May 4, 1937. H. C. YARBROUGH 2,079,140

FORMATION TESTER

Filed March 12, 1934

FIG. 1.

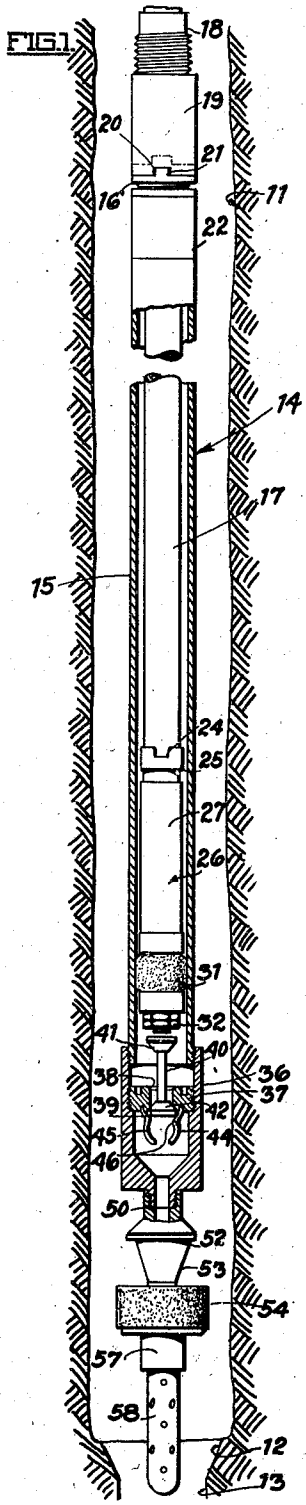


FIG. 2.

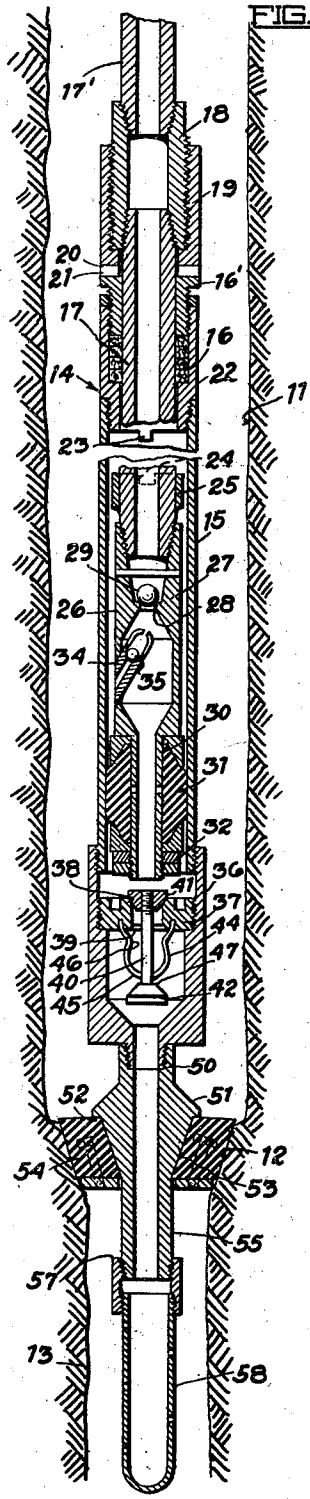
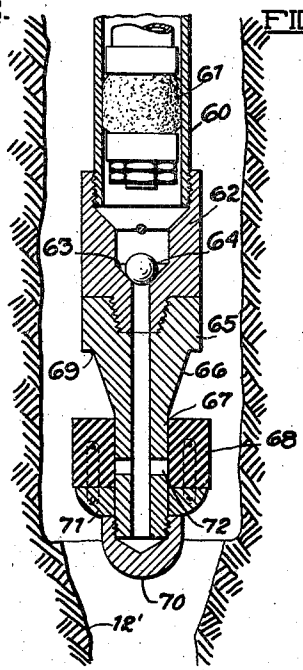


FIG. 3.



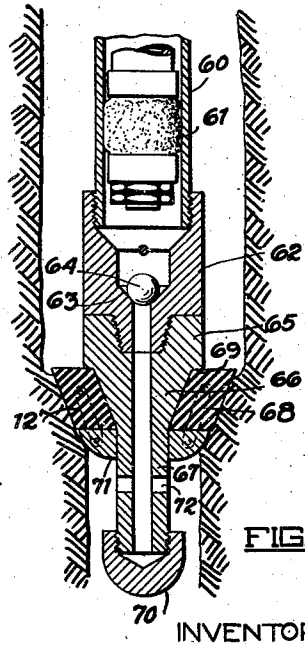


FIG. 4.

