April 12, 1932. J. C. FORTUNE 1,853,557

FORMATION TESTING

Filed May 28, 1928 2 Sheets-Sheet 1

Fig. 1.

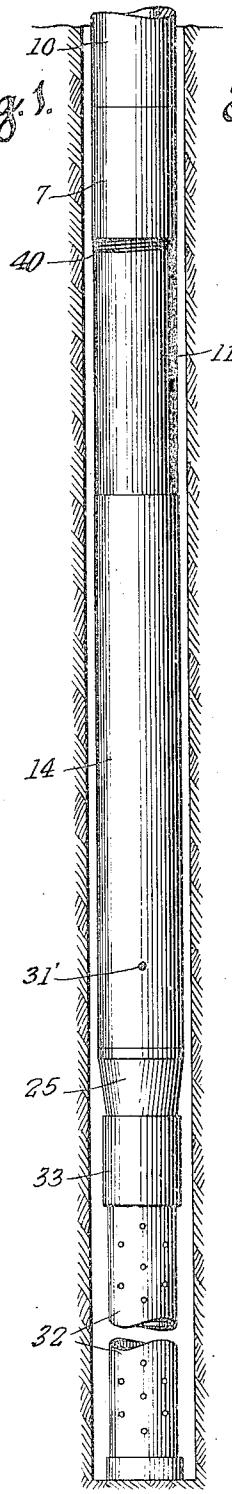


Fig. 2.

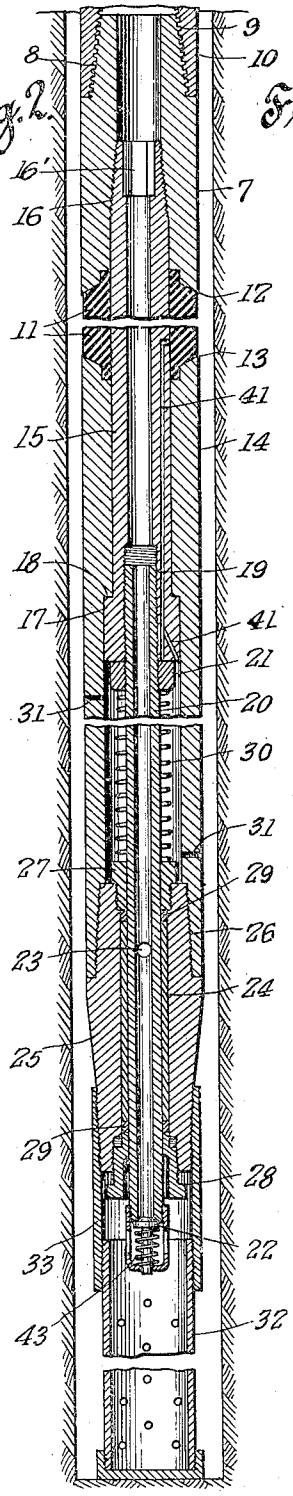
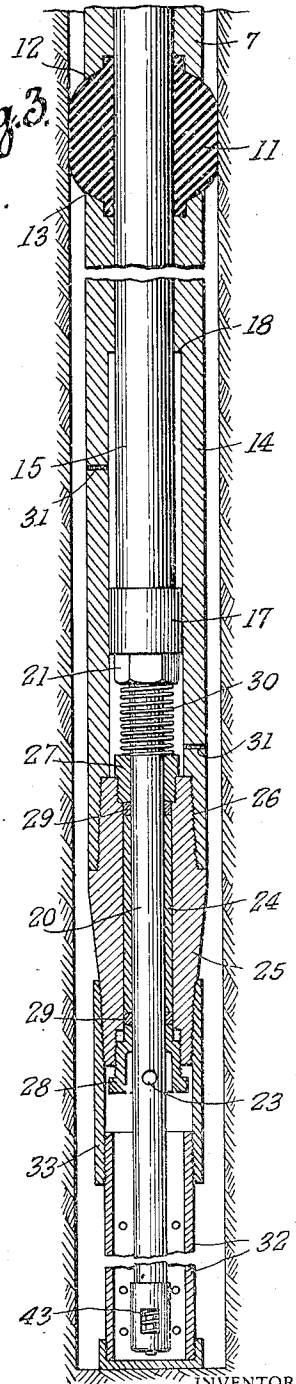


Fig. 3.



