the lower slips 14 upwardly along the lower expander and radially outward into anchoring engagement with the wall of the casing B. A split, contractile ring 28 may be disposed in the upper expander, for engagement with one of several circular ratchet teeth 28a formed on the exterior of the body 10, to lock the latter against downward movement (Fig. 4a).

It is apparent from a consideration of Fig. 4a that the annular space between the body 10 and casing wall has been sealed off by the packing sleeve 19, that upward movement of the packer A within the casing B is prevented by the upper expander 20 and slips 23, and that downward movement is prevented by the lower expander 18 and slips 14. It will also be evident that the full setting of the packer in the well casing has occurred as a result of a definite sequence of steps. These are the outward movement of the upper slips 23 to casing engaging position, the expansion of the packing element 19 against the casing, and the subsequent engagement of the lower slips 14 with the casing. A definite time interval should be provided between these main operational steps, to insure proper setting of the packer in the well casing. As disclosed in the drawings, such operational sequence is provided by the use of a gaseous force, in which the gas under pressure is developed by products of combustion within the setting tool C connected to the well packer A, which enables the well packer to be run in the casing on the wire line (not shown).

As shown in the drawings, a gas pressure is developed within a cylinder 30 consisting of a generally cylindrical sleeve 31, an upper head 32 threaded into the sleeve and a lower head 33 threaded into the sleeve. A piston 40 is slidably mounted in the cylinder 30. This piston has one or more ring grooves 41 in its periphery for the accommodation of seal rings, 42, to prevent leakage between the piston and cylinder. As disclosed, these rings 42 may consist of rubber of round cross-section to guard against leakage in either direction. The upper end of a piston rod 43 is threadedly connected to the piston, the rod extending downwardly through the lower cylinder head 33 to a point therebelow where an anvil or cross-piece 44 is mounted within a transverse slot 45 in the rod. Leakage between the rod 43 and lower cylinder head 33 is prevented by suitable rod packing, in the form of one or more round rubber, or rubber-like, seals 46 engaging the periphery of the rod and disposed within suitable ring grooves 47 in the head.

It is desired to transfer the downward movement or force of the piston 40 and piston rod 43 to the upper slips 23 of the packer and the relative upward movement of the cylinder 30 to the packer body 10, in order to obtain the desired anchoring of the packer in the well casing. To accomplish this purpose, a tubular actuating

mandrel 48 is threadedly connected to the lower end of the lower cylinder head 33. The lower end of this mandrel is secured to a sleeve 49, threaded into the upper end of the body 10, through the agency of a frangible pin 51, the pin extending transversely through the sleeve 49 and mandrel 48.

The piston rod 43 is movable downwardly within the bore 52 of the actuating mandrel 48, the cross-piece 44 projecting in opposite directions from the rod through diametrically opposed longitudinally extending slots 53 formed through the mandrel wall. A cross-piece also extends into opposed slots 55 formed through a setting ring or sleeve 56 slidably mounted on the actuating mandrel 48, to form a connection between the piston rod 43 and the setting ring 56. A setting sleeve or skirt 57 is adjustably threaded on the setting ring, this skirt depending from the ring and being slidable along a flange or head 58 threaded on the lower end of the actuating mandrel 48. Leakage around the head is prevented by a suitable seal ring 58a mounted on it and slidably engaging the sleeve 57. This sleeve 57 extends beyond the head 58 and may be rotated or threaded on the setting ring to engage its lower end 59 with the tops of the upper slips 23.

A fluid or gaseous force is developed within the cylinder 30 above the piston 40, this force moving the piston and piston rod 43 downwardly and the cylinder 30 relatively upwardly. The downward movement of the rod 43 is transmitted to the setting sleeve or skirt 57 through the anvil 44 and setting ring 56, while the upward movement of the cylinder 30 is transmitted to the packer body 10 through the actuating mandrel 48, frangible pin 51 and sleeve 49. Accordingly, it is apparent that the development of sufficient pressure in the cylinder 30 would eventually shear the screws 26 holding the upper slips 23 to the expander 20, and move the slips outwardly against the casing B, whereupon the cylinder 30 will move upwardly to pull the body 10 in the same direction, to expand the packing sleeve 19 against the casing B and then the lower slips 14 against the casing.

In order to obtain the desired operational sequence, a combustible fuel is contained within the upper end of the cylinder 30. This fuel has a slow burning rate and may require several seconds after its ignition to develop sufficient gaseous pressure for fully setting the well packer A and for applying sufficient upward force on the cylinder to shear the frangible pin 51 attaching the setting tool C to the well packer, for the purpose of removing the setting tool from the well bore. One form of fuel actually used in the cylinder may be a fusee or railway flare, which may require from eight to twelve seconds to develop gradually a sufficiently high pressure to fully set the well packer A and shear the pin 51, assuming that about 25,000 lbs. total force is required to disrupt the pin.