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FORMATION TESTER

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9 Claims. (Cl. 166—1)

This invention has to do in a general way with the so-called formation tester used in obtaining samples from underground formations or regions in bore holes.

It is a primary object of this invention to produce an improvement to formation testers whereby a complete sample of the liquid produced by the formation tested can be recovered, regardless of how small the natural formation pressure may be. My invention, therefore, consists broadly in providing a formation tester with positive means for applying suction directly to the formation and withdrawing liquid from isolated packed-off area in the bottom of a bore hole.

Broadly, my invention embodies packing means adapted to engage a wall in the bore hole or a casing to form an isolated packed-off area in the bottom of the well and pumping means for positively withdrawing the liquid from the isolated area into or through a liquid delivery tubing. A valve of some kind is provided to prevent the entrance of well fluid into the pump until such time as the packer has been set.

The packing means may be one of two general types known as the shoulder or bottom hole packer, and the wall or straight hole packer. In the use of the first packer, it is customary to provide what is known as a rat hole in the bottom of the main bore hole, such rat hole being connected with the main bore hole by a tapered shoulder formed with a suitable reaming device. In the case of the latter packer, the packing member is associated with slips adapted to be actuated in any suitable manner well known to those familiar with the art, such as by rotating the tubing or pipe whereby the unit is suspended.

Inasmuch as the application of the wall type packer will be obvious to those familiar with the art, I will illustrate and describe my invention only in conjunction with the shoulder or bottom hole packer.

It is a further object of this invention to provide a formation tester of the class described with a novel valve construction which may be employed to prevent the ingress of liquid from the bore hole into the tester while it is being lowered, and in a modified form of my invention, I provide a novel form of valve means for preventing ingress of liquid into the tester while it is being raised.

It will be understood that in the ordinary type of tester described hereinabove, it is positively essential that the tester be closed against the ingress of liquid while it is being raised. In my invention, however, I may operate the pumping element to deliver the sample to the surface of the ground before the tester is removed, and when operated in this manner it is not necessary to close the tester when it is raised. In operating at great depths, however, there are certain advantages in removing the tester and the sample before the liquid has been pumped to the surface of the ground and when it is desired to operate the unit in this manner, I may employ the modified form of the device, or I may employ one of the conventional valve mechanisms used in practice.

The details in the construction of certain preferred forms of my invention, together with other objects attending its production, will be best understood from the following description of the accompanying drawing which is chosen for illustrative purposes only, and in which—

Fig. 1 is an elevational view partly in section showing one form of formation tester, contemplated by my invention, as having been lowered into the bore hole to a point just prior to its engagement with the shoulder or a rat hole;

Fig. 2 is an enlarged sectional elevation illustrating the device shown in Fig. 1 as having been lowered into position with the packer engaging the shoulder;

Fig. 3 is a fragmentary sectional elevation showing a modified form of the invention lowered into a bore hole and positioned just prior to the engagement with the packer with a rat hole shoulder; and

Fig. 4 is a sectional elevation similar to Fig. 3 showing the tool as having been lowered into testing position.

More particularly describing the invention as herein illustrated, reference numeral 11 indicates a bore hole which terminates at its lower end in a tapered shoulder 12 below which a rat hole 13 extends a substantial distance.

It is to be understood that the formation situated below the rat hole 13 is that from which the test sample is to be obtained, and it is to be further understood that the bore hole may have been provided with a casing which in turn may or may not have been cemented off in the conventional manner at the region of the rat hole prior to boring the rat hole.

The formation tester, generally indicated by reference numeral 14, embodies a working barrel 15, the upper end of which is provided with a packing gland 16 through which a hollow plunger rod section 17 extends.

The plunger rod section 17 is connected through

an externally threaded collar 18 with tubing 17' which extends to the surface of the ground where it can be reciprocated in any suitable manner.

A stop collar 19 is threaded on the connecting collar 18, such stop collar being provided with a clutch face shown as comprising a notch 20 which is adapted to receive another clutch member shown as comprising a projection 21 provided on the top of a packing nut 16'.

The stop collar just described is provided to optionally extend or shorten the effective length of the hollow plunger rod section 17 which extends into the working barrel for the purpose of actuating a control valve in the manner which will be hereinafter described.

The packing nut 16' is mounted in a sub 22 which forms the upper end of the working barrel, and such sub is provided with a clutch member 23 adapted to engage a corresponding clutch member 24 formed in a collar 25 which is rigidly secured to the lower end portion of the hollow plunger rod section 17, this last mentioned clutch mechanism being for the purpose of actuating wall slips in the manner well known to those familiar with the art.