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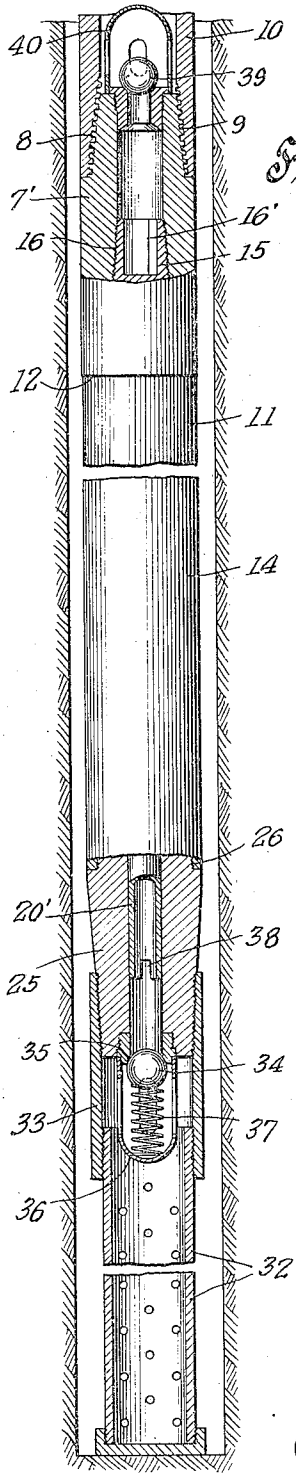

Fig. 4.

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Patented Apr. 12, 1932 1,853,557

UNITED STATES PATENT OFFICE

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FORMATION TESTING

Application filed May 28, 1928. Serial No. 281,136.

Special objects of this invention are to enable the testing of the formation in wells, irrespective of the methods by which such wells are drilled, to provide reliable apparatus for the purpose of and by which tests may be made at any level between the surface and the bottom of the hole, as the drilling progresses or after the drilling of the well has been finished and regardless of the diameter of the hole; to enable such tests being made with the full diameter of the hole and without the need for providing a seat or specially preparing the hole or utilizing special conditions at the bottom of the hole, or by sinking a smaller bore or "rat hole" as has been required heretofore; to insure safe positive action and attain practically automatic operation in the taking of samples; to enable maintenance of the static head in the well by not disturbing the drilling or well fluid above the point in the well being tested while taking the samples and to provide suitable mechanism for accomplishing the foregoing, which will be simple, practical and efficient in every respect.

The foregoing and other desirable objects are attained in this invention by certain novel features of construction, combinations and relations of parts as hereinafter set forth.

The drawings accompanying and forming part of this specification illustrate certain commercial embodiments of the invention, but it is to be understood that the structure may be varied as regards this particular disclosure without departure from the true spirit and broad scope of the invention.

Fig. 1 is a broken side elevation illustrating the tester as lowered into the hole at the lower end of the drill pipe or at the foot of several sections of pipe forming a container for the sample to be recovered; Fig. 2 is a somewhat enlarged and broken sectional view of the tester in the condition shown in the first view, that is with the anchor pipe just touching bottom and before the relatively telescopic parts have shifted to expand the packer and open the valve; Fig. 3 is a view generally similar to Fig. 2 but showing the parts as shifted to expand the packer and open the valve; Fig. 4 is a sectional view illustrating a modified form of the valve mechanism.

In the present disclosure, the apparatus is made as a unitary structure in the nature of a tool, which can be secured to the lower end of the drill string in place of the bit in case of rotary drilling or be lowered into the well by a cable, rods, or the like, in the case of other methods of drilling. In the particular embodiment of the invention shown, a connecting collar is indicated at 7 having a screw 8 to fit the screw socket 9 in a drill collar 10, which is attached to the lower end of the drill string. It is to be understood however, that other modes of attachment or means of supporting the tool may be employed, depending primarily on the method of drilling whether it be rotary, by cable tools, diamond drill or a combination of these, or other methods.

The collar 7 in the illustration forms the upper member of an expander for a packer 11, which is shown in the form of an expansible sleeve of rubber, rubber composition, canvas, jute, hemp, oakum, or other suitable material or materials, engaged at the upper end beneath the under-cut shoulder 12 of the connecting collar and at the lower end with the under-cut shoulder 13 of the sliding barrel 14.