The combustion charge, such as the railway flare or fusee 60, of cylindrical or stick form, is placed in the head end 32 of the cylinder within a combustion chamber 61 formed therein. The stick 60 rests within a cup-shaped recess 62 in the upper end of the piston 40.

The fusee 60 is ignited by a blank cartridge 64 which is contained within a gun barrel 65 inserted within the upper end of the cylinder head 32. Leakage between the barrel 65 and head is

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prevented by a suitable side seal 66 on the barrel engaging the wall of the head. The barrel is threaded into a gun body 67, which is threadedly attached to the upper end of the cylinder head 32. This body also contains a breechblock or cap 68 threaded onto the upper end of the barrel 65 and having an inwardly directed flange 69 firmly engaging a thin metallic disc 70 bearing against the cartridge. In effect, the breechblock 68 clamps the disc 70 and cartridge to the gun barrel 65.

The cartridge 64 is fired by a mechanism disclosed in the above application, Serial No. 1,845, which includes a pin 73 that can enter a tapered hole 74 in the breechblock to strike and indent the disc 70 and thereby fire the cartridge. The flame from the cartridge ignites the upper end of the fusee 60 and initiates its combustion, which then becomes self-sustaining.

In running the tool through the drilling mud or other liquid in the well casing, the hydrostatic head of the well fluid tends to counteract or offset the gaseous pressure developed in the cylinder 30 as a result of the combustion of the product 60. This offsetting force is held to a minimum by providing the seals 46 between the lower cylinder head 33 and the piston rod 43. Thus, the hydrostatic head of fluid can act only in an upward direction upon the cross-sectional area of the piston rod. At the outset, the space between the piston 40 and lower cylinder head 33 is filled with air at atmospheric pressure. Of course, this air is compressed somewhat during downward movement of the piston 40, but the extent of compression is small when compared with the relatively high pressures that can be developed in the cylinder (of the order of 1,000 p. s. i., 2,000 p. s. i., 3,000 p. s. i. and much higher).

The gas pressure developed in the upper end of the cylinder 30 is acting over a relatively large piston area, while the offsetting hydrostatic head of fluid is acting over a comparatively small piston rod area. Accordingly, the pressure in the cylinder required to offset the hydrostatic head is only a small fraction of the hydrostatic head pressure.

The expansion rate of the gases developed in the cylinder 30 are retarded to insure a sufficient lapse of time in obtaining the desired sequence of operation of the well packer A, or other well tool, that might be secured to the setting or operating device C. A dash pot is provided within the setting sleeve or skirt 57. The rate at which the well fluid can be discharged from the sleeve 57 is retarded during movement of the setting ring 56 toward the dash pot head 58 attached to the lower end of the actuating mandrel 48. When in their initial positions, the head 58 is disposed below a relatively large size hole 121, which permits the well fluid to flow into the setting sleeve 57, completely filling it and forcing any air within the setting sleeve 57 through a relatively small size bleeder hole or orifice 122, extending through the setting sleeve 57 adjacent the setting ring 56. This air can also escape through the working clearance spaces provided between the setting ring 56 and the mandrel 48, and also between the anvil 44 and sides of the mandrel slots 53.

As the piston 40 moves downwardly, the setting sleeve 57 is also moved downwardly along the dash pot head 58, the large hole 121 passing below the packing ring 58a on the head, and causing all of the well liquid in the setting sleeve to be forced out through the small bleeder hole

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or orifice 122, and the aforementioned clearance spaces. This hole 122 and the clearance spaces are of relatively small area and restrict the passage of the well fluid from the setting sleeve 57. In this manner, a dash pot effect is provided, which increases the time interval during which the parts are movable. In effect, it retards the movement of the piston 40 in the cylinder 30 and the expansion rate of the gaseous products of combustion.

In the use and operation of the apparatus disclosed, it is lowered through the well casing on the lower end of the wire or other line (not shown), with the parts in the relative positions shown in Figs. 1 and 1a, to the point at which the packer A is to be anchored to the casing. The firing pin 73 is then projected downwardly, as described in the above-identified application, Serial No. 1,845, to strike and indent the thin disc 70 with sufficient force to fire the cartridge 64. The flame emanating from the cartridge ignites the upper end of the fusee 60, which begins burning away in a downward direction.