The bottom of the hollow plunger rod section 17 is secured to a plunger member which is generally indicated by reference numeral 26, and it comprises what I may term a housing 27 having a valve seat 28 therein, such valve seat supporting a working valve 29.

The lower end of the housing 27 carries a downwardly projecting hollow stem 30 which supports a plunger member 31 shown as being of the rubber packing type, such plunger member being held on the stem by means of a nut assembly 32.

Mounted in the wall of the body between the plunger and the working valve, I provide relief valve means shown as comprising a short nipple 34 which is provided with a check valve 35 at its inner end. This last mentioned valve is for the purpose of relieving the pressure in the top of the working barrel during the up stroke of the plunger.

The bottom of the working barrel is formed by a chambered housing 36 which contains an apertured diaphragm 37 having seats 38 and 39 in both its top and bottom faces. Extending through the aperture in this diaphragm, is a loose fitting valve stem 40 which has valves 41 and 42 on its ends, such valves being adapted for engagement with the valve seats 38 and 39 respectively.

The valve 41 is adapted to act as an automatic check valve during the reciprocation of the plunger, and the valve 42 is provided for the purpose of preventing ingress of liquid from the bore hole into the working barrel while the tester is being lowered into the well.

In order to successfully function for this purpose, it is necessary to provide some means for holding the valve 42 in engagement with its seat 39 until such time as the tool may have been immersed. In this form of my invention, this is done by providing a pair of spring fingers 44 and 45 in the bottom of the diaphragm plate 37 adjacent the lower valve seat 39. These fingers are shaped so as to provide shoulders 46 which extend below the bottom face of the valve 42 and hold the valve in engagement with its seat in the manner shown in Fig. 1.

The portions of the fingers below the shoulders 46 are turned inwardly so that when the valve is forced downwardly below the fingers they engage the valve stem and prevent upward movement of the valve unit by virtue of the engagement of the ends of the fingers with a shoulder 47 formed on the top of the bottom valve.

Reference numeral 50 indicates a conduit section which co-operates with the chambered housing 36 to form what I may term a liquid inlet conduit. The tubing 50 is provided with an enlargement 51 having a shoulder 52 below which exends a tapered face 53, such tapered face being provided for the purpose of expanding a packing ring 54 which is slidably mounted upon a straight or untapered portion 55 of the tubing and which normally rests on a shoulder which is shown as being formed by the upper edge of a collar 57. The collar 57 supports a strainer pipe 58.

In the operation of a tool of the type just described, the tester is assembled with the stop collar 19 screwed down into the position shown in Fig. 1, and with the valve 42 releasably locked in its uppermost position by means of the spring fingers 44 and 45 as illustrated in Fig. 1. The unit is then lowered into the well by means of a hollow plunger rod or conduit 17' such as an ordinary drill stem, until the packing ring 54 engages the shoulder 12.

It will be understood that the valve 42 will prevent the entrance of any liquid from the well into the working barrel during the downward movement of the tool, and it is also to be understood that the length of the section 17 of the hollow plunger rod and the threaded stop collar 19 is such that the upward movement of the working barrel, such as is caused by its buoyancy when it is immersed in the liquid of the well, will not bring the upper valve 41 into engagement with the bottom of the plunger.

When the tool has been lowered into the well to a point at which the packing ring 54 engages the shoulder 12, the continued application of weight by the downward movement of the tubing forces the conical face of the tubing section 50 through the packing ring expanding the same into engagement with the shoulder, thereby sealing the bottom portion of the bore hole from the upper portion.

In most wells in which a device of this character is used, the well normally contains a substantial quantity of mud or rotary drilling fluid and the weight of such fluid on the packer in a device of this character is sufficient to anchor the tool in the well. If the operator considers it advisable, however, he may, after the packer has been set, pump additional drilling fluid into the well in order to anchor the tester and hold the barrel against movement during the pumping operation. After the device has been positioned in the manner just described, it will be understood that the packer is in the position shown in Fig. 2 and that the plunger and its associated operating tubing are in the position shown in Fig. 1 where the clutch members 20 and 21 are engaged and the bottom of the plunger is supported a slight distance above the upper valve 41. With the parts arranged in this manner, the operator next rotates the tubing 17' at the surface of the ground, such rotation being effective, by virtue of the engagement of the clutch members 20 and 21, to rotate the collar member 18 within the stop collar 19, thereby advancing the collar 18 and the tubing 17—17' downwardly so as to bring the bottom of the plunger into pressure engagement with the valve 41. The length of the threads is such that by continued rotation

the valve is forced downwardly off its seat admitting the liquid from the rat hole or the sealed zone below the packer into the working barrel.

