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E. P. HALLIBURTON
APPARATUS FOR CEMENTING WELLS

2,235,318

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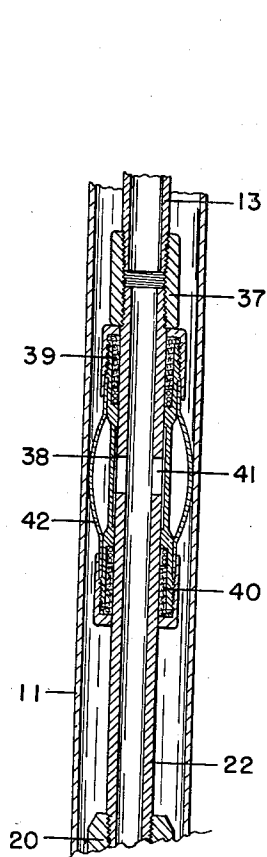


FIG 1

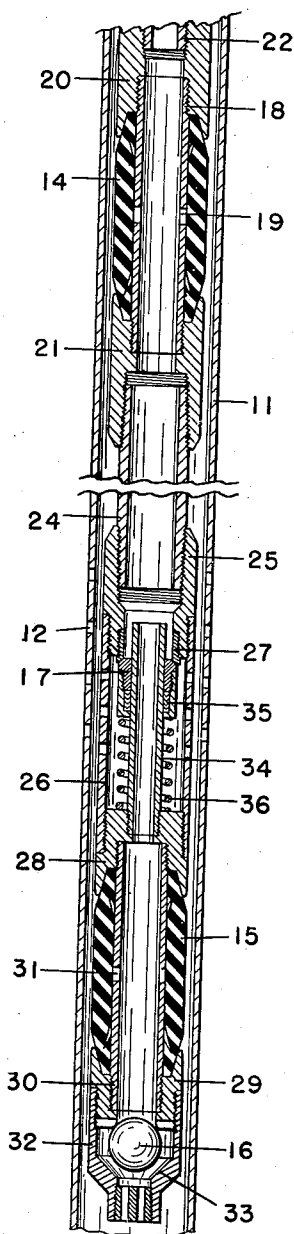


FIG 2

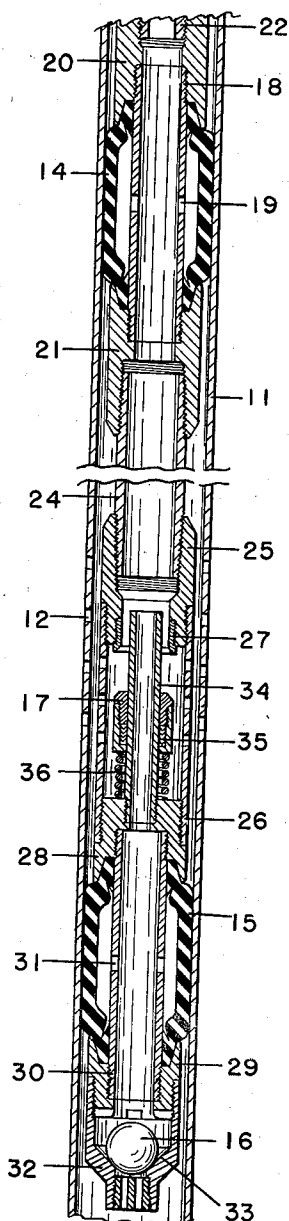


FIG 3

INVENTOR
ERLE P. HALLIBURTON
BY *Earl Babcock*

UNITED STATES PATENT OFFICE

2,235,318

APPARATUS FOR CEMENTING WELLS

Erle P. Halliburton, Los Angeles, Calif., assignor
to Halliburton Oil Well Cementing Company,
Duncan, Okla.

Application June 6, 1940, Serial No. 339,137

15 Claims. (Cl. 166—1)

This invention relates to apparatus for cementing wells or other holes in the ground and more particularly to an arrangement for sealing a conduit in a hole in the earth so that cement or other sealing liquid may be forced into an earth formation.