The gases, or products of combustion, gradually build up pressure in the firing chamber 61 and cylinder 30, urging the piston 40 downwardly and the cylinder 30 upwardly. The force of the piston 40 is transmitted through the rod 43, cross-piece 44 and setting ring 56 to the sleeve 57 which bears against the upper slips 23. When sufficient pressure has been developed in the cylinder to overcome the shear strength of the screws 26, and also the hydrostatic head of fluid acting upwardly on the piston rod 43, the slips 23 are released from the expander 20 and are pushed downwardly along the latter into outward engagement with the casing B. During such downward movement, the large hole 121 in the setting sleeve is shifted below the packing ring 58a on the dash pot head, entrapping the well fluid in the setting sleeve above the head and insuring that it can only escape from the setting sleeve through the orifice or bleeder hole 122 and through the working clearance spaces between the setting ring 56 and mandrel 48 and between the latter and the anvil 44.

As the combustion charge 60 continues to burn, the gas pressure within the cylinder 30 increases to a further extent. Since the upper slips 23 are wedged against the casing B, the piston cannot move downwardly to any further appreciable extent. Instead, the cylinder 30, actuating mandrel 48, sleeve 49 and packer body 10 are urged in an upward direction, carrying the dash pot head upwardly with them. When the pressure or force in the cylinder has increased sufficiently to overcome the shear strength of the screws 24 holding the upper expander 20 to the body, such screws are disrupted and the packer body 10 is moved upwardly within the upper expander 20, to compress the packing sleeve 19 between the upper and lower expanders 20, 18 and force it into firm sealing engagement with the casing wall. Again, the rate of such movement is retarded by the action of the dash pot head in being required to force the liquid thereabove through the relatively small orifice 122.

As the cylinder gas pressure increases further, as a result of the continued combustion of the charge 60, the shear values of the screws 25, 27 attaching the lower expander 18 to the body 10 and the lower slips 14 to the lower expander are exceeded and these shear screws are disrupted, allowing the cylinder 30 to move upwardly and carry the body 10 and lower slips 14 in an upward

direction, to shift the latter radially outward into engagement with the casing B. Again, the rate at which this action can occur is retarded by the upward movement of the dash pot head 58 in the setting sleeve 47, and the necessity for the fluid in the setting sleeve above the dash pot to be ejected through the small bleeder hole or orifice 122.

The pressure in the cylinder continues to increase as combustion of the charge proceeds and all of the packer elements are engaged more firmly with the casing B. When the pressure exceeds the shear strength of the pin 51, securing the lower end of the actuating mandrel 48 to the sleeve 49, this pin is sheared, to release automatically the setting tool C from the well packer A. All of the mechanism, with the exception of the packer, may now be removed from the well casing B.

Inasmuch as the gas developed within the cylinder 30 is at a comparatively high pressure at the time the disconnect pin 51 is sheared, such high pressure gas tends to shift the piston 40 downwardly within the cylinder at an exceedingly rapid rate, upon release of the load on the piston and cylinder as a result of disruption of the pin 51. The only substance under the piston 40 is air at very little pressure, which offers substantially no resistance to downward movement of the piston within the cylinder. As a result, the release of the load on the piston and cylinder would allow the high pressure gas to shift the piston 40 downwardly at a very high rate and strike an exceedingly great blow upon the lower cylinder head 33. This action would occur were it not for the presence of the dash pot retarding device. When the pin 51 is disrupted to release the load on the apparatus, the piston is prevented from moving downwardly within the cylinder at too rapid a rate, in view of the necessity for the dash pot head 58 to eject all of the fluid in the setting sleeve through the orifice 122 and the small clearance spaces between the mandrel 48 and the setting ring 56 and anvil 44. The retarding action of the fluid in the setting sleeve 57 means that the piston 40 is lowered relatively in the cylinder 30 at a slow rate, until it comes to rest against the lower cylinder head 33, without striking any substantial blow thereon.

It is, therefore, apparent that the dash pot connected to the cylinder and piston not only increases the time over which the definite operational steps can occur, to insure their occurrence in proper sequence, but it also acts to prevent or greatly minimize the force with which the piston 40 will strike the lower head 33, following disconnection of the setting tool C from the anchored well packer A.

The inventor claims:

1. In well apparatus: a well device adapted to be operated in a well bore; fluid actuated means operatively connected to said well device, comprising a cylinder, a piston slidable in said cylinder, a piston rod secured to said piston and extending from said cylinder, and packing means between said rod and cylinder to provide a confined space between said piston, rod and cylinder into which well fluid cannot enter; means in said cylinder for gradually generating a gas of increasing pressure; and means operatively connected to said fluid actuated means for retarding expansion of said gas in said cylinder, including means providing an orifice and a piston for forcing a liquid through said orifice.