Inasmuch as the valve 41 is to act as a standing valve during the reciprocation of the plunger in the working barrel, the rotation of the tubing is continued until the valve 42 has been forced into the position shown in Fig. 2 where it is below the spring fingers 44 and 45' such fingers being compressed against the stem 40 where they will be engaged by the shoulder 47 to prevent the upward movement of the valve 42 into engagement with its seat during the up stroke of the plunger. It will be seen, therefore, that when the unit is installed in the manner just described, the plunger can be reciprocated by suitable means at the surface of the ground to pump a sample from the formation and deliver the same to the surface of the ground.

As pointed out hereinabove, it may, under certain circumstances, be undesirable to pump the sample to the surface of the ground, and, under such circumstances, I contemplate using a pump and packer mechanism which is associated with means for preventing the ingress of fluid from the well during such times as the unit is being lowered into the well or withdrawn therefrom. Although various types of valve mechanisms may be employed for this purpose, I show in Figs. 3 and 4 one form of such mechanism wherein the valve means for closing the tester, during such times as the packer is not set, is shown as being incorporated in the packer itself.

In this form of my invention, reference numeral 60 indicates a working barrel containing a piston 61 which is similar in its construction and operation to the piston and working barrel assembly shown in Figs. 1 and 2 except that it is unnecessary to employ the stop 19 in this latter construction. The bottom of the working barrel 60 engages what I may term a bushing member 62 which is provided with a valve seat 63 and a standing valve 64.

The bushing 62 is connected to and communicates with a connection 65 which has a tapered portion 66 and a straight portion 67 upon which a packer 68 is slidably mounted. The tapered portion 66 terminates in an upper shoulder 69 which limits the upward movement of the packer. The bottom of the straight portion 67 is provided with a closure cap 70 which forms a shoulder for supporting the packer against downward movement, and the packer is shown as being secured at its lower edge to a metal ring 71.

For the purpose of admitting fluid into the tubing through the connection 65, I provide the straight portion 67 of the connection with a port or a plurality of ports, generally indicated by reference numeral 72. These ports, as shown in Fig. 3, are normally closed by the packer, but when the tool is lowered into a position at which the packer is spread over the tapered portion 66 into sealed engagement with a shoulder 12' in the bore hole, the ports 72 are uncovered for admitting liquid from the packed off lower portion of the bore hole.

When the tool is lifted from the formation, it will be seen that the pressure of the liquid in the upper portion of the bore hole is effective to hold the packer against upward movement so that it is forced into its lower position to close the ports 72 before it is lifted from the shoulder 12'.

In this construction, it will be seen that the packer and the ports 72 co-operated to constitute what is in effect a sleeve valve which is automatically opened when the packer is set and is automatically closed before the packer can be released by an upward pulling force. Other types of valve mechanism may be employed to seal the tester during installation and removal.

It will be understood from the foregoing description, that my invention contemplates a novel method of obtaining a sample of fluid from an underground formation which includes lowering a sealed tubing into the formation in the bore hole, then packing the bore hole around the tubing to seal the bottom of the bore hole and the formation in question from the remainder of the bore hole, then breaking the seal in the tubing and pumping the fluid from the bore hole in the isolated region of the formation being tested.

It is to be understood that, while I have herein described and illustrated certain preferred forms of apparatus for attaining the objects of this invention and practicing the method just described, the invention is not limited to the precise forms of apparatus shown and described herein but includes within its scope whatever changes fairly come within the spirit of the appended claims.

I claim as my invention:

1. A testing device of the class described embodying: a working barrel adapted to be suspended in a bore hole; a hollow plunger in said working barrel; a hollow plunger rod extending through the top of said working barrel for supporting said plunger; a working valve in said plunger; a standing valve in the bottom of said working barrel; a liquid inlet conduit in the bottom of said working barrel having an enlarged conical shaped upper portion; packing means slidably mounted on said liquid inlet conduit; and valve means associated with said liquid inlet conduit for releasably sealing said working barrel against ingress of liquid from said bore hole.

2. A testing device of the class described embodying: a working barrel adapted to be suspended in a bore hole; a hollow plunger in said working barrel; a hollow plunger rod extending through the top of said working barrel for supporting said plunger; a working valve in said plunger; a standing valve in the bottom of said working barrel; a liquid inlet conduit in the bottom of said working barrel; packing means on said liquid inlet conduit; valve means associated with said liquid inlet conduit for releasably sealing said working barrel against ingress of liquid from said bore hole; and means operable by the weight of said hollow plunger rod when said packer is supported against further downward movement for opening said last mentioned valve.