In the drilling of oil wells and also in the building of dams or other structures, it is common practice to force cement slurry under pressure into earth formations either in uncased holes or through perforations in casing. It is customary to provide some kind of bridge or cement retainer either above or below perforations in casing, or both above and below. Cement retainers have usually been fixed in the well and it has been necessary to drill them out after the cementing operations have been completed.

More recently it has been proposed to provide removable packers or cement retaining devices. Apparatuses of this type which have met with extensive commercial success are disclosed in the following copending applications:

Serial No. 319,546, Sladen R. Robinson et al., filed February 17, 1940, for "Cementing tool"; Serial No. 319,547, Sladen R. Robinson, filed February 17, 1940, for "Cementing tool"; Serial No. 319,550, Hugh Francis Boggs et al., filed February 17, 1940, for "Cementing tool"; and Serial No. 335,494, Maarten M. Verheul et al., filed May 16, 1940.

In these applications the packers illustrated have consisted of swab rubbers or cups commonly used in the oil fields, these swab rubbers being so mounted as to face each other so as to retain pressure therebetween.

While swab rubbers can, and are being used successfully in cementing tools of the type here under consideration, they have certain disadvantages. They wear out rapidly and are difficult to remove from the hole unless special means is devised to cause fluid to bypass or flow around them when they are moved upward.

In accordance with the present invention, it is proposed to use, in connection with cementing apparatus, packers which are expanded under the influence of fluid pressure and to provide simple and effective means for expanding or collapsing the packers when desired. The use of packers which are expanded under the influence of fluid pressure is not new. One of the first packers ever proposed for use in oil wells was of this type (see the patent to Spooner, No. 31,567, granted February 26, 1861). The disadvantage of fluid operated packers as employed heretofore results from the requirement of special means for setting the

same. With such a packer it is, of course, true that whenever the pressure on the outside of the packer is equal to, or greater than the pressure on the inside thereof, the packer collapses and no longer serves as sealing means in the well.

In accordance with the present invention, it is proposed to provide a simple spring biased valve arrangement which will serve automatically to control the setting of one or more fluid operated packers in a well or bore hole and at the same time serve to control the flow of fluid from a conduit sealed off thereby.

Accordingly, it is one object of the invention to devise new and improved apparatus for use in wells or the like, so that cementing operations such as squeeze cementing through perforations in casing may be carried out advantageously and so that like operations can be performed in a convenient and expeditious way.

It is a further object of the invention to provide new and improved apparatus for cementing wells which provides convenient means for carrying on cementing operations and which may then be removed from the well, making it unnecessary to drill out cement retainers, packers or other apparatus.

It is still a further object of the invention to provide apparatus for cementing wells wherein packers are employed in which means is provided for collapsing the packers when desired, so that fluid may readily flow past the same as the assembly is moved in the well.

It is still another object of the invention to provide apparatus for use in oil wells in which novel means is provided for controlling the setting and collapsing of packers.

Other objects and advantages reside in certain novel features of the arrangement and construction of parts as will be apparent from the following description taken in connection with the accompanying drawing in which:

Figure 1 is a vertical cross-sectional view of a fragmentary portion of casing with a portion of apparatus constructed in accordance with the present invention being lowered therethrough, the apparatus being shown in vertical cross-section and illustrating primarily a circulating sub;

Figure 2 is a vertical cross-sectional view of a perforated section of casing with additional apparatus constructed in accordance with the invention shown in cross-section, Figures 1 and 2 being contiguous; and

Figure 3 is a vertical cross-sectional view of the apparatus of Figure 2, showing the parts in

the position they occupy when the packers are expanded.

Referring to the drawing in detail, it will be seen that a section of the casing of an oil well is there illustrated at 11, the casing being provided with a number of perforations, as illustrated at 12.

The present invention relates to apparatus adapted to be lowered into the well on a conduit (such as drill pipe or tubing) for effecting one or more seals between the conduit and the open hole or casing in the hole. In the arrangement illustrated, the apparatus is lowered on tubing 13 and is used for sealing the tubing to the casing above and below the perforations 12 and for forcing cement or other sealing fluid through the perforations 12 after which the casing may be washed out or various other operations performed and the apparatus then removed from the well.