The lower barrel member 14 is held to the upper member 7 by a sliding bearing over the wash pipe piston 15 which is shown as screwed up into the lower end of the connecting collar at 16 and as having a wrench socket 16′ in its upper end by which it may be screwed in place. A head 17 is shown provided on the lower end of the wash pipe, serving by engagement with a shoulder 18 in the barrel to limit the downward sliding movement of the barrel as shown in Fig. 2, this being the position of the parts with the packing sleeve in the contracted or unexpanded form.

The member 15 is shown as provided in its lower end with a long screw socket 19 adjustably receiving the correspondingly screw threaded end portion of a wash pipe 20, which is held in its adjusted relation by a lock nut 21. This pipe acts as a valve or valve operating member to control communication

between the drill pipe and the formation sealed off below the packer.

In the form of the invention illustrated in Figs. 1 to 3 inclusive, the wash pipe is normally closed at the lower end as indicated and has a port or ports 23 in the side of the same back from the closed lower end which is, or are, closed by the surrounding valve sleeve 24 under one set of conditions, Fig. 2 and opens, or open, to the space within the well under a different set of conditions, Fig. 3.

The valve sleeve 24 is shown as seated in a valve body 25 screwed into the lower end of the sliding barrel at 26. Glands 27 and 28 are shown screwed into the upper and lower ends of the valve head and as acting on lead or other suitable packing rings 29 to seal the valve sleeve in place and effect a non-leaking sliding connection with the wash pipe or valve pipe 20. The lower gland in particular is adjustable for the purposes of taking up wear on the packings.

While the weight of the sliding barrel and the expansive force of the rubber packing ring or sleeve are usually sufficient to insure the barrel normally remaining in its lowered position, as indicated in Figs. 1 and 2, with the packer unexpanded and the valve closed, a spring is shown at 30 surrounding the valve or wash pipe, abutting against the lock nut 21 and acting against the upper gland nut 27 to thrust the valve head and consequently the entire barrel structure downwardly, as indicated in Fig. 2. Vents 31 are shown provided in the side wall of the barrel about the valve pipe to prevent, if desired, trapping a cushion of fluid or creating a partial vacuum within the barrel, which might, if present, interfere with the desired operation of the apparatus.

A perforated anchor pipe 32 is shown detachably secured to the lower end of the valve head by a coupling sleeve 33. This so-called anchor pipe by engagement with the bottom of the hole serves to effect the expansion of the packer and the opening of the valve. It further serves as a guard and strainer about the lower end of the valve pipe, as will be clear from Fig. 3, and by regulating its length or its place in a string of pipe, it will be seen that the drill pipe may be opened to the surrounding formation directly at the bottom of the hole or at any desired distance above the bottom.

The operation and use of the invention will be apparent from the above description. When the device is attached to the lower end of the drill pipe, cable, rods, or the like, and lowered into the hole, it will be seen that the sliding barrel being in suspended relation will leave the packing sleeve unexpanded and the valve mechanism closed as in Figs. 1 and 2. The drill pipe or sections of drill pipe above the packer thus enter the hole "dry" and sealed against the liquid in the hole. When the anchor pipe or the lower end of the string reaches bottom, a further lowering movement will cause the upper part, carrying the upper packer expander and valve sleeve, to advance relative to the sliding barrel carrying the lower expander and the valve seat, and hence effect the expansion of the packer as in Fig. 3, to seal off the formation and the automatic opening of the valve to establish communication between the formation and the interior of the drill pipe or the length of drill pipe forming the container. In this condition, the formation will be sealed off at the level of the packer and the well contents below the packer will be opened up to the pipe at atmospheric pressure and at the level determined by the length of the anchor pipe, or position of the apparatus in the drill string. When the sample has been taken, the valve is closed and the packer is contracted by simply lifting on the pipe or suspending line, this having the effect of sliding the upper part of the device relative to the lower part so as to retract the upper packer expander and to withdraw the valve pipe into the valve sleeve to close the valve. The sample taken is thus in this action automatically trapped in the pipe and the packer freed from the hole, so that the pipe can be withdrawn with the sample sealed therein, and further, this withdrawal can be effected without releasing the static pressure and fluid contents of the well.