3. A formation tester of the class described embodying: the combination of a working barrel; a hollow plunger in said working barrel; a hollow plunger rod extending through the top of said working barrel for operating said plunger; a liquid delivery tubing mounted on the bottom of said working barrel; packing means associated with said working barrel for engaging the wall of the bore hole; a working valve in said hollow plunger rod; an upwardly opening standing valve in the bottom of said barrel; a downwardly opening valve on the bottom of said barrel; and releasable means for holding said last mentioned valve in a closed position.

4. A formation tester of the class described embodying: the combination of a working barrel; a hollow plunger in said working barrel; a hol-

low plunger rod extending through the top of said working barrel for operating said plunger; a liquid delivery tubing mounted on the bottom of said working barrel; packing means associated with said working barrel for engaging the wall of the bore hole; a working valve in said hollow plunger rod; a diaphragm plate in the bottom of said working barrel said plate having a passage therethrough provided with valve seats in the ends of said passage; a valve stem extending through said passage; valves on the end of said stem for engaging the respective valve seats; releasable means for holding the lowermost of said valves in engagement with its corresponding seat; and means for imparting downward movement to said plunger to engage the uppermost valve and force the lowermost valve from its seat.

5. A formation tester of the class described embodying: the combination of a working barrel; a hollow plunger in said working barrel; a hollow plunger rod extending through the top of said working barrel for operating said plunger; a liquid delivery tubing mounted on the bottom of said working barrel; packing means associated with said working barrel for engaging the wall of the bore hole; a working valve in said hollow plunger rod; a diaphram plate in the bottom of said working barrel; said plate having a passage therethrough provided with valve seats in the ends of said passage; a valve stem extending through said passage; valves on the ends of said stem for engaging the respective valve seats; releasable means for holding the lowermost of said valves in engagement with its corresponding seat; means for imparting downward movement to said plunger to engage the uppermost valve and force the lowermost valve from its seat; and means for holding said lowermost valve away from its corresponding seat.

6. A formation tester of the class described embodying: the combination of a working barrel; a hollow plunger in said working barrel; a hollow plunger rod extending through the top of said working barrel for operating said plunger; a liquid delivery tubing mounted on the bottom of said working barrel; packing means associated with said working barrel for engaging the wall of the bore hole; a working valve in said hollow plunger rod; a diaphragm plate in the bottom of said working barrel, said plate having a passage therethrough provided with valve seats in the ends of said passage; a valve stem extending through said passage; valves on the ends of said stem for engaging the respective valve seats; releasable means for holding the lowermost of said valves in engagement with its corresponding seat; means for imparting downward movement to said plunger to engage the uppermost valve and force the lowermost valve from its seat; and means for holding said lowermost valve away from its corresponding seat; said valve holding means being formed so as to permit a substantial upward movement of said upper valve.

7. A formation tester of the class described embodying; the combination of a working barrel; a hollow plunger in said working barrel; a hollow plunger rod extending through the top of said working barrel for operating said plunger; a liquid delivery tubing mounted on the bottom of said working barrel; packing means associated with said working barrel for engaging the wall of the bore hole; a working valve in said hollow plunger rod; a diaphragm plate in the bottom of said working barrel, said plate having a passage therethrough provided with valve seats in the ends of said passage; a valve stem extending through said passage; valves on the ends of said stem for engaging the respective seats; releasable means for holding the lowermost of said valves in engagement with its corresponding seat; and threaded means operable by rotating said plunger rod for imparting downward movement to said plunger to engage the uppermost valve and force the lowermost valve from its seat.

8. A formation tester of the class described embodying: the combination of a working barrel; a hollow plunger in said working barrel; a hollow plunger rod for operating said plunger; a standing valve in the bottom of said working barrel; a liquid delivery tubing on the bottom of said working barrel; a packing member slidably mounted on said liquid delivery tubing; means including a tapered surface on the upper portion of said liquid delivery tubing for expanding said packer during the downward movement of said liquid delivery tubing through said packer; and closure means in the bottom of said liquid delivery tubing, said liquid delivery tubing being provided with wall ports positioned so as to be covered by said packer when it is in its lowermost position and adapted to be uncovered when said tubing is moved downwardly relative to said packer.

9. A formation tester of the class described embodying: a working barrel adapted to be suspended in a bore hole; pump means in said barrel; a liquid inlet conduit in the bottom of said barrel having an enlarged conical shaped upper portion; a packing member slidably mounted on said conduit and adapted to slide upwardly over said enlarged portion; and means for releasably sealing said working barrel against the ingress of liquid from said bore hole.

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