The essential parts of the apparatus are shown in Figure 2 and include an upper packer 14, a lower packer 15, a downwardly seating ball check valve 16, and a spring biased control valve 17.

Both packers 14 and 15 may be made of heavy flexible rubber; they are somewhat cylindrical in form and are mounted by means of the usual shoes on sections of pipe having holes or openings therein for applying fluid pressure to the interior thereof. Thus the packer 14 is mounted upon the pipe 18, having one or more perforations 19 therein. The packer 14 is clamped in position by means of the shoes 20 and 21, which are threaded on to the pipe 18.

The upper shoe 20 also serves as a collar for mounting the remainder of the apparatus shown in Figure 2 on a special mandrel 22 connected to the tubing 13, as will presently be described, while the lower shoe 21 has a depending flanged portion threaded on the inside for making connection to a nipple 24. The nipple 24 may be of any convenient length depending upon how far apart the packers are to be spaced.

Mounted on the lower end of the nipple 24 is a coupling member 25, the lower portion of which is threaded on the outside to make connection with a perforated pipe 26 and threaded on the inside to make connection with a cylindrical valve seat member 27. The lower end of the perforated pipe 26 is threaded into the upper shoe 28 of the lower packer 15. The upper shoe 28 and the lower shoe 29 of the packer 15 are mounted on a pipe 30, having perforations 31 therein, the arrangement being similar to that of the packer 14 described above.

The lower shoe 29 has a valve cage 32 thereon, which has a seat 33 adapted to receive the ball valve 16.

Within the perforated pipe 26 means for spring loading or spring biasing valve 17 is mounted. This arrangement serves to control the setting of the packers 14 and 15, as will be described hereinafter. The valve itself is mounted on a small piece of pipe 34 screw threaded into the top of the upper shoe 28 of the packer 15. This pipe has a smooth exterior surface and serves as a guide for the valve. Suitable packing such as is illustrated at 35 is provided between the valve member 17 and the pipe 34. The loading or biasing is effected by a coil spring 36 abutting against the shoe 28 and the valve 17, urging the latter upwardly to its closed position against the valve seat 27.

With this arrangement it will be seen that fluid can always flow upwardly from the point beneath both packers 14 and 15 into the mandrel 22 and

thence into the tubing 13, this flow being through the valve cage 32, the pipes 30 and 34, the nipple 24 and the pipe 18. Fluid cannot flow downwardly through the entire assembly, however, because of the ball valve 16.

The circulating valve or sub illustrated in Figure 1 is mounted on the mandrel 22 above the shoe 21 and below a collar 37 which serves to connect the mandrel to the tubing 13. The sub consists of a sleeve 38 slidably fitted upon the mandrel 22 and having packing glands 39 and 40 at its upper and lower ends so that when the sleeve occupies the position shown, no fluid can flow through the openings or ports 41 in the mandrel. The sleeve 38 is thus merely a valve.

To provide frictional engagement with the wall of the hole or with casing therein, the sleeve 38 is provided with drag springs 42. As long as the tubing 13 is being lowered into the well or held stationary after being lowered, the sleeve 38 will cover the ports 41.

When the tubing is moved upwardly, however, the sleeve 38 remains stationary, due to the drag on the walls of the hole until it abuts against the shoe 20, in which position the ports 41 are uncovered. Thus a convenient circulating sub, operated by merely raising or lowering the tubing, is provided.

The operation of the arrangement illustrated in carrying out a squeeze cementing operation through perforations 12 in the casing 11, may be as follows:

With the packers collapsed, as shown in Figure 2, the apparatus is lowered into the hole. As it is lowered, fluid may flow upwardly around the outside of the assembly and also upwardly there-through in the manner described above. When the assembly has reached the point in the well shown in Figure 2; that is when the packer 15 is below the perforations 12 in the casing and the packer 14 above the same, the tubing is raised slightly, opening the ports 41 in the circulating sub. Fluid may then flow downwardly through the tubing and outwardly through the ports 41 to establish regular circulation. If desired, the formation to be squeezed, namely that adjacent the perforations may be "broken down" at this time by forcing fluid under high pressure thereinto, this being accomplished by merely lowering the tubing to close the ports 41 in the circulating sub.