In the form of the invention illustrated in Fig. 4, the valving is effected by the wash pipe, but the valve itself is a separate instrumentality and the wash pipe operates as an actuating means for such valve. The valve is illustrated as a downwardly opening ball check valve 34 closing upwardly against a seat 35 carried by the valve cage structure 36, which is screwed upwardly into the bore of the valve body 25. This valve is normally held upwardly to its seat by a spring 37, in the downward path of the wash pipe 20', which in this instance is open at its lower end and notched at 38, so that it cannot be closed by the ball. In this form of the invention, there is shown in addition to the lower valve an upwardly opening ball check valve 39 confined in a valve cage 40 screwed into the upper end of the connecting collar 7'.

The operation of this second embodiment of the invention is substantially as before described in connection with the first form, it being evident that as the bottom of the hole is reached the packer will be expanded to seal off the formation and the wash pipe will open up communication between the formation and the inside of the drill pipe by forcing valve 34 downwardly off its seat. The top valve 39 will be lifted by the upward flow into the drill pipe, and this valve will close when the pipe is lifted out of the hole to trap

the formation sample. Thus as the packer is contracted and the lower valve 34 is closed as the wash pipe is retracted, the upper check valve carries the burden of holding the trapped liquid.

It will be observed that the expansion packer in addition to sealing against the walls of the well also has a sealing contact with the sliding piston. It thus serves the double function of sealing the formation and of preventing leakage between the two relatively sliding parts of the apparatus.

In using the apparatus with cable drilling equipment, a sufficient number of lengths of drill pipe are employed to provide the necessary sampling chamber, and the weight to set the packer and open the valve, the complete apparatus being lowered into the well by cable, rods, or the like. The invention is thus adaptable for use with various forms of drilling equipment and may be put to service in the course of drilling the well or when the well is completed or even when the well is flowing. Tests may be taken at different depths for instance, for the purpose of determining the point or points of production in a well or a location where water is coming in and all these tests may be conducted the full diameter of the hole. Also, if desired, the well may be sunk deeper and a test made of the new formation, leaving the old well as it was, to be again used if desired. The device also may be used to temporarily close off the well and permit a smaller outflow for the purpose of starting a well flowing. The packer engages with the side of the well at whatever level it may be expanded, so as to make it unnecessary to provide any seat therefor, and as no "rat-hole" is required, the sample is taken from the full diameter of the well and hence provides a more accurate and more comprehensive test than can be had where the sample is taken from the reduced sized bore or "rat-hole". No mechanical turning of the drill pipe is required either to set the packer or to open or close the valve, the sliding relation of the parts and the weight of the pipe serving to effect the necessary expanding of the packer and opening of the valve, and the weight of the valve head and attached parts operating to release the packer and close the valve when the drill string or length of drill pipe is lifted. When using only a certain length or drill pipe, as when the device is lowered in the hole by a cable, the top length may be sealed off at atmospheric pressure, the fluid in the formation then flowing into the pipe until the air trapped therein is compressed equal to the pressure on the formation. This ordinarily allows a sufficient sample being taken, the quantity of the sample depending on the length of pipe used.

The packer sleeve may be secured at one or both ends so as to surely follow the movements of the two telescopically related parts, for instance, by wrapping it with wire 40 at one or both ends as indicated in Fig. 1. To aid in the expansive and contractive movements of the packer, pressure may be utilized as by conducting fluid from the space within the barrel to a point in back of the packer sleeve. There is thus shown for this purpose in Fig. 2 a passage 41 extending from the lower chamber in the barrel up through the wall of the wash pipe piston and in back of the packer sleeve. The vent ports 31 are indicated as screw-threaded, so that they may be closed, if desired, by screw plugs 31′ as indicated in Fig. 1, so as to cause this chambered portion of the apparatus to act as a pump for forcing fluid in back of the packer when the pipe is lowered and to draw out this fluid from in back of the packer when the pipe is lifted. There is thus provided a pump mechanism automatically operable to positively expand and contract the packer as the pipe is lowered and lifted. Sufficient of this pumping effect may be obtained for short periods, without using the plugs 31′ if the vents 31 are small enough.