2. In well apparatus: a well device adapted to

be operated in a well bore; fluid actuated means operatively connected to said well device, comprising a cylinder, a piston slidable in said cylinder, a piston rod secured to said piston and extending from said cylinder, and packing means between said rod and cylinder to provide a confined space between said piston, rod and cylinder into which well fluid cannot enter; means in said cylinder for gradually generating a gas of increasing pressure; and means connected to said cylinder and piston rod for retarding relative movement of said piston in said cylinder, including means providing an orifice and a piston for forcing a liquid through said orifice.

3. In well apparatus: a well device adapted to be operated in a well bore; fluid actuated means operatively connected to said well device, comprising a cylinder, a piston slidable in said cylinder, a piston rod secured to said piston and extending from said cylinder, and packing means between said rod and cylinder to provide a confined space between said piston, rod and cylinder into which well fluid cannot enter; means in said cylinder for gradually generating a gas of increasing pressure; and a dash pot connected to said cylinder and piston rod.

4. In well apparatus: a well device having initially retracted means engageable with a well casing; fluid actuated means for expanding said initially retracted means against the casing, comprising a cylinder and a piston slidable in said cylinder; means in said cylinder on the high pressure side of said piston providing a motivating force for shifting said piston in said cylinder, said cylinder and piston providing a closed fluid tight space on the low pressure side of said piston into which well fluid cannot enter; means releasable by said fluid actuated means initially securing said fluid actuated means to said well device; and means operatively connected to said cylinder and piston for retarding relative movement of said piston in said cylinder following release of said releasable means.

5. In well apparatus: a well device adapted to be operated in a well bore; fluid actuated means for operating said well device, comprising a cylinder and a piston slidable in said cylinder; means in said cylinder on the high pressure side of said piston providing a motivating force for shifting said piston in said cylinder, said cylinder and piston providing a closed fluid tight space on the low pressure side of said piston into which the well fluid cannot enter; means releasable by said fluid actuated means initially securing said fluid actuated means to said well device; and means operatively connected to said cylinder and piston for retarding relative movement of said piston in said cylinder upon release of said releasable means.

6. In well apparatus as defined in claim 4, wherein said retarding means includes a cylindrical member, a piston member slidable in said cylindrical member, one of said members having an orifice through which liquid is forced upon relative movement between said members.

7. In well apparatus as defined in claim 5, wherein said retarding means includes a cylindrical member, a piston member slidable in said cylindrical member, one of said members having an orifice through which liquid is forced upon relative movement between said members.

8. In well apparatus as defined in claim 4, wherein said retarding means comprises a cylindrical member having an orifice therein, a piston slidable in said member and adapted to force a

liquid in said cylindrical member through said orifice.

9. In well apparatus as defined in claim 5, wherein said retarding means comprises a cylindrical member having an orifice therein, a piston 5 slidable in said member and adapted to force a liquid in said cylindrical member through said orifice.

10. In well apparatus as defined in claim 5, wherein said retarding means comprises a cylindrical member operatively connected to said piston, a piston member operatively connected to 10 said cylinder, one of said members having an orifice through which liquid in said cylindrical member is forced upon relative movement between said members. 15

11. In well apparatus: a well device adapted to be operated in a well bore; fluid actuated means operatively connected to said well device, comprising a cylinder and piston means slidable in 20 said cylinder, said cylinder and piston means providing a confined space on the low pressure side of said piston means into which fluid in the well bore cannot enter; means providing a gas of increasing pressure within said cylinder on the high pressure side of said piston means to effect 25 relative movement between said cylinder and piston means, the gas expanding in said cylinder during such relative movement; and gas expansion retarding means operatively associated with said cylinder and piston means for retarding such relative movement, said gas expansion retarding means having an orifice through which a liquid

is forced during relative movement of said piston means in said cylinder.

12. In well apparatus: a well device adapted to be operated in a well bore; fluid actuated means operatively connected to said well device, comprising a cylinder and piston means slidable in 5 said cylinder, said cylinder and piston means providing a confined space on the low pressure side of said piston means into which fluid in the well bore cannot enter; means providing a gas of increasing pressure within said cylinder on the high pressure side of said piston means to 10 effect relative movement between said cylinder and piston means, the gas expanding in said cylinder during such relative movement; means releasable by said fluid actuated means for initially securing said fluid actuated means to said well 15 device; and gas expansion retarding means operatively associated with said cylinder and piston means for retarding relative movement between said cylinder and piston means after release of said releasable means, said gas expansion retarding means having an orifice through which a 20 liquid is forced during relative movement of said piston means in said cylinder. 25

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