At any event, with the ports 41 open, cement slurry may be pumped into the tubing and forced downwardly therein, the fluid displaced thereby passing out through the ports 41 until the cement is down to or slightly above the packer assembly. The tubing is then set down enough to close ports 41 and pressure exerted on the cement. As the pressure on the inside of the tubing rises above that on the outside, first the packers 14 and 15 expand and effect a seal with the casing, (the ball valve 16 also closing if it has been open, of course) while the valve 17 remains closed on account of the bias or loading imparted thereto by the spring 36. It will be seen that the pressure on the inside of each of the packers 14 and 15 will build up until it exceeds the pressure on the outside thereof by an amount equal to the bias placed upon the valve 17 by the spring 36. When this difference in pressure is obtained, the valve 17 will open. It probably will not open as far as illustrated in Figure 3 (the opening being exaggerated by the draftsman for purpose of illustration) but the parts will now generally take the position shown in Figure 3. The cement 75

slurry may then flow downwardly through the tubing 13 and through the valve 17, out through the perforations in the pipe 26 and on out through the perforations 12 in the casing 11. No matter
 5 what pressure is required to squeeze cement into the formation, it will be seen that the pressure inside of the packers 14 and 15 will always be slightly greater than that on the outside thereof, for as soon as the pressure tends to equalize,
 10 the valve 17 will close and will remain closed until the requisite difference in pressure is again built up.

After the cement has been squeezed, the direction of circulation may be reversed to wash out the entire assembly. As the circulation is reversed, it will be seen that the pressure on the outside of the packers is greater than that on the inside and these packers will immediately collapse. The washing fluid may then flow downwardly on the outside of the assembly and upwardly through the check valve 16 and on up through the tubing or drill pipe 13, so as to completely wash out any excess cement. If desired, the assembly may now be moved to another location in the well and the cementing operation repeated, or the entire assembly may be removed from the well. No difficulty will be experienced in moving the apparatus either up or down in the well. If moved upwardly the
 25 ports 41 in the circulating sub will open equalizing any pressure difference between the inside and outside of the tubing and preventing any tendency for the packers to expand. If moved downwardly the check valve 16 opens if the
 30 pressure on the outside is greater than that on the inside of the tubing.

Only one embodiment of the invention has been illustrated and described but it is obvious that the invention may be carried out in a
 40 wide variety of ways and may be adapted to various purposes other than those mentioned. Materials other than cement may be used as sealing fluid. The apparatus can also be used for acidizing oil wells. Various changes may be made
 45 in the arrangement or construction of parts without departing from the spirit of the invention or the scope of the annexed claims.

I claim:

1. Apparatus adapted for use in holes in the
 50 earth, to force cement slurry or other sealing fluid into earth formations, including a tubular member adapted to be lowered into a hole for delivering sealing fluid into the same, two packers mounted in spaced relation on said tubular
 55 member, each of said packers being designed to expand and contact the wall of the hole and effect a seal therewith under the influence of fluid pressure exerted internally thereof, means providing an outlet for said tubular member between said packers, valve means controlling the
 60 flow of fluid from said tubular member through said outlet means and means for closing said valve except upon the existence of a predetermined excess of fluid pressure on the inside of said packers over the fluid pressure on the outside
 65 thereof, the arrangement being such as to prevent the discharge of sealing fluid from said tubular member through said outlet means except when said packers are effecting a seal with the wall of the hole.