The wash pipe may be equipped with an automatic check valve, such as shown at 22 in Figs. 2 and 3, to enable mud being circulated in the well for the purpose of killing a blow-out while the tester is being withdrawn. This check valve opens downwardly, and while normally held closed by the superior static pressure in the well, is acted on by a closing spring 43 of sufficient strength to seat the valve against any possible superior pressure caused by any difference in level between the liquid inside and outside in pulling the pipe out of the well. This check valve will remain closed during ordinary sampling operations, but provides a means which may be utilized any time a blow-out is likely to occur to circulate the drilling fluid, remove the old drilling fluid and introduce fresh drilling mud to kill the pressure, the superior pressure created by the pump being sufficient to open the valve when this use of the same is required. When this automatic valve is not considered necessary, the end of the wash pipe may be closed by a suitable cap or plug.

What is claimed is:

1. In apparatus of the character disclosed, a supporting collar, a wash pipe piston set in said collar, an expansible packer surrounding said wash pipe piston, a barrel slidingly suspended on said wash pipe piston and operable in its upward movement over the wash pipe piston to expand the packer, a wash pipe adjustably set in the wash pipe piston and cooperating valving means carried by the barrel and wash pipe for controlling communication between well formation and the interior of said wash pipe.

2. In apparatus of the character disclosed, a supporting collar, a wash pipe piston set

in said collar, an expansible packer surrounding said wash pipe piston, a barrel slidingly suspended on said wash pipe piston and operable in its upward movement over the wash pipe piston to expand the packer, a wash pipe adjustably set in the wash pipe piston, cooperating valving means carried by the barrel and wash pipe for controlling communication between well formation and the interior of said wash pipe and an anchor pipe of predetermined desired length dependent from the barrel for engagement with the bottom of the well.

3. In apparatus of the character disclosed, a supporting collar, a wash pipe piston set in said collar, an expansible packer surrounding said wash pipe piston, a barrel slidingly suspended on said wash pipe piston and operable in its upward movement over the wash pipe piston to expand the packer, a wash pipe adjustably set in the wash pipe piston, cooperating valving means carried by the barrel and wash pipe for controlling communication between well formation and the interior of said pipe, the valve means including a valve body carried by the barrel and the wash pipe having a valve element cooperating with the valve body to form the companion members of a valve structure.

4. Apparatus of the character disclosed, comprising a support, a wash pipe adjustably secured to said support, a barrel suspended from and longitudinally shiftable relative to said support, valving means cooperatively related as to the wash pipe and barrel to control communication between well formation and the interior of said wash pipe, a packer operable in the sliding movements of the barrel relative to the wash pipe, said wash pipe being closed at its lower end and the valving means including a port in the side of the wash pipe and a cooperating valve sleeve carried by the barrel.

5. Apparatus of the character disclosed, comprising a wash pipe having a closed end and provided with a port in the side thereof, a valve sleeve slidable over said wash pipe to open and close said port, and an expansible packer operable in conjunction with the sliding movements of said valve sleeve.

6. Apparatus of the character disclosed, comprising a wash pipe having a closed end and provided with a port in the side thereof, a valve sleeve slidable over said wash pipe to open and close said port, an expansible packer operable in conjunction with the sliding movements of said valve sleeve, said wash pipe having an adjustable mounting relative to said valve sleeve to predetermine the timing of the valve opening and closing action relative to the sealing and unsealing operations of the packer.

7. Apparatus of the character disclosed, comprising telescopically related parts, valve mechanism carried by said parts and operable in the telescopic movements of the same, a packer carried by said parts and pump means incorporated in said parts and operable in the movement of the same for applying pressure to and removing pressure from in back of said packer.

8. In apparatus of the character disclosed, the combination of tubular members having limited sliding movement one over the other, an abutment section carried by the outer tubular member to effect relative movement of the two members upon engagement with the bottom of a well, said inner member having a wash pipe portion extending down into said abutment section, a valve sleeve carried by the outer member for cooperation with said wash pipe portion to control communication with the interior of the apparatus and an expansible packer operable in the relative movement of the over-sliding members.

9. Apparatus of the character disclosed, comprising telescopically related parts, valve mechanism operable in the telescopic movements of said parts, an expansible packer carried by said parts, said parts including a pump barrel, a piston element operating therein and a fluid passage extending from the pump barrel to a position in back of the packer, whereby in the telescopic movements of the parts pressure will be applied to or removed from in back of the packer.

In testimony whereof I affix my signature.

JAMES C. FORTUNE.