2. Apparatus adapted for use in holes in the earth, to force cement slurry or other sealing fluid into earth formations, including a tubular member adapted to be lowered into a hole for
 75 delivering sealing fluid into the same, two pack-

ers mounted in spaced relation on said tubular member, each of said packers being designed to expand and contact the wall of the hole and effect a seal therewith under the influence of fluid pressure exerted internally thereof, means
 5 providing an outlet for said tubular member between said packers, valve means controlling the flow of fluid from said tubular member through said outlet means and a spring exerting force upon said valve tending to keep the same closed,
 10 said spring serving to bias or load said valve and prevent the opening of the same except upon the existence of a predetermined excess of fluid pressure on the inside of said packers over the fluid pressure on the outside thereof, the arrange-
 15 ment being such as to prevent the discharge of sealing fluid from said tubular member through said outlet means except when said packers are effecting a seal with the wall of the hole.

3. Apparatus adapted for use in holes in the
 20 earth, to force cement slurry or other sealing fluid into earth formations, including a tubular member adapted to be lowered into a hole for delivering sealing fluid into the same, a packer mounted on said tubular member, said packer
 25 being designed to expand and contact the wall of the hole and effect a seal therewith under the influence of fluid pressure exerted internally thereof, means providing an outlet for said tubular member adjacent said packer, valve means
 30 controlling the flow of fluid from said tubular member through said outlet means and means for closing said valve except upon the existence of a predetermined excess of fluid pressure on the inside of said packer over the fluid pressure on the
 35 outside thereof, the arrangement being such as to prevent the discharge of sealing fluid from said tubular member through said outlet means except when said packer is effecting a seal with the wall of the hole.

4. Apparatus adapted for use in holes in the
 40 earth, to force cement slurry or other sealing fluid into earth formations, including a tubular member adapted to be lowered into a hole for delivering sealing fluid into the same, a packer
 45 mounted on said tubular member, said packer being designed to expand and contact the wall of the hole and effect a seal therewith under the influence of fluid pressure exerted internally thereof, means providing an outlet for said tubu-
 50 lar member adjacent said packer, valve means controlling the flow of fluid from said tubular member through said outlet means and a spring exerting force upon said valve tending to keep the same closed, said spring serving to bias or
 55 load said valve and prevent the opening of the same except upon the existence of a predetermined excess of fluid pressure on the inside of said packer over the fluid pressure on the outside thereof, the arrangement being such as to prevent the discharge of sealing fluid from said tubular member through said outlet means except when said packer is effecting a seal with the wall of the hole.

5. Apparatus for cementing cased or uncased
 65 holes in the earth, including a conduit for conveying cement into the hole and having an outlet near the lower end thereof, a pair of hydraulically expansible packers mounted on said conduit, one on each side of the outlet thereof, a
 70 valve for controlling the discharge of cement through said outlet and means for holding said valve closed except when said packers are set to effect seals with the walls of the hole.

6. Apparatus for cementing cased or uncased 75

holes in the earth, including a conduit for conveying cement into the hole and having an outlet near the lower end thereof, a pair of hydraulically expansible packers mounted on said conduit, one on each side of the outlet thereof, a valve for controlling the discharge of cement through said outlet and means for holding said valve closed except when said packers are set to effect seals with the walls of the hole, said last mentioned means including a spring for loading said valve and for preventing the opening of the same until a predetermined pressure is built up within said packers.

7. Apparatus for cementing cased or uncased holes in the earth, including a conduit for conveying cement into the hole and having an outlet near the lower end thereof, a hydraulically expansible packer mounted on said conduit near said outlet, a valve for controlling the discharge of cement through said outlet and means for holding said valve closed except when said packer is set to effect a seal with the wall of the hole.

8. Apparatus for cementing cased or uncased holes in the earth, including a conduit for conveying cement into the hole, said conduit having a check valve at its lower end for preventing the discharge of fluid therefrom while permitting the entrance of fluid into the conduit, said conduit also having an outlet near the lower end thereof, a pair of hydraulically expansible packers mounted on said conduit, one on each side of said outlet, a valve for controlling the discharge of cement through said outlet and means for holding said valve closed except when said packers are set to effect seals with the walls of the hole.

9. Apparatus for cementing cased or uncased holes in the earth, including a conduit for conveying cement into the hole, said conduit having a check valve at its lower end for preventing the discharge of fluid therefrom while permitting the entrance of fluid into the conduit, said conduit also having an outlet near the lower end thereof, a pair of hydraulically expansible packers mounted on said conduit, one on each side of said outlet, a valve for controlling the discharge of cement through said outlet and means for holding said valve closed except when said packers are set to effect seals with the walls of the hole, said last mentioned means including a spring for loading said valve and for preventing the opening of the same until a predetermined pressure is built up within said packers.

10. Apparatus for cementing cased or uncased holes in the earth including a conduit for conveying cement into the hole, said conduit having an outlet near the lower end thereof, a circulating sub incorporated in said conduit above said outlet, a pair of hydraulically expansible packers mounted on said conduit, one between said circulating sub and said outlet and the other below said outlet, a valve for controlling the discharge of cement through said outlet and means for holding said valve closed except when said packers are set to effect seals with the walls of the hole.

11. Apparatus for cementing cased or uncased holes in the earth, including a conduit for conveying cement into the hole, said conduit having a check valve at its lower end for preventing the discharge of cement therefrom while permitting the entrance of fluid into the conduit,

said conduit also having an outlet near the lower end thereof, a circulating sub incorporated in said conduit above said outlet, a pair of hydraulically expansible packers mounted on said conduit, one between said circulating sub and said outlet and the other below said outlet, a valve for controlling the discharge of cement through said outlet and means for holding said valve closed except when said packers are set to effect seals with the walls of the hole.

12. Apparatus adapted for cementing wells having casing with a perforated section therein, said apparatus including a conduit for conveying cement into the well and having an outlet adapted to discharge the cement at a point in the well adjacent the perforations in the casing, a pair of hydraulically expansible packers mounted on said conduit in spaced relation and adapted, when expanded, to effect a seal with the casing above and below the perforations therein, a valve for controlling the discharge of cement through said outlet and means for holding said valve closed except when said packers are set to effect seals with the casing.

13. In oil well apparatus, a conduit having an outlet therein, a pair of packers on said conduit, one above and one below said outlet, means permitting the entrance of fluid into said conduit whenever the pressure on the outside thereof is greater than that on the inside, means for setting the packers in response to an increase in pressure on the inside of said conduit over that on the outside thereof and means for causing the packers to collapse whenever the pressure on the outside of said conduit exceeds that on the inside thereof.

14. In oil well apparatus, a conduit having an outlet therein, a pair of packers on said conduit, one above and one below said outlet, means permitting the entrance of fluid into said conduit whenever the pressure on the outside thereof is greater than that on the inside, means for setting the packers in response to an increase in pressure on the inside of said conduit over that on the outside thereof, means operable from the surface for controlling said packer setting means to render the same ineffective to set the packers even though the pressure on the inside of said conduit exceeds that on the outside thereof and means for causing the packers to collapse after they have been set whenever the pressure on the outside of said conduit exceeds that on the inside thereof.

15. In oil well apparatus, a conduit having an outlet therein, a pair of packers on said conduit, one above and one below said outlet, means permitting the entrance of fluid into said conduit whenever the pressure on the outside thereof is greater than that on the inside, means for setting the packers in response to an increase in pressure on the inside of said conduit over that on the outside thereof, means operable by pulling upwardly on said conduit for rendering said packer setting means ineffective to set the packers even though the pressure on the inside of said conduit exceeds that on the outside thereof and means for causing the packers to collapse after they have been set whenever the pressure on the outside of said conduit exceeds that on the inside thereof.

ERLE P. HALLIBURTON.

DISCLAIMER

2,235,318.—*Erle P. Halliburton*, Los Angeles, Calif. APPARATUS FOR CEMENTING WELLS. Patent dated March 18, 1941. Disclaimer filed January 22, 1942, by the assignee, *Halliburton Oil Well Cementing Company*.

Hereby enters this disclaimer to claims 1, 2, 3, 4, 5, 6, 7, 10, and 12.

[*Official Gazette February 17, 1942.*]